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# Crowdsourcing, Digitisation and Acceleration: Is Corporate R&D Disrupting Itself?

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**New approaches to develop innovative products and services are increasingly important in today's corporate environment. Leading edge solutions are more and more developed outside the structures of big corporations. Automation and digitisation are more and more influencing R&D processes both at the front-end and within the development process. This raises the question if corporate R&D departments as we know them will remain relevant in the future or if they will disrupt themselves and be replaced by alternative approaches. Within this paper, these alternative approaches will be analysed and evaluated critically in a hypothetical experiment concerning their disruption potential related to the traditional corporate R&D process.**

## 1. Today's raison d'être of corporate R&D

The development of successful products and services is the key objective of corporate research and development (R&D). To reach this objective, a variety of different methods, instruments, processes and organizational structures exist to assure that R&D results fulfil technical, economic or societal requirements (see e.g. Schäppi et al. 2005).
Beyond trends and challenges in R&D, such as improved customer and employee orientation and the improvement of effectiveness in strategic technology and innovation management (Gelec and Wagner 2014, 921), the importance of concepts able to substitute or disrupt traditional R&D departments for the development of products and services is increasing. Today, especially fundamental alterations in products and services are developed only to a minor part in big corporations (Pillkahn 2012). An increasing share of successful companies is outsourcing R&D or is handling innovation through start-up venturing and external acquisitions. Open source development approaches are applied to revolutionize the development process of traditional industries not only in software but also in hardware development[1]. In extreme cases, companies chose to completely let the users develop innovative products and to concentrate on later stages of the value chain[2]. Furthermore, Asia is gaining strengths in industrial R&D, becoming the number one destination for industrial R&D investments in 2015 (Jaruzelski, Schwartz, and Staack 2015). All these developments are challenging corporate R&D and raise the question if R&D in its traditional form will maintain its right to exist in the future. Thus the hypothetical question if corporate R&D is disrupting itself is considered as a basis for the analysis in this paper. For the analysis, selected indicators that define potential disruptive innovations are mapped with selected categories that can be considered as alternative approaches to traditional corporate R&D.
The work presented is based on the analysis of academic publications in the thematic area R&D Management, especially related to R&D trends able to potentially disrupt traditional corporate R&D. This includes new models, key developments, issues and problems of R&D Management (e.g. Howells 2008; Raynor and Panetta 2005), trends and key success factors in R&D (Wagner et al. 2015; e.g. Gelec and Wagner 2014), sector specific R&D trends and methodologies (e.g. Accenture 2015) or the analysis of specific methods, tools or instruments relevant in the categories able to disrupt traditional R&D (e.g. Raynor and Panetta 2005; Williamson and Yin 2014).

[1] See e.g. the co-creating and micro-manufacturing company Local Motors: www.localmotors.com (Apr. 2016)
[2] See e.g. the community invention company Quirky: www.quirky.com (Apr. 2016)

## 2. Structuring R&D in a generic R&D process

For the analysis of traditional corporate R&D, a generic model of the R&D process consisting of five major phases is considered as a basis. This includes the phases of (1) pre-project planning, (2) concept development, (3) system-level design, (4) detail design and (5) testing and refinement (Ulrich and Eppinger 2008; VDI 1977; Schimpf and Sturm 2010; Schimpf and Binzer 2012; Schmelzer 1992). These phases allow a more focused analysis of the disruption potential as this might vary between each of the process phases. Key activities in each of the phases can be described as follows:

- **Pre-project planning:** includes the identification of opportunities as well as their allocation to appropriate channels for further development or analysis. This provides the basis for the prioritization of potential projects and their planning and integration into R&D programmes and project portfolios.
- **Concept development:** is about clarifying and further defining the problem or challenge to be addressed as well as the definition of exploration fields for potential solutions. This phase also includes the development of high-level concepts aiming to solve the problem or challenge.
- **System-level design:** targets the adaptation of selected concepts to the overall system in which they will be applied or produced. Within this phase, aspects of all life-cycle stages shall be considered, including e.g. manufacturing, usage, maintenance as well as end of life aspects.
- **Detail design:** includes the complete specification of details e.g. on products, components, technical aspects, linked production processes and market aspects. This phase may also include the production of functional prototypes that are a key input for the phase of testing and refinement.
- **Testing and refinement:** is about testing, validating and refining prototypes. Refinement generally includes all specifications along the life-cycle of the solution as well as all specifying aspects based on technical and market requirements.

