Springer Texts in Business and Economics

Kurt Gaubinger · Michael Rabl
Scott Swan · Thomas Werani

Innovation and Product Management

A Holistic and Practical Approach to Uncertainty Reduction

Springer

Springer Texts in Business and Economics

For further volumes:
http://www.springer.com/series/10099

Kurt Gaubinger • Michael Rabl •
Scott Swan • Thomas Werani

Innovation and Product Management

A Holistic and Practical Approach to Uncertainty Reduction

Springer

Kurt Gaubinger
Michael Rabl
School of Engineering &
Environmental Sciences
Upper Austria University of
Applied Sciences
Wels
Austria

Scott Swan
School of Business Administration
Tyler Hall
The College of William & Mary
Williamsburg, Virginia
USA

Thomas Werani
Department for Business-to-Business-Marketing
Johannes Kepler University Linz
Linz
Austria

Substantially revised and translated from German language edition: Praxisorientiertes Innovations-und Produktmanagement by Kurt Gaubinger, Thomas Werani, Michael Rabl

Additional material to this book can be downloaded from http://extras.springer.com.

ISSN 2192-4333 ISSN 2192-4341 (electronic)
ISBN 978-3-642-54375-3 ISBN 978-3-642-54376-0 (eBook)
DOI 10.1007/978-3-642-54376-0
Springer Heidelberg New York Dordrecht London

Library of Congress Control Number: 2014946798

Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

Preface

The increasing complexity and dynamics of today's marketplace create an environment in which it is difficult for companies to produce innovations and market them successfully. Moreover, this environment dramatically increases the uncertainty of innovation activities. Against this backdrop, a company's systematic innovation and product management is increasingly important for success in these countervailing realities.

This is the point of departure for the book. Based on the fundamentals of innovation and product management, a holistic process model is offered in a compact manner with particular focus on innovation and uncertainty. This integrated consideration of innovation management *and* product management within an interdisciplinary approach represents a unique characteristic of this book. This position is important for practice-oriented research and education in the field of innovation and product management. It also provides an opportunity for practitioners to re-evaluate day-to-day issues within the context of conceptual considerations. Hence this book is addressed to thinking managers who want a practical but well-researched guide to innovation and product management. Furthermore, the book is approachable by graduate students from innovation management, engineering management, marketing, and product management disciplines to deepen their knowledge in their field. Additionally, many of the chapters are appropriate for advanced undergraduate students. Educational support materials are available including slides, recommended cases, and popular press articles that illuminate the ideas discussed in the book. In order to meet these requirements, the book was designed with a process-oriented structure (see Fig. 1). The book is divided into three major parts:

Part I covers the *Fundamentals of Innovation and Product Management*. *It* explains the connection between market-driven innovations and business success. Subsequently, the authors derive an integrated process model of innovation and product management on which the structure of the book is based. The "fuzzy" front end of innovation is explored and finally innovation strategy is discussed in the context of the planning of innovation and new product management.

Part II takes a closer look at the *Process of Innovation and Product Management*. Concepts related to idea management and open innovation are detailed along with

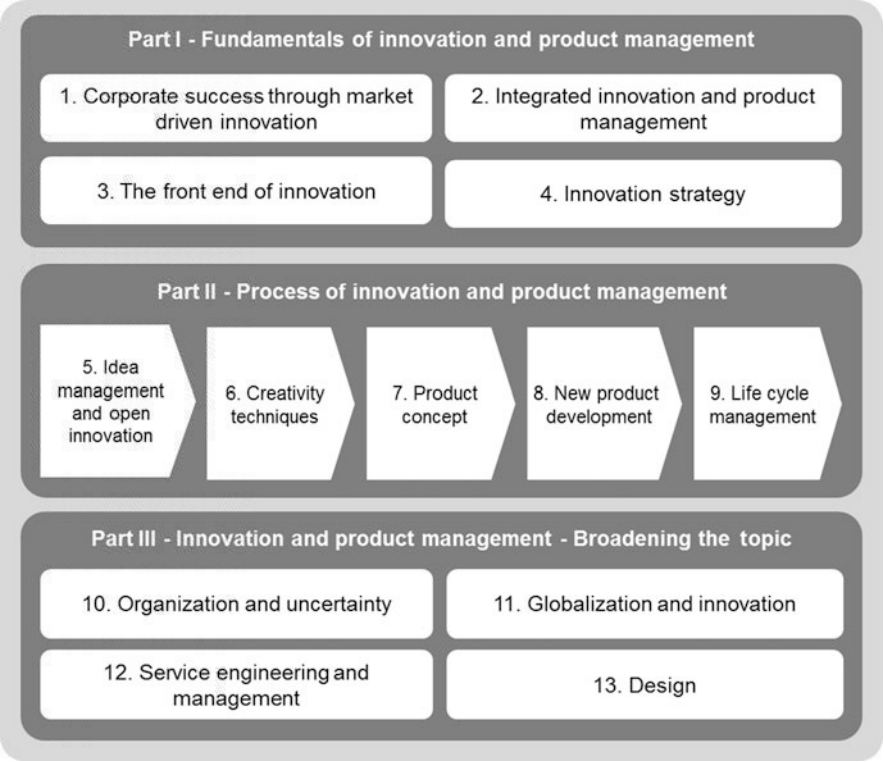


Fig. 1 Process-oriented structure of the book

creativity techniques. In the early chapters of this section, both the collection and generation of ideas are discussed alongside open innovation tools such as empathic design, idea contests, innovation communities, and the integration of lead users. Creativity techniques focus on the problem-solving process and offer a number of specific approaches. Next, ideas related to the product concept are described. The process of product design from a conceptual perspective and the fundamentals of product positioning and preference measurement are explained. Moreover the authors explain how methods like Quality Function Deployment and Target Costing contribute to an increase in customer orientation towards development activities. The next chapter describes the steps required for successful development projects along with the guidelines and the effects of Simultaneous Engineering, prototyping, model building, and model analysis. In the final chapter of this section, the fundamental tasks of marketing management throughout a product's life cycle are introduced.

