Derivation of a Target System for Continuous Innovation Based on a Systematic Literature Review

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***Abstract*—The manufacturing industry faces critical changes due to the increasing importance of sustainability. Ever faster changing customer requirements and the need to consider circular economy require a rethink of today's business models. Continuous innovation, realized through upgrades to existing technical products, holds the key to addressing these challenges. However, operational hurdles hinder its implementation, prompting the need for support in manufacturing companies. An essential point to support and set guard rails is the development of a target system, as it supports manufacturing companies in the prioritization of activities for the realization and implementation of continuous innovation. There is currently a scientific deficit in this area, as the targets of continuous innovation are not sufficiently described, taking into account the relevant dimensions of the product, business models, process and organization. Therefore, this paper focuses on the derivation of a target system for continuous innovation for technical products in the usage phase. It encompasses a systematic literature review-based methodology, a target clustering and target descriptions.**

***Keywords*—continuous innovation, innovation management, manufacturing companies, target system**

I. Introduction

The increasing importance of sustainability leads to changing conditions and new requirements for the manufacturing industry [1, 2]. Thereby, the linear economic system consumes finite resources due to the "take-make-dispose" principle and is not sustainable. To move to a more sustainable economy, more comprehensive steps need to be taken [3]. In this context, the concept of circular economy plays a decisive role in meeting the challenges of sustainability [4]. Furthermore, innovative products become more important in order to maintain customer satisfaction despite frequent changes in customer requirements and market share in international markets [5]. By implementing new features and components (upgrades) into existing technical products, the concept of continuous innovation is a promising approach to successfully support a value-enhancing circular economy [3, 6]. Furthermore, it helps to address the increasing changes in customer needs. Fig. 1 shows the overall potential of continuous innovation. Many manufacturing companies are aware of the potentials of continuous innovation However, the implementation of this innovation approach fails due to a lack of operational support [7]. Therefore, it is necessary to support the implementation of continuous innovation in manufacturing companies [8]. To this end, a target system for continuous innovation is first required.

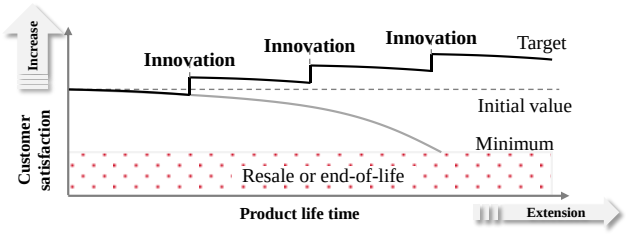

Fig. 1. Schematic concept for a possible value enhancement of customer satisfaction over time through continuous innovations [9, 10]

With the help of targets and a structured target system, manufacturing companies are able to define a desired state. The targets describe the direction and future state that will be supported and addressed through continuous innovation and thereby could be used to prioritize initiatives for implementation [7]. In order to develop such a target system for continuous innovation for technical products in the usage phase, this paper is structured as follows. First, relevant fundamentals are presented. Second, the methodology within this paper is described. Thereby, the relevant targets within the target systems are identified. Thus, a systematic literature review is used. Based on this, the identified targets are structured into perspectives based on clustering algorithms. The results in the form of a target system are presented in section four. Finally, a conclusion as well as an outlook on further research activities are given in section five.

II. Fundamentals

In the following section, relevant fundamentals regarding continuous innovation and target systems are described.