In reality, these phases only seldom appear in a linear and structured form but are often overlapping, incorporate iteration cycles and should be adapted to specific R&D tasks depending on the situational context in which the process takes place. For this work, however, they provide a generic basis for the detailed analysis of disruption potentials along the R&D process phases.

## 3. Categorizing potentially disruptive approaches for traditional corporate R&D

A large variety of different trends are under discussion in the context of corporate R&D (see e.g. Howells 2008; Gelec and Wagner 2014; Wagner et al. 2015; Accenture 2015). As they highly vary by sources or application area, most relevant trends have been clustered and consolidated for the analysis in this paper within three major categories:

- **R&D carried out by external[3] actors:** this category refers to R&D service suppliers involved through contracting into the R&D process as well as different forms of open innovation or crowdsourcing, including the involvement of suppliers, customers, users, or other stakeholders in different phases of the R&D process (Chesbrough 2003a; Chesbrough 2003b; see Boudreau and Lakhani 2013). Beyond outsourcing of R&D activities, a current trend is the more unspecified integration of external actors in corporate R&D through competitions. This includes e.g. idea challenges, calls for proposals or hackathons. Reasons to integrate external actors into a corporate R&D process may include the acquisition of external know-how in areas which are not represented by internal actors, the search for inspiration looking beyond the solutions developed internally, the equilibration of resource shortages or the achievement of cost advantages enabled by external R&D suppliers. The increasing globalization paired with improved methods and tools for data exchange and communication are considered as key drivers for an increased distribution of R&D across different organizations or units.
- **Digitisation and automation in R&D:** in early R&D phases, big data analysis allows the automated identification and continuous updating of user requirements based on information directly provided by sensors in products or services. Within the R&D process, concepts, samples or prototypes can be automatically tested and selected based on identified requirements to filter most appropriate solutions (see Davenport, Harris, and Morison 2010; Nambisan 2010). Especially within digital solutions, companies are directly provided with information on user behaviour enabling instantaneous and automatized recognition of potentials for improvements – as well as the adaptation of product configurations. Key drivers for advances in digitisation along the entire value chain of products, services or solutions are the decreasing cost of computer and sensor equipment as well as the almost ubiquitous availability of communication networks. Digital disruption or digital transformation, also highly overlapping with the terms of Internet of Things or Industry 4.0, can be considered as one of the key challenges for companies across all sectors today (see e.g. Cole 2015).

[3] 'External' is understood in this context from a corporate perspective enabling the differentiation between corporate R&D and R&D that is carried out by actors outside of the company.

- **Efficient and accelerated R&D:** R&D in emerging countries as well as the development of new R&D methodologies is leading to industrialized R&D processes that are based on highly specialized process steps already in early stages of the overall process (Williamson and Yin 2014). Furthermore, the amount of methods to render R&D processes more efficiently is increasing (Morgan and Liker 2006). Current trends include the application of agile methods not only in software development but also in R&D on hardware based on the principle to come up with solutions in a faster pace and with accelerated iteration cycles. Furthermore, lean process designs enable to carry out R&D more efficiently. A driver for efficient and accelerated R&D is the continuous decrease of product and technology life-cycles.

Whereas R&D carried out by external actors as well as digitisation and automation in R&D are able to substitute traditional R&D through the provision of holistic alternatives, methodologies for efficient and accelerated R&D change existing paradigms on how to carry out R&D on a process level. Methodologies in this context are able to reduce the amount of R&D efforts necessary for the development of successful products and services by time and cost.