Part III broadens the topics of *Innovation and Product Management*. In more depth, the authors tackle the organizational challenges of uncertainty. It explains the organizational forms of product management and deals with the organizational

integration of innovation management in enterprises. Next, the authors describe the characteristics and peculiarities of innovation and product management in globalizing firms. Specifics of the service development process are developed in the context of engineering, management, and marketing. The book ends with an explanation of the ideas of industrial design, design orientation, and design thinking. It offers tools, current practitioner views, and an integration with the holistic framework of innovation and product development.

We owe a debt of gratitude to the many who supported us in writing this book. Our appreciation goes to Marion Huber for thoroughly formatting this book and to Lisa Schweitzer for refining the manifold figures. We would like to express our thanks to Beate Damm and Doris Coker who were responsible for the translation of a number of chapters of the book. We also acknowledge the support and enthusiasm of the team at our publisher, in particular, Barbara Bethke, Frank Tumele, and Prashanth Mahagaonkar. In addition, we are grateful to all of the specialists and practitioners in leading European and American companies who supported us in writing the variety of practical insights. These insights from different industry sectors offer valuable awareness into specific aspects of innovation and product management. Finally a very special word of thanks goes to Johann Füller who helped to establish the unique and valuable "Austrian-American relationship" of the authors.

According to the open innovation approach, we welcome feedback and contributions to improve further publications. We look forward to your response via the e-mail address: innovation_book@fh-wels.at.

Wels, Austria — Kurt Gaubinger
Wels, Austria — Michael Rabl
Williamsburg, VA — Scott Swan
Linz, Austria — Thomas Werani
Spring 2014

Contents

Part I Fundamentals of Innovation and Product Management

1 Corporate Success Through Market Driven Innovation 3
1.1 Introduction 3
1.2 Innovation and Innovation Management 5
1.2.1 Framing of the Term "Innovation" 5
1.2.2 Innovation Management 5
1.2.3 Classifying Types of Innovation 6
1.3 Innovation and Uncertainty 8
1.3.1 Dimensions of Uncertainty 9
1.3.2 Levels of Uncertainty 12
1.4 Significance of Innovations for Business Management 14
1.5 Success Factors of Innovation Management 15
1.5.1 Innovation Strategy 15
1.5.2 Innovation Process 17
1.5.3 Resources and Innovation 19
1.5.4 Innovation Culture 20
1.6 Innovation Related Special Features of SMEs 20
References 21

2 Integrated Innovation and Product Management: A Process Oriented Framework 27
2.1 Introduction 27
2.2 The Role of Product Management 29
2.2.1 Strategic Tasks 29
2.2.2 Operational Tasks 30
2.3 Process-Oriented Innovation and Product Management 31
2.3.1 Innovation Management as a Core Task 31
2.3.2 Integrated Process Model of Innovation and Product Management 35

2.4 Implementing the Process Model . . . 37
2.4.1 Team-Building . . . 38
2.4.2 Analysis . . . 38
2.4.3 Process Specification . . . 39
2.4.4 Process Implementation . . . 40
References . . . 41

3 The Front End of Innovation . . . 43
3.1 Introduction . . . 43
3.2 Characteristics of the Front End of Innovation . . . 44
3.3 Success Factors at the FEI . . . 46
3.4 Models of Front End of Innovation . . . 46
3.4.1 Variable Degree of Structuring the Front End of Innovation . . . 48
3.4.2 Theoretical Process Models for the Front End of Innovation . . . 48
References . . . 58

4 Innovation Strategy . . . 61
4.1 Introduction . . . 61
4.2 Innovation Strategy as Part of the Corporate Strategy . . . 63
4.2.1 What Does Strategy Mean? . . . 63
4.2.2 Innovation Strategy and Strategic Business Management . . . 64
4.3 A Closer Look at Innovation Strategy . . . 65
4.3.1 Components of the Innovation Strategy . . . 66
4.3.2 Characteristics of the Innovation Strategy . . . 67
4.3.3 Innovation Strategy and Uncertainty . . . 68
4.4 Bringing Innovation Strategy to Life: A Process Oriented Approach . . . 70
4.4.1 Situation Analysis . . . 71
4.4.2 Strategy Formulation . . . 76
4.4.3 Strategy Implementation . . . 76
4.4.4 Evaluation and Control . . . 77
References . . . 78

Part II Process of Innovation and Product Management

5 Idea Management and Open Innovation . . . 83
5.1 Introduction . . . 83
5.2 Open Innovation: A Central Approach . . . 84
5.3 Gathering Ideas . . . 86
5.3.1 Collection Versus Generation of Ideas . . . 86
5.3.2 Definition of Search Fields . . . 87
5.3.3 Sources of Information and Ideas . . . 88
5.3.4 External Sources of Information and Ideas . . . 88
5.3.5 Internal Sources of Information and Ideas . . . 92

5.4 Open Innovation Tools . . . 93
5.4.1 Empathic Design . . . 94
5.4.2 Idea Contest . . . 95
5.4.3 Integration of Lead Users . . . 97
5.4.4 IT-Based Innovation Toolkits . . . 100
5.4.5 Idea Market Places . . . 103
5.4.6 Innovation Communities . . . 103
5.4.7 Classical Market Research . . . 103
5.4.8 Challenges with Open Innovation . . . 104
5.5 Idea Management . . . 104
5.5.1 Collecting and Storing Ideas . . . 105
5.5.2 Idea Evaluation . . . 106
5.5.3 Incentive System . . . 108
References . . . 109

6 Creativity Techniques . . . 115
6.1 Introduction . . . 115
6.2 Creativity . . . 117
6.3 The Creative Process . . . 118
6.4 Use of Creativity Techniques . . . 120
6.4.1 Classification of Creativity Techniques . . . 121
6.4.2 Creativity Techniques in the Problem Solving Process . . . 121
6.4.3 Comparison of Creativity Techniques . . . 131
References . . . 131