A. Continuous Innovation

Innovations make a significant contribution to competitiveness and the ability to grow manufacturing companies [11, 12]. From a scientific view, an innovation starts with an idea that is characterized by a high degree of novelty [11]. If the idea is successful on the market, the idea is transformed into an innovation [13]. The concept of continuous innovation has been discussed for several years in the context of various fields, including product, knowledge management or cooperation. [14, 15]. Despite a high level of discussion, however, there is no uniform definition of the term in the scientific literature [16, 17]. The first approaches in the context of continuous innovation, often known under the term DevOps, originate from the software industry by continuously

providing customers with software updates and software releases [18]. In the context of physical products, Lianto et al. categorizes existing definitions of continuous innovation [17]. According to the authors, continuous innovations comprise an ongoing innovation process as well as innovation activities that are carried out continuously, repeatedly and regularly over a longer period [17]. Riesener et al. revive this definition and characterize the innovation approach of continuous innovation holistically [19]. From a more technical product perspective, they describe continuous innovations as an approach for the continuous identification of customer needs during product usage as well as the development, integration and delivery of new functions, components, technologies and services.

B. Target System

There are different definitions of the term target. Hausschildt defines targets as normative statements of decision makers, which describe a desired, future state of reality [20]. Vahs et al. add that targets are a result of decisions and their realizations [12]. In general, targets can be distinguished between guiding targets (main targets) and accompanying targets (secondary targets). While main targets address a strategic long-term perspective, secondary targets serve to support the achievement of main targets and can represent additional constraints. The targets are therefore related to each other using a means-purpose relationship and can be mapped based on a hierarchical target structure [12, 21]. By considering these relationships between targets, a target system is created. Thereby, a target system can consist of one (singular target system) or several key targets (plural target system) [22].

C. Target System for Continuous Innovation

In the scientific literature, different approaches exist that describe general target systems for innovations and innovation management. With the Innovation Balanced Scorecard, for example, [23, 24] adapted the approach of the classic Balanced Scorecard with a focus on innovations. Furthermore, different approaches such as [8, 17, 25] name different reasons and motivations for companies to continuously innovate. However, there is a lack of a target system that, considering the various perspectives of product, business model, process and organization systematically shows the targets of continuous innovations holistically. Furthermore, no cause-effect relationships are used systematically in the target systems to structure targets into perspectives. For this reason, this paper is dedicated to filling this gap and answering the research question: How to derive a target system for continuous innovation? For this purpose, the method of application is presented in the next section.

III. Methodology

The methodology for the design of a target system for continuous innovation is based on two main parts. On the one hand, relevant targets for the target system are identified based on a systematic literature review according to Brocke et al. [26]. On the other hand, the identified targets are analyzed and structured into a target system. Fig. 2 summarizes the necessary steps.

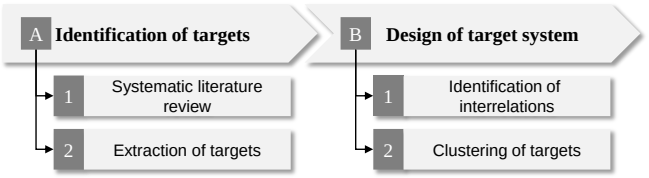

Fig. 2. Overview of steps of the methodology.

In the following, the two steps of the methodology are explained in more detail.

A. Identification of Targets

The aim of the first part of the methodology is the identification of targets. Therefore, two steps must be conducted.

1) Systematic literature review

The systematic literature review follows a defined structure. First, an analytical-deductive analysis of the literature is conducted based on the approach according to vom Brocke et al. [26]. Afterwards, the targets are validated and double-checked with expert interviews and case studies in the industry to achieve a practical set of targets. For the systematic literature review, combined keywords and their synonyms are used: “Continuous innovation”, “Innovation”, “Upgradability”, “Product upgrade”, “Technical products” “Target” and “Target system”. The terms are connected by Boolean operators and searched for in the literature databases Web of Science, Google Scholar and IEEE Xplore. The identified sources are first reviewed by title and second by abstracts. The literature is analyzed regarding the expected usability of the literature for the identification of targets for continuous innovation. Therefore, paper are excluded that do not address topics of innovation management, innovation, circular economy, upgradeability or DevOps within their abstracts. In addition to the above described forward research, supplementary sources that came up additionally during the research (backward research) are analyzed as well.