## 4. Methodology for the evaluation of disruption potentials

The key question of this paper is if alternative approaches are able to disrupt traditional forms of corporate R&D. Based on the theory of disruptive innovation (Christensen 1997; Christensen 1992; Christensen, Anthony, and Roth 2004; Raynor 2011), disruption is understood in the context of this paper from a market perspective as a substitute for traditional corporate R&D, rendering established investments obsolete (see Danneels 2004, 248).

Based on the market-related definition, disruptions can only be identified "post mortem", when the investment from incumbents is or has been destroyed. Thus, selected indicators will be used for the evaluation of the disruption potential of upcoming solutions. Firstly, this includes the question if new approaches primarily target segments that are economically unattractive to traditional R&D and only fulfilling a basic set of user requirements. Secondly, new approaches have to be analysed according to potential for further development following the logic that they are only potentially disruptive if they can be further developed towards the upper-end of the market. Thirdly, cost structures have to be considerably below incumbents' solutions as disruptive innovations most often attract customers through a competitive cost advantage. Finally, a key question to answer is if incumbents are overcomplying customer requirements and thereby opening the market to disruptions from the low-end. These four indicators, within practical examples often highly interlinked with each other, including relevant drivers in the context of disruption potentials in corporate R&D are defined in more detail in the following chapters.

Whereas disruption was recently described as "*a process whereby a smaller company with fewer resources is able to successfully challenge established incumbent businesses*"(Christensen, Raynor, and McDonald 2015), potentially disruptive innovations in the context of this paper do not necessarily have to be provided by small companies but also incorporate technological or methodological developments.

### *4.1 Fulfilment of a basic set of user requirements*

As described above, the starting point of potentially disruptive innovations is located most often at the low end of the market by means of functionalities provided. These are differentiating from incumbents' solutions through the provision of only a basic set of functionalities matching most important user requirements. These can be identified e.g. through functional and dysfunctional questions as e.g. used in the kano analysis (see e.g. Bailom et al. 1996) or through methodologies applied in user-centred design able to analyse user behaviour and extract latent user requirements (see e.g. Kelley 2006; Kelley and Littman 2001; Kelley and Kelley 2013).

A major driver for the fulfilment of a basic set of requirements in corporate R&D is the orientation towards object oriented development, not only in software development but also in hardware. The maker movement shows that only little investment and pre-existing know-how is required to develop products and services that are able to compete with traditional solutions. The same can be observed in start-ups that often use existing technology platforms for the development of innovative solutions.

### *4.2 Overall potential for further development*

In technology or innovation life-cycle models, potentially disruptive technologies are often immature or underperforming but able to substitute solutions currently applied when further developed. The retrospective analysis of R&D spending, cost of application and key technological performance indicators as well as their projection into the future support the identification of the potential for further development. A key challenge consists in the emergence of disruptive innovations from value networks that are different from the ones that are in the key focus area of incumbents. Therefore, the observation of disruptive innovations might fail with a conventional technology s-curve that is principally on a focused set of performance features in a restricted value network (see Christensen 1997, sec. 129,2/534 f.).

### *4.3 Low cost compared to incumbents' solutions*

In a first place, potentially disruptive solutions most often compete through lower cost in incumbents' markets, combined with a reduced and more focused fulfilment of a basic set of requirements. They are thus following the strategy of cost leadership for market entry and, to be fully disruptive, develop towards the upper-end of the market in later stages (see Porter 1998, 35f.). Disruptive innovations, especially low-end disruptions, thus have comparable performance specifications to frugal or low cost innovations and often create a radically new understanding of price performance compared to the one of incumbents' solutions (see Prahalad 2010, 28f.). Whereas price performance is the most important indicator within this category, this might be combined with e.g. the hybrid usage of existing infrastructure, an increased scale of operations, reduced and more focused functionality, process innovations as well as new interfaces or distribution channels. Traditional R&D, especially in large corporations, tends to be relatively expensive. This is principally due to heavy processes, administrative quality mechanisms and specialized R&D structures. R&D that is carried out with lean and less costly structures can be found in upcoming small companies or start-ups (see e.g. Ries 2011). Furthermore, Asia as a provider of low-cost R&D is gaining importance and overtook other global regions as the number one destination for corporate R&D investments in the year 2015 (Jaruzelski, Schwartz, and Staack 2015). Additional trends that are often mentioned in the context of low-cost R&D are open source development systems or object orientation, not only in software but also in hardware environments. Another trend that that has still to be fully integrated in most corporate R&D departments, is opening up R&D processes to external actors, and more especially to users, e.g. through competitions or idea challenges (Chesbrough 2003a).