7 Product Concept . . . 135
7.1 Introduction . . . 135
7.2 Systematic Product Concept Development . . . 137
7.3 Analyzing Markets and Competitors . . . 137
7.3.1 Information Needs . . . 137
7.3.2 Positioning Analysis . . . 139
7.4 Concept Definition . . . 142
7.4.1 Preference Measuring via Conjoint Analysis . . . 142
7.4.2 Target Costing . . . 146
7.4.3 Requirements Specification Sheet . . . 151
7.5 Concept Evaluation . . . 152
7.5.1 Dimensions and Procedure of Concept Testing . . . 152
7.5.2 Scoring Models . . . 154
7.5.3 Profitability Analysis . . . 154
7.6 Concept Approval . . . 156

7.7 Quality Function Deployment 157
7.7.1 Introduction 157
7.7.2 What Does Quality Function Deployment Mean? 157
7.7.3 Systematic Quality Management Through QFD 158
7.7.4 The QFD Process 159
7.7.5 Strengths and Weaknesses of QFD 169
References 169

8 The New Product Development 175
8.1 Introduction 175
8.2 New Product Development 177
8.2.1 Uncertainty in New Product Development 177
8.2.2 Classification of New Products 178
8.2.3 Agile Product Development 179
8.3 The V-Model for a Systematic Product Development Process 180
8.3.1 Requirements for Development 182
8.3.2 Specifications 183
8.3.3 System and Product Design 183
8.3.4 Model Formation and Simulation 183
8.3.5 Domain-Specific Component Draft 184
8.3.6 Prototypes 184
8.3.7 Component Integration 185
8.3.8 Module Test 185
8.3.9 System Integration (Hardware) 186
8.3.10 System Integration (Software) 187
8.3.11 System and Product Tests 187
8.3.12 Field Tests 187
8.3.13 Production and Market Tests 189
8.4 Simultaneous Engineering (Concurrent Engineering) 191
8.4.1 Guiding Principles of Simultaneous Engineering 192
8.4.2 Effects of Simultaneous Engineering 193
8.5 Tools of Virtual and Rapid Prototyping 195
8.5.1 Definition Prototyping 196
8.5.2 Options for Product Representation 197
8.5.3 Model Building and Model Analysis 198
8.5.4 Product Data Management 201
8.5.5 Rapid Prototyping 202
8.5.6 Reverse Engineering 202
References 203

9 Life Cycle Management 207
9.1 Introduction 207
9.2 The Product Life Cycle Concept 209
9.3 Market Introduction of New Products 212

9.3.1 The Introduction Phase's Significance for the Market Success of Innovations . . . 212
9.3.2 Management Tasks During the Introductory Phase . . . 212
9.4 Product Maintenance as a Core Task of Product Management . . . 213
9.4.1 Information Base for Product Maintenance . . . 213
9.4.2 Strategy Continuum in Product Maintenance . . . 214
9.4.3 Management Tasks During the Growth Phase . . . 214
9.4.4 Management Tasks During the Maturity Phase . . . 216
9.4.5 Management Tasks During the Phase of Decline . . . 218
References . . . 219

Part III Innovation and Product Management: Broadening the Topic

10 Organization and Uncertainty . . . 223
10.1 Introduction . . . 223
10.2 Fundamental Dimensions of Organizations . . . 227
10.2.1 Specialization . . . 228
10.2.2 Configuration . . . 230
10.2.3 Coordination . . . 233
10.3 Organizational Structures for Innovation Management . . . 237
10.3.1 Company-Internal Innovation Activity . . . 238
10.3.2 External Innovation Activities . . . 244
10.3.3 Ambidextrous Organization . . . 245
10.4 Organizational Structure for Product Management . . . 248
10.4.1 Requirements for a PM Organization . . . 248
10.4.2 PM as Unilinear Function . . . 250
10.4.3 PM as Executive Support Unit Function . . . 250
10.4.4 PM in a Matrix Organization . . . 250
10.5 Organizational Structure Framework . . . 250
References . . . 253

11 Globalization and Innovation . . . 259
11.1 Introduction . . . 259
11.2 Globalization and Innovation Interactions . . . 261
11.2.1 Globalization Drivers . . . 262
11.2.2 Global Marketing Levers . . . 263
11.2.3 Innovations for Global Markets . . . 264
11.2.4 The Effects of Uncertainty in Globalization . . . 264
11.2.5 Opportunities at the Bottom of the Pyramid . . . 265
11.2.6 Diffusion in Global Markets . . . 266
11.3 Global Environment Assessment . . . 267
11.3.1 Global NPD and Culture . . . 267
11.3.2 Economic Environment . . . 268
11.3.3 Financial Environment . . . 269
11.3.4 Political and Legal Environment . . . 269
11.3.5 Scenario Analysis . . . 269

11.4 Strategic Aspects of Global Product Management 270
11.4.1 Global Expansion Strategies 270
11.4.2 Standardization vs. Adaptation? 270
11.4.3 Complexity of Global Sourcing 273
11.4.4 Entry Strategies 275
11.5 Managing Global Offers 275
11.5.1 Global Product Policy 275
11.5.2 Pricing, Communication, Global Logistics and Distribution 279
References 280

12 Service Engineering and Management 283
12.1 Introduction 283
12.2 The Importance of Services 285
12.3 Characteristics of Services 287
12.4 Specifics of the Service Development Process 288
12.4.1 Sub Concepts Within the SDP Process 290
12.4.2 Implementation of Services 292
12.5 Marketing for Services 293
References 294

13 Design 297
13.1 Introduction 297
13.2 Design as a Comprehensive Approach 300
13.2.1 History of Industrial Design 300
13.2.2 Understanding Design Orientation 301
13.3 How to Engender a Design Orientation 302
13.3.1 Processes 302
13.3.2 Structure 303
13.3.3 People 304
13.4 Transition from “Designer” to “Way of Thinking” 304
13.5 Traditional Business Approach vs. Design Approach 305
13.6 Current Views of Design Thinking 306
13.6.1 Stanford’s Hasso Plattner Institute of Design 306
13.6.2 IDEO 306
13.6.3 Frogdesign 307
13.7 Design Thinking Outcomes 308
13.8 Tools & Integration with NPD 309
13.9 Design as an Operational Process 310
13.9.1 Robust Product Design 310
13.9.2 Dieter Rams Ten Principles of “Good Design” 312
13.9.3 Process-Oriented Industrial Design 313
13.9.4 Integration of Design into a Holistic Framework 314
13.9.5 Setting up a Design Innovation Center 316
References 317