2) Extraction of targets

The extraction of the targets from the literature is done in three steps. First, thematically relevant targets are collected from the identified literature. Then, the first structuring of extracted targets takes place through a reduction of duplicates and synonyms. The last step of the narrowing down process aims at consolidating the targets concerning the MECE principle. MECE stands for the acronym “Mutually-Exclusive-And-Collectively-Exhaustive”. For this purpose, the targets are divided into overarching dimensions of product, process, business model and organization, as these dimensions represent the object domain within the systematic literature review. Then, the targets are consolidated according to the proximity of content within a dimension and are bundled into non-overlapping targets through uniform naming.

B. Design of Target System

The aim of the second part of the methodology is the derivation of the target system. For this purpose, two steps need to be taken. First, the interrelations between targets must be described. Based on the interrelations, the targets need to be clustered and the target system can be derived.

1) Identification of interrelations

For the identification of interrelations, the method of a binary design structure matrix (DSM) is used. Therefore, the targets are listed on both sides of the matrix. The dependencies within the matrix are analyzed using a binary evaluation scale. It is sufficient to fill one side of the matrix because the matrix builds up synchronously above and below the diagonal. If the targets within the target system strengthen each other, this is referred to as a complementary target interrelation (positive interrelation = 1). On the other hand, if there is a negative correlation between the targets (negative interrelation = −1), it is a conflicting target interrelation. Fig. 3 illustrates the systematic of the DSM.

Fig. 3. Systematic visualization of interrelations between the targets.

The result of this step is a matrix, that illustrates the interrelationships between the identified targets. Based on this groups of targets can be built in the next step.

2) Clustering of targets

The second step addresses the clustering and structuring of targets, based on the Idicula-Gutierrez-Thebeau Algorithm (IGTA+), [27]. Therefore, only complementary (positive) interrelations are used. The algorithm is used to reorganize the rows and columns of the DSM. It forms blocks along the diagonal. Within these blocks, there is an increased positive connection between targets. The targets of each block are merged within a cluster, which forms a perspective of the target system. Fig. 4 shows a schematic result of the clustering algorithm.

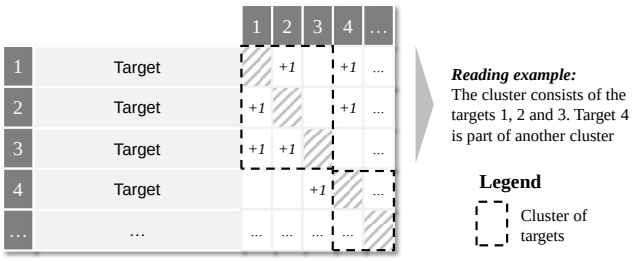

Fig. 4. Systematic overview of clustered targets.

The result of this step are groups of targets and interrelations between targets. In the following section, the results in the form of the target system are explained.

IV. Research Findings and Target System

This section aims to describe the results from the previously presented methodology. In total, 28 consolidated targets could be derived based on the approach. These targets are divided into seven clusters by using the presented approach: The derived clusters form the respective perspectives of the target system: Finance, Collaboration, Customer, Product, Process, Company, and Competitive. In

The overall target system with its perspectives is presented in Table 1. The sources on which the targets are mainly derived are listed.