### *4.4 Overcompliance of user requirements by incumbents' solutions*

In contrast to the indicator of fulfilling a basic set of functionalities, overcompliance of customer requirements is related to performance features that are addressing the high-end of the market. These performance features are often linked to high margins and therefore of high interest for incumbents. A key danger is that companies that are concentrating on the high-end of the market are losing sight of user groups requiring only a basic set of functionalities or a value network different from high-end solutions. Whereas the other indicators described are aiming at the evaluation of upcoming and potentially disruptive solutions, this indicator shall be applied for the established solution that is potentially disrupted. Overcompliance of user requirements is evolving over time where previously delighting features become basic needs expected by customers (see e.g. Bailom et al. 1996). The evaluation of functionalities therefore has to be based rather on latent customer requirements than on explicit expectations.
Especially in big corporations, traditional R&D tends towards an overcompliance of user requirements due to development processes that are often engineering driven, combined with high cost-levels. A general tendency therefore exists to address the upper end of the market that is able to cover these high costs either through high quality solutions or through a concentration on topics where high-volumes can be expected. A key driver for the overcompliance of user requirements is the distance between R&D departments in large corporations and the final users of solutions developed. User requirements are often communicated through various organizational levels before influencing the development of new solutions and are managed in a rather short time-horizon.

To complement these indicators, it has to be considered that potentially disruptive technologies are often first developed within engineering departments of incumbent companies and thus shall not only be searched for outside of these (Christensen 1997, sec. 150,1/534).

## 5. Disruption potential analysis for alternative approaches to traditional corporate R&D

Bringing together the categories able to potentially disrupt traditional R&D with the indicators extracted from literature relevant to disruptive innovation in a hypothetical experiment, the disruption potential is analysed by qualitatively evaluating the disruption potential of each of the categories described along the generic R&D process.

### *5.1 Relevance of potentially disruptive categories for R&D process phases*

The relevance of potentially disruptive innovations related to traditional corporate R&D may vary between the phases of the R&D process. Thus each of the categories able to potentially disrupt traditional corporate R&D is analysed in more detail to identify the most relevant process phases to be considered for each category, referring to the generic R&D process described in Chapter 2:

- **R&D carried out by external actors:** external actors may include users, the crowd as well as R&D suppliers such as research organizations, engineering or design companies. Engineering companies and research organizations generally support selected tasks, either in the development of a specific component or technology. Design companies tend to support the entire development process from user-research up to the

production launch or might be focused on exterior appearance of a solution. Users are generally rather involved into the generation of ideas in early R&D phases due to their limited capability to fulfil R&D requirements of later phases. The crowd as an external actor is gaining importance throughout the entire R&D process from idea generation towards carrying out specific tasks through development platforms or open source approaches. Considering all external actors able to carry out R&D, no special emphasis in the R&D process is allocated for this category.

- **Digitisation and automation in R&D:** within the R&D process, digitisation and automation shall be considered concerning two major aspects: The first aspect is the automated feedback from digital products on user behaviour, automatically deriving relevant improvement areas concerning functionalities provided. This includes both, the improvement of the current set of functionalities by means of an optimal match with user requirements as well as the generation of potentials for new functionalities. The second aspect is the automation of R&D processes during the development of new solutions. This includes e.g. computer based testing and virtual prototyping for a high amount of different options able to automatically identify the best possible solution in a defined range. Both aspects which are of concern for the entire R&D process will be considered in the analysis.
- **Efficient and accelerated R&D:** Efficiency and acceleration as e.g. supported by lean or agile development principles is a key issue for processes that are costly and require a high amount of resources. This is mainly the case within later stages of the R&D process after initial concepts have been prioritized for further development and specification. Thus the evaluation of efficient and accelerated will be carried out for these later stages.