Index 321

About the Authors

Kurt Gaubinger is a Professor of Innovation Management & Industrial Marketing at University of Applied Sciences Upper Austria. He is Head of the Master's Degree Programme Mechatronics and Business Management and Vice Dean of the School of Engineering & Environmental Sciences. He received his Ph.D. in social and economic science from the Johannes Kepler University Linz, Austria. After teaching at the Universities of Applied Sciences Burgenland and Salzburg, Kurt Gaubinger became a full-time professor at the University of Applied Sciences Upper Austria in 2005 and was named Head of Department for Innovation, Design and Industrial Marketing in 2009. In 2013 he developed the Master's Degree Programme Mechatronics and Business Management. Prior to his career in academia he worked as a medical engineer for Siemens AG Austria and afterwards for an Austrian IT service provider as business unit manager. He presented his research at numerous conferences and has published several books and articles. His research interests include strategic innovation and product management, front end of innovation, commercialization of innovations, as well as IT-based innovation management.

Michael Rabl is Professor of Sensor Technology and Mechatronics at University of Applied Sciences Upper Austria. He is Head of the Bachelor's Degree Programme Innovation Engineering and Management and the international Master's Degree Programme Innovation and Product Management. He is acting as an independent expert for the European Commission for Research and Technological Development. As a senior researcher he was part of an international research group at the University of California Los Angeles working on the development of methods to cultivate algae as a feedstock for biofuels. In 2002 Michael Rabl became a full-time professor of Sensor Technology at the University of Applied Sciences in Wels, Upper Austria and was named Head of Study of Innovation and Product Management in 2003. In 2000, he received his Ph.D. in Electrical Engineering from the Friedrich Alexander University Erlangen, Germany. In 2013 he received his MBA in Innovation and Business Creation from Technische Universtät München, Germany. From 1999 to 2002 he worked for Siemens AG in Munich, first as an R&D engineer and later as a product manager. His current research interests are in the field of mechatronics, innovation management, and the development of international study programmes.

K. Scott Swan is a Professor of International Business, Design, and Marketing at The College of William & Mary (rated #1 undergraduate Marketing programme by BusinessWeek). He has lectured internationally at Tsinghua University in Beijing; Aoyama Gakuin University in Tokyo; WHU in Koblenz, Germany; Corvinus University, Hungary; the Vienna Business School; Management Center Innsbruck; and University of Applied Sciences Upper Austria. He has also conducted economic impact studies for the Virginia Port Authority and Norfolk Redevelopment and Housing Authority. His research interests include design, sourcing strategies, cooperative strategies, global product development, as well as the interaction between innovation and culture that have led to publications in journals such as *Strategic Management Journal*, *Journal of International Management*, *Journal of International Business Studies*, *Management International Review*, *Journal of Business Research*, and *The Journal of Product Innovation Management*. He is on the Editorial Review Board of *The Design Journal* and *The Journal of Product Innovation Management*. Professor Swan has worked in project management for Flour-Daniel, marketing management for Foremost Corporation of America, as well as founding several small businesses related to design.

Thomas Werani is Associate Professor at the Institute for Retailing, Sales and Marketing and Head of the Department for Business-to-Business-Marketing, Johannes Kepler University Linz. He studied business administration with a specialization in marketing, advertising, and marketing research at the University of Augsburg and the Vienna University of Economics and Business Administration (WU Wien). Dr. Werani started his academic career in 1993 at the Marketing Department of the University of Klagenfurt. In 1995 he joined Johannes Kepler University Linz, where he finished his doctoral thesis on the value of cooperative business relationships in 1998. After completing his habilitation Dr. Werani was appointed Associate Professor in 2004. He has received several prestigious research awards, including the 1996 Business Marketing Doctoral Support Award of the Institute for the Study of Business Markets (ISBM) at the Pennsylvania State University, and the Fourth Nestlé-Prize for Economics. Dr. Werani has presented his research at numerous international conferences and has published in several journals and books. He is on the Editorial Review Board of the *Journal of Business Market Management* and the *International Journal of Marketing*. His main research interests are in the field of business-to-business-marketing with special emphasis on pricing/value, innovation, branding, and relationship issues. In addition, Dr. Werani is a marketing consultant for a number of national and international companies.

Part I

Fundamentals of Innovation and Product Management

Corporate Success Through Market Driven Innovation

1

1.1 Introduction

Innovations continuously increase in significance in companies aiming at securing success in the long term [1]. The relevance of innovations in businesses and the national economy was already pointed out by Schumpeter [2]. However, increasing competitive pressure and an environment characterized by dynamism and complexity renders the task of successfully creating and marketing innovations more and more difficult for companies [3, 4]. For a company to survive under these difficult conditions, it needs to significantly increase the effectiveness as well as the efficiency of its internal innovation activities. This goal can be reached by means of *systematic innovation management* comprising a set of strategic and operational tasks for planning, organizing and controlling innovation processes.

This Chapter Will Discuss

- How can we differentiate between types of innovation?
- Which tasks are the core tasks of innovation management?
- Which key dimensions of uncertainty are crucial for innovation management?
- Which factors of innovation management positively impact the company's success?

Practical Insight

BMW Group: Focusing on Innovation

The BMW Group is one of the leading automobile and motorcycle manufacturers worldwide with a workforce of more than 100,000 associates in over 100 countries. Since the company was founded, innovations have ranked among the BMW Group's success factors. BMW is pursuing the goal of developing new, pioneering ideas for customers as efficiently as possible.

(continued)

K. Gaubinger et al., *Innovation and Product Management*,
Springer Texts in Business and Economics, DOI 10.1007/978-3-642-54376-0_1,

The company's constant effort is to create enthusiasm with technologically innovative products that are at the same time also emotionally appealing.