Table 1. Overview of targets

Target	Perspective	Source
1) Reduction of development expenses	Financial	[28–35]
2) Regular revenue through innovations	Financial	[23, 29, 32, 36, 37]
3) Establishment and strengthening of external partnerships	Collaboration	[17, 31, 38–42]
4) Promotion of collaboration within the organization	Collaboration	[31, 43–45]
5) Establishment of an open innovation culture	Collaboration	[23, 25, 28, 44, 46–48]
6) Increased customer focus in the innovation process	Customer	[29, 31, 36, 49–52]
7) Increased customer satisfaction and customer value	Customer	[17, 28, 36, 53–57]
8) Establish long-term customer loyalty	Customer	[28, 36, 47, 58]
9) Realization of product individualization	Customer	[50, 59–61]
10) Improved identification and satisfaction of actual customer needs	Customer	[17, 59, 62–67]
11) Preservation and increase of product value in the use phase	Product	[31, 68, 69],
12) Increase of innovation frequency	Product	[17, 28, 29, 70–72]
13) Increase of product sustainability	Product	[6, 73–76]
14) Increase of material reuse	Product	[69, 77–80]
15) Increasing resource efficiency	Product	[28, 31, 47, 55, 77]
16) Regular improvement of product quality	Product	[17, 81–84]
17) Continuous improvement of product performance	Product	[10, 31, 45, 47, 49, 66, 67, 85–87]
18) Extension of the product life cycle	Product	[28, 40, 47, 66, 75, 88]
19) Increasing the effectiveness of the innovation process	Process	[15, 23, 72, 89–91]
20) Increasing the efficiency of the innovation process	Process	[28, 45, 70, 86, 89, 92, 93]
21) Improvement and application of information and knowledge from product use	Process	[17, 31, 43, 50, 85, 94–96]
22) Shortening the time-to-market of an innovation	Process	
23) Increase of innovation capability	Company	[16, 17, 25, 67, 97]
24) Focusing of a sustainable company	Company	[34, 46, 66, 69, 86, 98–101]
25) Ensuring the growth of the company	Company	[25, 36, 44, 83, 87]
26) Ensuring robustness and flexibility of the company	Company	[17, 67, 102]
27) Opening up new markets	Competitive	[32, 44, 62, 67, 91, 103]
28) Ensuring competitiveness	Competitive	[25, 28, 29, 46, 47, 49, 53, 90, 97, 104, 105]

In the following, the targets are explained in more detail. The subchapters are based on the perspectives of the target system.

A. Financial Perspective

From the financial perspective, there are two overarching targets: Reduction of development expenses and regular revenue through innovations. Cost for a new "thing" for the customer can be reduced in the long term because implementing smaller incremental innovations in existing products with a consistent base lowers the development costs. Furthermore, cooperation with development partners is easier [30, 32–35, 47]. At the same time, regular revenue is targeted through continuous innovation flows and regular customer orders [23, 29, 32, 36, 37]. Manufacturing companies do not focus on transactional business model but address regular upgrade sales during the usage phase of an existing product.

B. Collaboration Perspective

Within the collaboration perspective, three targets are grouped, which relate to collaboration with partners, within the organization, and to the culture required for open collaboration. Creating and managing a network with partners enables access to knowledge and innovation potential outside the company. Continuous innovation requires and targets this collaboration and consequently encourages the organization to open up and take advantage [17, 31, 38, 39]. Thereby, integrating external actors into the innovation process can increase access to resources, reduce costs, leverage shared infrastructure, and promote continuous innovation [40–42]. In addition to external collaboration, internal collaboration plays a crucial role in the context of continuous innovation. The implementation of the holistic approach for continuous innovation requires but also enables and improves collaboration across disciplines at all levels of the company [31, 43–45]. This development of new organizational forms combined with the creation of an innovation-friendly culture enables all employees of the company to participate in a continuous innovation process. Furthermore, the approach of continuous innovation manages to maintain openness in the innovation process [23, 25, 28, 37, 46–48].

C. Customer Perspective

Within the customer perspective, five targets are summarized, which are closely related to the customers of continuous innovation. The first target, increasing customer focus in the innovation process, addresses the necessity for the central focus of innovations on the customer and the integration of customers into the innovation process. This supports and leads to improved satisfaction of customer needs at the same time [29, 36, 49–52]. Through the continuous delivery of customer-oriented innovation and the associated increase in customer benefit, customer satisfaction can be sustainably increased [28, 36, 53, 55–57]. Improving customer satisfaction and customer value is one of the key objectives in the context of continuous innovation [17, 53, 54]. Thereby, the identification of the correct and actual customer benefits and needs is aimed at continuous innovation and is one of the central benefits in contrast to typical innovation approaches. To do so, data-driven approaches are used, to achieve this target and support the satisfaction of needs from current and future stakeholders [17, 59, 62–67]. The customer focus results in two further targets, the establishment of long-term customer loyalty as well as the realization of product individualization [28, 36, 47, 50, 58–61]. The achievement of both targets is part of continuous innovation.