The relation between potentially disruptive categories and R&D process phases will be used as a basis for the evaluation of the categories through the indicators described in Chapter 4.

## *5.2 Disruption potential evaluation for corporate R&D*

The analysis of disruption potential is still a key challenge for industrial companies. The approach of extracting indicators able to evaluate the disruption potential of innovative solutions from literature and applying those to corporate R&D as an object of potential disruption is, as previously mentioned, a hypothetical experiment that aims at testing the indicators while at the same time analysing trends that are highly relevant for corporate R&D. It will thus be used as a starting point to carry out further research on the interdependencies between the selected indicators and disruptive innovations. By nature, high level assumptions are taken for this qualitative evaluation. Thus the results have to be further questioned for the application in specific cases. A more detailed evaluation would be feasible by concentrating on a specific sector or even a case within a specific company for future evaluations. The overcompliance of traditional R&D differs from the other indicators as the object of evaluation is not the potentially disruptive category but the object of disruption itself. Accordingly, it will be evaluated independently from the potentially disruptive categories.

### *5.2.1 Disruptive potential evaluation of R&D carried out by external actors*

For the indicator of the fulfilment of a basic set of customer requirements, it is assumed that tasks allocated to external actors are often described in more detail and more focused in comparison with those carried out internally. This allows a much more focused fulfilment of basic customer requirements through adapted R&D structures, e.g. a higher concentration level of most relevant aspects that can then be realized at lower cost. This is the case for both, external R&D providers as well as the crowd. The potential for further development for R&D suppliers is mainly envisioned in the area of IT support facilitating the extraction and re-integration of selected tasks in the R&D process. This enables a continuous communication flow even with suppliers that are located in a geographic distance. For the involvement of the crowd, also the methodological perspective incorporates potential for further development as only little is known about optimal processes and the cost-benefit ratio of crowdsourcing in R&D in comparison with traditional corporate processes. For external R&D suppliers, the cost highly varies but it can be generally be assumed that, especially in long-term cooperation with smaller suppliers, it is lower than the internal cost of corporate R&D. The same can be assumed for the usage of open source development approaches where external developers contribute freely to publicly available systems.

### *5.2.2 Disruptive potential evaluation of digitalisation and automation in R&D*

Todays' products are increasingly able to communicate information on user behaviour back to the R&D department. Especially in modular systems, adaptations can be initiated automatically based on this information aiming to optimize the match between functionalities delivered and functionalities required by users. Especially for basic customer requirements, this match is expected to be automated to a high level in modular structures. However, it is assumed that non-automated R&D activities will be necessary in the future to cover the upper-end of market requirements. The potential for further development is considered to be very high, driven especially by new digitisation capabilities,

ubiquitous high-speed data networks and further reductions in the cost of equipment. The cost of digitisation and automation in R&D compared to traditional corporate R&D is expected to be considerably lower, especially in highly developed economies with high labour cost. Digital models are generally easy to adapt and can be produced at a lower cost than real models. Also data analysis based on automated feedback on user behaviour is less costly than user-research carried out by specialized actors. Major barriers for the application of feedback on user behaviour are the legislation on data security as well as underlying user-appreciation of data collection.

*5.2.3 Disruptive potential evaluation of efficient and accelerated R&D*

Efficient R&D through e.g. the application of lean principles works best in stable conditions whereas accelerated R&D through e.g. agile principles is best applied for complex challenges where close collaboration with customers is feasible. Especially the application of lean principles seems well suited to fulfil a basic set of customer requirements in an efficient and accelerated way. However, many of these principles are already applied in corporate R&D and are rarely leading to a substitution of R&D capacities. They rather enable companies to create additional R&D output while maintaining current R&D capacities. The potential for further development is rather limited as many of the principles of lean of agile R&D are known since a relatively long time. Cost can be reduced through their application but do not considerably differ from the cost of traditional corporate R&D. Whereas efficient and accelerated R&D has only little potential for disruption while thinking about process improvements in corporate R&D departments, the provision of efficient and accelerated R&D by external R&D actors might be able to substitute activities currently carried out by internal R&D due to considerable advantages in development cost and time.