To pool all the relevant forces, BMW built the "FIZ" Research and Innovation Centre in 1986, which intentionally promotes interpersonal communication with its honeycomb-like floor plan, short routes, and open spaces. The Centre is the technical "brain" of the company and promotes the cooperation of more than 8,500 specialists in all areas and disciplines. Engineers, designers, model builders, computer specialists, scientists, production specialists as well as purchasing managers and employees from suppliers work together here to convert new concepts and ideas into genuine automotive innovations. One question is of fundamental significance at the FIZ Centre: What does the customer want and how quickly is a vehicle developed? To answer this question, the BMW Group has established the so called Product Evolution Process, abbreviated as PEP. This process is distinguished by the fact that as many individual tasks as possible are handled simultaneously and compiled in a multi-level, exactly defined plan providing the final result. Cooperation is therefore based not on isolated responsibilities, but rather on joint project management. In this context interdisciplinary, interdivisional decision-making groups ensure optimum support and follow-up on innovations from the initial idea all the way to its actual implementation in vehicle concepts of the future.

BMW Group FIZ, Munich *Photo: Copyright © by BMW*

Source: BMW [5]

1.2 Innovation and Innovation Management

In research as well as at the operational level, innovation is a term that is frequently used, but often not clearly defined. In order to prevent misunderstandings and to clearly identify tasks, we need to frame the term.

1.2.1 Framing of the Term "Innovation"

An analysis of current definitions [6, 7] shows the criterion of *novelty* to be a core feature. We need to identify the perspective from which the novelty of an achievement, a performance or a business model is assessed. There is a lot of support for labeling products and processes as innovative that are being introduced in a company for the first time.

A characteristic feature for differentiating an innovation from an invention is the aspect of its commercial exploitation and its utilization at the operational level. An innovation introduces an invention (a new product or process) to the market (innovation in a narrow sense) and making it competitive in the market (innovation in a broader sense) [8]. Furthermore, innovations differ from inventions in that they do not refer to a point in time, but are *process-relational*. A variety of concepts and models for structuring innovation processes can be found at the operational level and in literature [4, 9]. Such models help in visualizing and managing the process in its entirety. They aim at depicting tasks that are typical for a specific process-stage, allowing for a goal-directed use of methods. An example for a model of this kind is the process model developed by the authors of this book, integrating dimensions of innovation management as well as product management (Cf. Chap. 2/Fig. 2.4). However, we must be aware that innovation is doing something new in a complex and dynamic world and so the process involves dealing with *uncertainty*. Innovation management tries to convert this uncertainty to a calculated risk by means of target-oriented and early information provision. Tidd and Bessant [10] characterize innovation as process of reducing uncertainty but increasing resource commitment at the same time.

1.2.2 Innovation Management

Goal-oriented steering and shaping of innovation activities within a company require structured and coordinated activities aimed at an innovation's successful introduction on the market or for the company's internal use. Those activities are subsumed under the term *innovation management*. They comprise a set of strategic and operational tasks for the planning, organization and control of innovation processes and the creation of the required operational framework. Following Vahs and Brem [11], the following tasks are among the core tasks of innovation management:

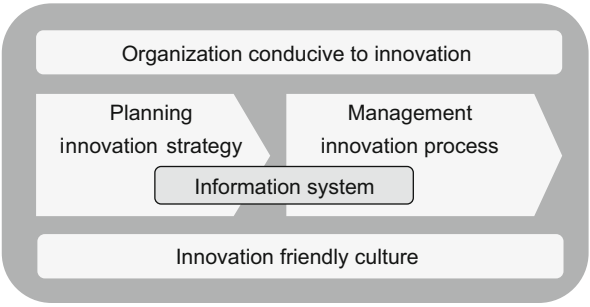


Fig. 1.1 Core tasks and elements of innovation management

- Defining innovation goals and strategies
- Planning, steering and controlling innovation processes
- Building and maintaining an information system serving as the basis for goal-oriented innovation control
- Building an organization structure conducive to innovation
- Building and maintaining an innovation-friendly company culture.

In addition to these tasks, (overview of task spectrum provided in Fig. 1.1), the overriding goal of innovation management consists in securing and expanding the *competitiveness* of the company in order to grant its economic success and continuance [12].

1.2.3 Classifying Types of Innovation

Based on their degree of novelty, innovations *by leaps and bounds* (radical innovations) from *step-by-step* (incremental) innovations can be distinguished [13]. The degree of innovation constitutes a multi-dimensional criterion. In general, it can be said that the degree of innovation correlates with the increasing proliferation of the following four dimensions [14]:

- The *technology dimension* diagnoses the technical uncertainty of innovation projects. A high degree of innovation is indicated if the technological know-how was not completely known or was not needed up to this point.
- If an innovation aims at customer needs that are new or have not been satisfied up to this point, it can be evaluated as radical in terms of its *market dimension*.
- Innovations can also necessitate change in the *organizational dimension*. The greater the extent of this change, the more radical the innovation.
- If innovations exert an influence on the *innovation environment* and if the changes brought about can be characterized as significant, e.g., the introduction of new modes of distribution, the radical quality of the innovation increases according to this dimension.

Innovations with a high degree of novelty have a strong profile in each of the four dimensions and generally entail a higher level of uncertainty. In contrast, product variants or incremental product improvements are bound to show a low

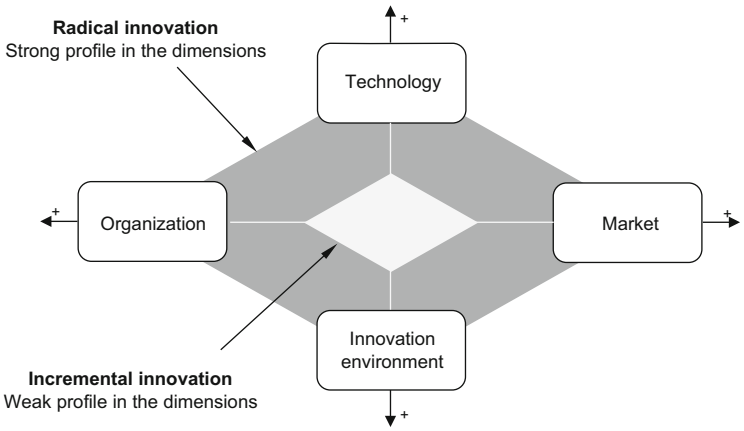


Fig. 1.2 Dimensions of the degree of novelty

to medium profile in the individual dimension. These interrelations are depicted schematically in Fig. 1.2.