D. Product Perspective

Within the product perspective, seven targets are grouped, which are closely related to the product. The first target within the product perspective is the increase of product sustainability. By creating sustainable products, objects should be created that go beyond the purely functional level. In this way, it is possible to respond continuously to the increasing sustainability aspects in customers' purchasing decisions [73–75]. Another sustainability target addressed by continuous innovation is increased material reuse. The use of upgrades in the product phase improves recycling rates, reduces the disposal of old products and waste volumes, and thus keeps resources in the cycle for a longer time [69, 77–80]. It interacts directly hand in hand with the target of extending the product life cycle. Furthermore, continuous innovation targets the efficient use of resources within its products. It can contribute to this target by providing resource efficient and target-oriented upgrades and new technologies as well as support the avoidance of additional new products that are not required [28, 31, 47, 55]. By continuously delivering and embedding new innovations, the current status of short-lived and unsustainable products can be overcome and the entire product lifecycle can be extended [28, 40, 47, 66, 75, 88]. Upgrades prevent premature disposal of the product before the end of its useful life. Therefore, continuous innovation addresses the target of short-cycle and high-frequency iterative introduction of innovations [17, 28, 29, 70]. This also enables a response to growing global competition and rapidly changing heterogeneous customer needs [28, 72]. The frequent introduction of innovations, e.g. in the form of technology upgrades, also enables regular improvements to be made regarding quality and performance. These are two additional targets within the target system, that are focused on continuous innovation. Improving the overall quality of a product can reduce failure rates and increase safety for companies and consumers [17, 81–84]. Besides the quality, the continuous improvement of product functionality and performance by optimizing product features is highly relevant in the context of continuous innovation [10, 31, 45, 47, 49, 66, 67, 85–87]. In the course of continuous innovation, customer benefits are to be constantly increased by providing more efficient products. In particular, identifying and evaluating potential areas of improvement in the product can add a lot of value in the early innovation process [17, 31, 86]. In summary, upgrades and continuous innovation not only reduce the depreciation of the product but also increase the value of the product and thus improve the attractiveness of the product for the customer [31, 68, 69, 106].

E. Process Perspective

Within the process perspective, five targets are summarized, which refer to the innovation process. Thereby two main targets can be formulated: increasing the

effectiveness of the innovation process and increasing the efficiency of the innovation process. Continuous innovation aims to identify the right innovations for the customer and thus avoid the risks of undesirable developments. This increases effectiveness in the innovation process [15, 23, 72, 89–91]. Another supportive target of the previous one is the improvement and application of information and knowledge from product use. Continuous creation, identification and transfer as well as the systematic organization of knowledge enables a continuous flow of innovation and creates sustainable competitive advantages [17, 31, 40, 43, 50, 85, 94–96]. To do this, various data streams from all actors in all phases of the product lifecycle must be brought together to effectively transform knowledge gained into innovations. Continuous innovation also targets the efficiency of innovation processes. It can increase the accuracy of achieving time, cost and quality targets, especially in fast-moving, technology-driven and more unstable environments, and incorporate the interests of different stakeholders [28, 45, 70, 86, 89, 92, 93]. The target of shortening the time-to-market of an innovation thereby influences the efficiency as well. By increasing the speed of innovation, the time to market can be reduced. This enables a respond promptly to changing customer needs in the course of continuous innovation [17, 23, 28, 31, 85, 107].