*5.2.4 Disruptive potential analysis through the overcompliance of traditional corporate R&D*

It is assumed that corporate R&D, especially in large corporations, tends towards an overcompliance of customer requirements due to engineering oriented approaches that often go beyond the optimal level of requirements fulfilment. Thus, this indicator generally opens up traditional corporate R&D to the danger of being disrupted by alternative approaches and provides the basis for the analysis carried out in the context of this paper.

An overview of the disruption potential evaluation in which the indicators identified in literature are mapped with relevant alternative approaches to traditional corporate R&D is provided in Table 1.

Table 1. Overview on the disruption potential evaluation for traditional corporate R&D

| | **R&D carried out by external actors** | **Digitisation and automation in R&D** | **Efficient and accelerated R&D** |
|---|---|---|---|
| **Fulfilment of a basic set of customer requirements** | ◑ | ● | ◑ |
| **Potential for further development** | ◑ | ● | ○ |
| **Cost compared to traditional corporate R&D** | ● | ● | ◑ |
| **Overcompliance of traditional corporate R&D** | | ● | |

●: High disruption potential ◑: Medium disruption potential ○: Low disruption potential

Based on this evaluation, the category of digitisation and automation in R&D seems to inhabit the highest disruption potential related to traditional corporate R&D. This is followed by R&D carried out by external actors. Despite playing an important role for corporate R&D, efficient and accelerated R&D has only a low potential to disrupt traditional corporate R&D.

## 6. Summary and outlook

This paper describes a hypothetical experiment based on existing literature bringing together trends in corporate R&D with the theory of disruptive innovation. Through the extraction of the key indicators able to identify potentially disruptive innovations, upcoming trends clustered in three major categories are analysed concerning their potential to disrupt traditional corporate R&D. Among the three categories of R&D carried out by external actors, digitisation and automation in R&D and efficient and accelerated R&D, digitisation and automation has been evaluated with the highest potential of having a disruptive impact on traditional corporate R&D. Furthermore, it is able to respond to a set of basic customer requirements, has a high potential for further development in the future and is able to fulfil selected tasks for considerably lower costs.

To go beyond a hypothetical experiment, both relevant trends as well as the indicators to analyse potentially disruptive developments shall be investigated in more detail, especially with the help of practical examples. Thus a retrospective analysis of examples for disruptive innovations is envisioned to validate and eventually adapt the evaluation indicators. Furthermore, the categories representing relevant trends in corporate R&D will be specified in more detail based on the close cooperation with corporate R&D departments and the long-term analysis of trends in practice and academia.

## 7. References

Accenture. 2015. "Digital Disruption in the Lab: The R&D of Tomorrow."

Bailom, F., H.H. Hinterhuber, K. Matzler, and E. Sauerwein. 1996. "Das Kano-Modell Der Kundenzufriedenheit." *Marketing. Zeitschrift Für Forschung Und Praxis* 18: 117–26.

Boudreau, Kevin J., and Karim R. Lakhani. 2013. "Using the Crowd as an Innovation Partner." *Harvard Business Review* April: 61–69.

Chesbrough, Henry W. 2003a. *Open Innovation*. Boston, Massachusetts: Harvard Business School Press.

Chesbrough, Henry W. 2003b. "A Better Way to Innovate." *Harvard Business Review*.

Christensen, Clayton M. 1992. "The Innovator's Challenge: Understanding the Influence of Market Environment on Processes of Technology Development in the Rigid Disk Drive Industry." Harvard University, Graduate School of Business Administration.

———. 1997. *The Innovator's Dilemma*. Boston, Massachusetts: Harvard Business School Press. First eBook Edition: January 1997.

Christensen, Clayton M., Scott D. Anthony, and Erik A. Roth. 2004. *Seeing What's Next: Using the Theories of Innovation to Predict Industry Change*. Boston: Harvard Business School Publishing Corperation. First eBook Edition: September 2004.