Based on an innovation's degree of novelty, the following types of innovations can be distinguished [15]:

- *Fundamental innovations* constitute the highest level of innovation. Implementation of new technologies gives rise to new principles of operation, thus to completely new product generations or procedures. The steam engine, the jet engine or the microprocessor are often listed as examples of fundamental innovations entailing a plethora of successive innovations [16].
- *Disruptive innovations*, unlike so-called preserving innovations, are products or services that interrupt existing paths of performance improvement and usually cover completely new dimensions of performance. Those innovations are therefore of a radical nature. Though usually inferior in performance to existing innovations at the time they are launched, disruptive innovations usually appeal to a customer segment which only has some basic demands on the product, but is very price-conscious. As time goes on, disruptive innovations are being improved upon, thereby earning the respect of established customers and becoming a threat for established suppliers who have closed themselves off from this development [17].
- *Quality-improving innovations* feature a lower degree of innovation than fundamental innovations do. With basic functions remaining constant, this category of innovation only changes specific utility parameters, in the sense of an evolutionary improvement [16].
- *Adaptive innovations* adapt existing solutions to specific customer requests, thus they are usually characterized by an incremental degree of innovation [15].
- *Imitations* constitute reiterations of solutions already existing in other companies. Though imitations are "tarnished by the odor of lacking

Dimension	Criteria	Score	Weight	Weighted value
Technology	New material			
	New components			
	New technologies			
	New technique of production			
	…			
Market	New customer needs			
	New customer groups			
	New marketing mix			
	New distribution channels			
	…			
Innovation environment	New sources of supply			
	New forms of financing			
	New business models			
	New competitors			
	…			
Organization	New strategy			
	New organization			
	New responsibilities			
	New production facility			
	…			
			Innovation level:	

Fig. 1.3 Utility analysis for classifying innovation projects (Adapted from Hauschildt [18])

imagination", a comprehensive framework of innovation management should always consider the potential of imitations [18].

- *Fake innovations* are characterized by a degree of innovation that is low or zero. They refer to changes in products or processes which do not really provide new utility for customers [19].

On the operational level, the degree of novelty of innovations may be assessed by means of *check lists*, or more extensively within the framework of a *utility analysis*. If the project that is being assessed surpasses a previously determined value, the project is considered as "innovative". It should be dealt with in a specific routine set apart from regular operations. This routine is to be developed by taking into account the higher level of uncertainty and especially risks associated with innovations. Cooper [20] points out that the elaboration and complexity of this type of decision process should positively correlate with the degree of risk of an innovation project. Figure 1.3 shows an exemplary *utility analysis* which can be used to assess an innovation project's degree of novelty. This tool should be supplemented by data specific to the company.

1.3 Innovation and Uncertainty

By its nature innovation is about the unknown, about opportunities and possibilities associated with doing something new, which may or may not pay back in the future. As already mentioned above, managing innovation processes means dealing with uncertainty; or in other words "uncertainty will always plague the process of innovation" [21]. In this context many scholars build on the Galbraith's [22]

definition of uncertainty: uncertainty means "the difference between the amount of information required to perform the task and the amount of information already possessed by the organization".

1.3.1 Dimensions of Uncertainty

Over 40 years of research has led to an extensive literature on types, sources and dimensions of uncertainty. These terms are often used interchangeably. Organization theorists have paid particular attention to one factor, which is referred to as environmental uncertainty and which plays a central role in the discussion about the interface between organization and environment, particularly in theories of organizational design [23–25]. Milliken [26] suggests three distinct types of external uncertainties, which are state, effect and response uncertainty. He distinguished the actual environment from its unpredictable characteristics, which may affect and change the organization and its actions that are not always under its control. Other scholars see innovation as a process of closing information gaps between user needs and technological opportunities [27–29]. Another school of thought highlights the contingent uncertainties between market, competition and technology [24]. Using a systematic approach to reviewing more than 100 scientific articles, Jalonen [30] identified 18 distinct factors, which create uncertainty in processes of innovation. Figure 1.4 shows these factors clustered into the three key factors of uncertainty which are technology, market and organizational resources.

These results are in line with other studies. Souder and Moenaert [31] state that the four main sources of uncertainty are *customer needs*, *competitive environments, technological environments* and *organizational resources*, whereas the first two sources are often stated as the cause for market uncertainty. The source *organization resource is* an internal dimension in which the gap of information (knowledge) can be reduced by adapting the organization of a company.

Technology Uncertainty An innovator faces technology uncertainty twofold, namely in terms of product specification as well as in terms of production processes [32]. It is the additional information about components and techniques a firm needs to create a new product or service according to a specification, which has to be also determined [33]. The uncertainty associated to product specification depends on the novelty of the technology, which itself causes uncertainty in respect to skills and knowledge required to successfully use a new technology [34]. In summary, this means that the technology uncertainty in innovation processes results from a lack of knowledge about the details of new technology or due to a deficit of knowledge required to use new technology or both [35].