F. Company Perspective

Within the company perspective, four targets, which address overall company and organizational aspects, are summarized. The first target addresses the increase of innovation capabilities. By developing innovation capabilities across all areas of a company in the context of continuous innovation, products, internal processes, technologies and procedures can be continuously improved and the position in global competition can be strengthened [16, 17, 25, 67, 97]. Furthermore, a company that wants to implement continuous innovations also focuses on flexibility and robustness, growth and sustainability. By implementing continuous innovation and attention to sustainability across the entire product portfolio, a foundation of sustainable business practices can be laid. Moreover, by aiming at upgradeability, continuous innovations improve a high environmental impact for the company [34, 46, 69, 86, 99–101]. However, it is always important to achieve long-term growth of the company with increasing continuous revenue and high profitability by introducing innovations [25, 36, 44, 83, 87]. Thereby, the recurring revenues as well as the organizational structure of continuous innovation help to ensure the robustness and flexibility of the company. Consequently, an adaptation to changing dynamic markets and dealing with uncertainty in the sense of resilience is supported by continuous innovation [17, 67, 102].

G. Competitive Perspective

The competitive perspective consists of two targets: Opening up new markets as well as ensuring competitiveness. By identifying and developing market gaps and distribution channels, innovations can be continuously sold. In addition, new market-side innovation potential can be identified at an early stage [44, 91]. The development of new market fields also leads, among other things, to the company's competitiveness. Especially in a changing and globalized business environment, continuous innovation can build competitive advantage and strengthen the company's long-term position [25, 28, 29, 47].

V. Conclusion

Within this paper, targets for continuous innovation were identified and a target system was built. Within the target system, 28 targets are described and grouped into 7 perspectives: Finance, Collaboration, Customer, Product, Process, Company, and Competitive. The designed target systems deliver an overview of targets, that are addressed by implementing continuous innovation of technical existing products in the usage phase. Based on the target system, relevant business models, organizational adaptions, product and process activities could be derived and designed. It serves as a base for manufacturing companies to structure the implementation of continuous innovation and measure the success of continuous innovation. However, various limitations apply to the results, the first of which is to be found in the search query. Limiting the language to English and German is warranted due to most of the research being in English and many own previous research activities being conducted in German. Nevertheless, completeness can thus not be ensured in a holistic manner. However, the research is limited by the scope defined by the search strings. Furthermore, a limit is placed due to the fact that a consistent definition of the term “continuous innovation” is not given in the scientific literature. Although the concept of continuous innovation appeared in the scientific literature several years ago, the importance and the scope of the approach changed due to the focus on digitalization and sustainability in recent years. This analysis can therefore only be a temporary description with a need for regular updates, especially in the next 2-5 years to consider an established view of continuous innovation in the context of circular economy. Therefore, further targets and the derivation of an adapted target system can be obtained following the same methodology. Within the next research phases, the identified target system must be further specified and detailed. This requires, in particular, the validation of the identified objectives and the cause-effect relationships underlying the target system from a practice-oriented perspective. Furthermore, the target system must be assigned to implementation activities for concrete support for the realization of continuous innovations. It is necessary to research which implementation activities have a special relevance due to the companies' focus and addressing of individual goals. The research activities will be further explored within the scope of a doctoral thesis and the Excellence Cluster of RWTH Aachen University, among others, as well as discussed in industry circles, in particular with companies from machinery engineering.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Michael Riesener: Supervision. Maximilian Kuhn: Writing

- review & editing, Supervision. Stefan Perau: Conceptualization, Methodology, Validation, Writing - original draft, Writing - review & editing, Project administration. Günther Schuh: Supervision. All authors had approved the final version.

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REFERENCES

[1] Circular Economy Initiative Deutschland, Zirkuläre Geschäftsmodelle: Barrieren überwinden, Potenziale freisetzen.

[2] M. Kuebler, W. Schuster, S. E. Schwarz, A. Braumandl, A. Siebe, and A. Albers, "Upgradeable mechatronic systems—an approach to determine changing product properties using foresight," *Procedia CIRP*, vol. 119, pp. 78–83, 2023.