Christensen, Clayton M., Michael E. Raynor, and Rory McDonald. 2015. "What Is Disruptive Innovation." *Harvard Business Review*, no. December.

Cole, Tim. 2015. *Digitale Transformation*. München: Vahlen.

Danneels, Erwin. 2004. "Disruptive Technology Reconsidered: A Critique and Research Agenda." *Journal of Product Innovation Management* 21 (4): 246–58.

Davenport, Thomas H., Jeanne G. Harris, and Robert Morison. 2010. *Analytics at Work: Smarter Decisions, Better Results*. Cambridge, Mass.: Harvard Business Press.

Gelec, Erdem, and Frank Wagner. 2014. "Future Trends and Key Challenges in R&D Management - Results of an Empirical Study within Industrial R&D in Germany." In *Proceedings of the R&D Management Conference, June 3-6*, 920–26. Stuttgart.

Howells, Jeremy. 2008. "New Directions in R&D: Current and Prospective Challenges." *R&D Management* 38 (3): 242–52.

Jaruzelski, Barry, Kevin Schwartz, and Volker Staack. 2015. "Innovation's New World Order." *Strategy+Business*, no. 81, Winter 2015.

Kelley, Tom. 2006. *The Ten Faces of Innovation*. London: Profile Books.

Kelley, Tom, and David Kelley. 2013. *Creative Confidence - Unleashing the Creative Potential within Us All*. New York: Crown Business.

Kelley, Tom, and Jonathan Littman. 2001. *The Art of Innovation*. London: Profile Books.

Morgan, James M., and Jeffrey K. Liker. 2006. *The Toyota Product Development System: Integrating People, Process, and Technology*. New York: Productivity Press.

Nambisan, Satish. 2010. *Information Technology and Product Development*. Edited by Springer Science + Business Media. New York.

Pillkahn, Ulf. 2012. "Innovation Zwischen Planung Und Zufall." Universität München.

Porter, Michael. 1998. *Competitive Strategy*. New York: the Free Press.

Prahalad, C. K. 2010. *The Fortune at the Bottom of the Pyramid*. New Jersey: Wharton School Publishing.

Raynor, Michael E. 2011. *The Innovator's Manifesto*. New York: Crown Business.

Raynor, Michael E., and Jill A. Panetta. 2005. "A Better Way to R&D." *Harvard Business Review*, no. March 2005.

Ries, Eric. 2011. *The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses*. New York: Crown Business.

Schäppi, Bernd, Mogens M. Andreasen, Manfred Kirchgeorg, and Franz-Josef Radermacher, eds. 2005. *Handbuch Produktentwicklung*. München: Hanser.

Schimpf, Sven, and Judith Binzer. 2012. "Sustainable R&D: A Conceptual Approach for the Allocation of Sustainability Methods and Measures in the R&D Process." In *Proceedings of the R&D Management Conference 2012*. Grenoble.

Schimpf, Sven, and Flavius Sturm. 2010. "Art and R&D: A Conceptual Approach on How Art Can Support the Product Development Process." In *Proceedings of the R&D Management Conference*. Manchester.

Schmelzer, H. S. 1992. *Organisation Und Controlling von Produktentwicklungen: Praxis Des Wettbewerbsorientierten Entwicklungsmanagements*. Stuttgart: Schäffer-Poeschel Verlag.

Ulrich, Karl, and Steven Eppinger. 2008. *Product Design and Development*. 4th Editio. Boston: McGraw-Hill.

VDI. 1977. "VDI-Guideline 2222 - Blatt 1: Methodic Development of Solution Principles." Düsseldorf: VDI-Verlag.

Wagner, Frank, Erdem Gelec, Judith Binzer, Liza Wohlfart, Manuel Kern, Michael Schubert, Stephan Schüle, and Sven Schimpf. 2015. *FuE - Fit Für Die Zukunft: Trends Und Erfolgsfaktoren in Der Forschung Und Entwicklung*. Stuttgart: Fraunhofer Verlag.

Williamson, Peter J., and Eden Yin. 2014. "Accelerated Innovation: The New Challenge From China." *MITSloan Management Review* Reprint 55.