Market Uncertainty Market uncertainties exist when a company is unsure about the nature of a particular market and its ability to create a product which will succeed in that market. They include issues related to customer needs and wants, which can be already existing or latent forms of interaction between the customer

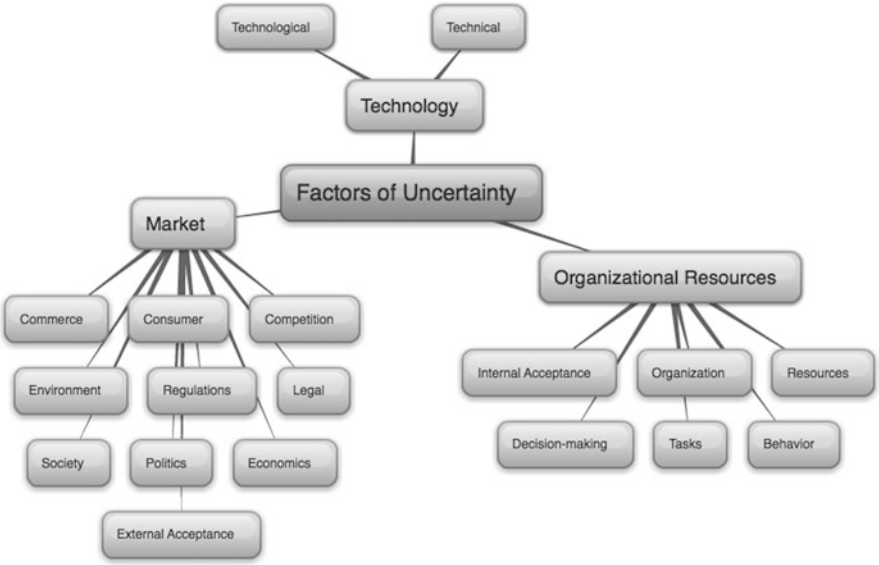


Fig. 1.4 Various factors of uncertainty in innovation (Based on Jalonen [30])

and planned products as well as methods of sales and distribution [36]. The uncertainty concerning unclear customer needs, the unknown behavior of customers, pricing and the demand for the innovation were recognized as the main sources of uncertainty caused by customers [37, 38].

But market uncertainty also manifests itself as a lack of knowledge about the activities of competitors. This kind of uncertainty faces a company typically in global and liberalized markets [39]. In summary, the market uncertainties in innovation processes exist, on the one hand, because of unexpected changes in the relations between company and customer and, on the other hand, due to unpredictable changes in relations between competitors, which might open new markets [40]. Many scholars include the dimension innovation environment (Cf. Sect. 1.2.3) in the dimension market [41, 42]. In this book this school of thought will be followed.

Organizational Uncertainty Organizational uncertainty contains factors of uncertainty such as resource uncertainty, decision-making uncertainty and acceptance uncertainty, where the last two factors can be subsumed as task uncertainty. Task uncertainty is caused by the non-routine nature of R&D-tasks and the high levels of technical and organizational interdependence required to execute them. A company has to reduce sources of uncertainty as a prerequisite to successfully innovate. But to do so, resources must be allocated, which introduces the *resource* uncertainty. The more uncertain the organization is about the market or the

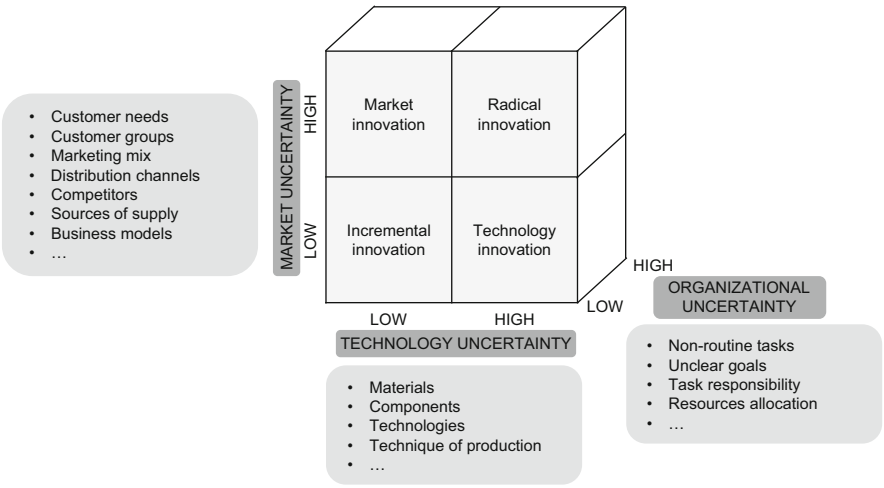


Fig. 1.5 Extended uncertainty matrix (Based on Lynn and Akgun [41])

technology, the more probable it is that the organization will be uncertain about the type and the amount of resources it needs [43].

Based on the model introduced by Lynn and Akgun [41] the authors developed an extended model including the third dimension organizational uncertainty which is shown in Fig. 1.5.

The matrix presents *four types of innovation* projects that differ in the level of technology uncertainty and market uncertainty. As already mentioned, technology uncertainty is characterized by factors like new materials, new components, new technologies, new technique of production, etc. In contrast, marketing uncertainty is related to factors like new customer needs, new customer groups, new marketing mix, new distribution channels, new competitors, new source of supply, new business models or similar factors.

Incremental innovations build on existing knowledge and thus are characterized by low technology and low market uncertainty. Examples of incremental innovations are product changes or improvements, extensions of product lines or "me too" products that are similar to the competition. *Market innovations* develop new markets with existing technologies and need a market-based strategy. The company has to obtain knowledge about the new market, its needs and requirements and the competitors. *Technology innovations* serve known markets with new technological solutions. The products are targeted to a well-defined market segment, but the intended technology is highly uncertain and new to the customer. The largest amount of uncertainty is associated with *radical innovation*. Both, the market and the technological requirements as well as the technical feasibility are not known at the beginning of the innovation project, since the market is not well understood and the product is evolving depending on the market.

The third dimension of the extended uncertainty matrix illustrates that the overall level of uncertainty for all types of innovation depends also on the structure of the organization and its resources.

Although uncertainty is inherent in every innovation process one can understand that depending on the amount of information already possessed different degrees of uncertainty can be distinguished. This will be explained in more detail in the following chapter.

1.3.2 Levels of Uncertainty

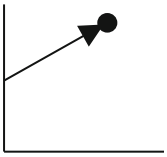
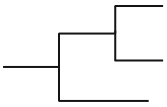
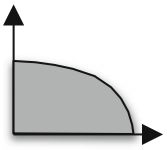
As already explained initially, innovation management tries to convert uncertainty to a calculated risk. Knowledge is of central importance to this process, since it is the key factor for this conversion [44]. Even in the most uncertain environments, it hardly ever occurs that an organization has absolutely no strategic important knowledge [45]. To differentiate between different levels of uncertainty it makes sense to think about uncertainty as "known unknowns" and "unknown unknowns", [46] which leads to different degrees or levels of uncertainty.

Courtney, Kirkland, and Viguerie [45] define four different levels of uncertainty and conceptualized a framework for determining the level of uncertainty surrounding decisions in an organization. They state that it is often possible to identify clear trends and a host of factors, which are currently unknown but in fact could be known if the right analyses were done. The remaining uncertainty is then called residual uncertainty, which falls into one of four levels [45]. In Table 1.1 they will be explained in more detail.

After understanding the influence of uncertainty on innovation activities, it can be hypothesized that the development and adoption of systemic innovation in an organization may be hindered due to uncertainty. As already explained a central task of innovation management is to gather task oriented information during all steps of the innovation process to reduce uncertainty and therefore increase the probability of success.

In addition to the presented producer-related uncertainty dimensions, literature also covers *customer-related uncertainty*. In many markets there is an uncertainty related to intended purchase on customer side, which depends on two main factors. Firstly, uncertainty is driven by the amount at stake. Therefore, the higher the customer's product specific investment the more uncertainty will play a role. The second factor refers to certain qualities of products. According to Darby and Karni [51] three qualities can be distinguished: search, experience, and credence qualities. Search qualities are known before the purchase, and products with such qualities do not lead to any customer related uncertainty. Experience qualities are known only after purchase, while credence qualities are unknown even after purchase. It is obvious that products with the latter two qualities involve a considerable amount of uncertainty at the time of purchase. Against this background the central task of a

Table 1.1 The four levels of uncertainty (Based on Courtney [47])

Level	Characteristics	Description
1	A clear-enough future 	One faces a Level 1 uncertainty; if the range of possible outcomes is narrow enough for this uncertainty to not be of importance for the decision at hand [48]. Of course this does not mean that the future is entirely predictable, but rather that a single forecast of the future can be developed for managing the innovation processes
2	Alternate futures 	Innovation managers face Level 2 uncertainty when the future can be described as one of a limited number of alternatives. In this case it is possible to define a limited set of possible future outcomes, one of which will occur [47]
3	A range of futures 	Level 3 uncertainty is similar to Level 2 uncertainty, in some respects. One can identify the range of potential futures, but the possible outcome may lie anywhere within the boundaries. No apparent point forecast appears although the range is defined by only a limited number of key factors [49]
4	True ambiguity 	For Level 4 uncertainties future outcomes are both unknown and unknowable. Not even the range of possible future outcomes can be identified [50]. Multiple dimensions of uncertainty interrelate and create an environment that is more or less impossible to foresee. Therefore, there is no basis to forecast the future

company is to reduce uncertainty and induce the customer to decide for the product. This uncertainty reduction has to consider two types of uncertainty [52]:

- *Behavior-related uncertainty*: this uncertainty is based on the fact that the customer rests his basic decision to purchase for a certain product or system unilaterally on the supplier's behavior. For the customer it is therefore crucial to well assess the supplier's behavior already during the initial acquisition. In particular, the customer has to be sure that the supplier does not exploit the product- or system-based relationship opportunistically by for example continuously increasing the prices for upgrading or neglecting the further development of the product.
- *Use-related uncertainty*: The second type of uncertainty can result from uncertainty regarding the evaluation of the offer's achievement potential, as parts of the service are sometimes purchased at a later stage. Use-related uncertainty can also result from the fact that customers are not able to evaluate type, frequency and time of future investments already before the purchase decision.

To avoid this uncertainty, appropriate actions like signaling, should be initiated by the supplier. Signaling activities serve as credible information about the

capabilities of the company in terms of a problem solution for the customer and his empathy [53]. This is done mainly through communication measures about potentials of the company or other satisfied (reference) customers. Especially in high-tech markets potential customers faces technology uncertainty associated with every buying decision. The technology uncertainty perceived by these customers can be shaped by the actions of technology supplier in informing the potential adopters about likely future developments. Such signaling activities are aimed at announcements concerning investments in new products and services and plans to enhance the features of a technology [54]. In this context one of a widely used signaling tools is new product preannouncement, a useful communication measure that companies use to send messages to target groups before launching a new technology, product or service [55]. Thus the amount and clarity of signaling measures is an important mechanism to reduce especially the technology uncertainty perceived by the potential adopters and can have an impact on technology diffusion as a consequence. It also should be stated that signaling activities are becoming less and less necessary with increasing duration of the relationship, because the mutual information base is increasing.

1.4 Significance of Innovations for Business Management

The fundamental importance of innovations for a company's success is nothing new, since the ability to generate and implement innovations have always been key to the success of a company [56]. What is new is an increasingly dynamic and complex economic environment, forcing companies that want to stay competitive into developing new products within increasingly shorter intervals of time. *Globalization* is a significant factor in this context. On one hand, it opens up new procurement markets and consumer markets; on the other hand, it puts local markets under increasing pressure from foreign providers. Globalization is not only characterized by an increased mobility of goods and labor, but also by a high mobility of information and knowledge. This results in dramatic knowledge-based rates of increase accompanied by *technological progress*, which in turn entail many solutions inconceivable only 10 years ago [57]. At the same time, the interval in which *knowledge* can be applied is also getting shorter.

In addition to technological progress, the fact that *customer needs* are getting more and more met by specific solutions leads to a drastic reduction in *product life cycles* [58]. Studies show that product life cycles in the past 50 years have decreased on average by 75 % [57]. In light of the developments we have discussed, it is obvious that only companies who beat the competition at introducing innovative market offerings on the market, respectively at implementing innovative processes at the operational level, will attain long-term *economic success*.

A range of *empirical studies* attests the elemental connection between innovation activity at the operational level and the company's success. For instance, the results of the PIMS study confirm a positive correlation between product and process innovations at the operational level and the company's success [59]. A