[3] G. Schuh *et al.*, "Grüne re-montage upgrade-fabrik," in *Empower Green Production: Tagungsband Aachener Werkzeugmaschinen Kolloqium (AWK)*, T. Bergs, C. Brecher, R. Schmitt, and G. Schuh, Eds., Aachen, 2023, pp. 337–360.

[4] Acatech, *Deutschlang auf dem Weg zur Circular Economy*, 2019.

[5] D. Dereli, "Innovation management in global competition and competitive advantage," *Procedia - Social and Behavioral Sciences*, vol. 195, pp. 1365–1370, 2015.

[6] S.-H. Chen, "The influencing factors of enterprise sustainable innovation: An empirical study," *Sustainability*, vol. 8, no. 5, p. 425, 2016.

[7] M. Riesener, M. Kuhn, S. Perau, and G. Schuh, "Concept for the design of an implementation process for continuous innovation in manufacturing companies," in *Proc. 2022 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM)*, Kuala Lumpur, Malaysia, 2022, pp. 1291–1295.

[8] A.'t Spijker, *Continuous Innovation*, Basking Ridge, NJ: Technics Publications, 2019.

[9] G. Schuh *et al.*, "Neue modularität und technologie-roadmapping," in *Empower Green Production: Tagungsband Aachener Werkzeugmaschinen Kolloqium (AWK)*, T. Bergs, C. Brecher, R. Schmitt, and G. Schuh, Eds., Aachen, 2023, pp. 98–125.

[10] M. Riesener, M. Kuhn, S. Perau, T. Walter, A. Keuper, and G. Schuh, *Framework for the Implementation of Continuous Innovation for Technical Products*, 2023.

[11] G. Schuh, *Innovationsmanagement*, Berlin, Heidelberg: Springer Berlin Heidelberg, 2012.

[12] D. Vahs and A. Brem, *Innovationsmanagement: Von der Idee zur erfolgreichen Vermarktung*, 5th ed., Stuttgart: Schäffer-Poeschel, 2015.

[13] J. Hauschildt, S. Salomo, C. Schultz, and A. Kock, *Innovationsmanagement*, 6th ed., München: Verlag Franz Vahlen, 2016.

[14] X. Xie, S. Zeng, and C. Tam, "Towards continuous innovation for regional high-tech industrial clusters," *Innovation: Management, Policy & Practice*, vol. 13, no. 3, pp. 361–375, 2011.

[15] M. Corso and S. Pavesi, "How management can foster continuous product innovation," *Integrated Mfg Systems*, vol. 11, no. 3, pp. 199–211, 2000.

[16] B. Lianto, M. Dachyar, and T. P. Soemardi, "A holistic model for measuring continuous innovation capability of manufacturing industry: A case study," *IJPPM*, vol. 71, no. 6, pp. 2061–2086, 2021. doi: 10.1108/IJPPM-02-2021-0062

[17] B. Lianto, M. Dachyar, and T. P. Soemardi, "Continuous innovation: A literature review and future perspective," *International Journal on Advanced Science, Engineering and Information Technology*, vol. 8, no. 3, p. 771, 2018. doi: 10.18517/ijaseit.8.3.4359

[18] R. Alt, G. Auth, and C. Kögler, *Innovationsorientiertes IT-Management mit DevOps*, Wiesbaden: Springer Gabler, 2017.

[19] M. Riesener, M. Kuhn, S. Perau, P. Guenther, and G. Schuh, "Characterization of continuous innovation for technical products in the usage phase," *Procedia CIRP*, vol. 119, pp. 987–992, 2023. doi: 10.1016/j.procir.2023.02.174

[20] J. Hausschildt, "Zur artikulation von unternehmenszielen," *Zeitschriften für betriebswirtschaftliche Forschung (ZfbF)*, vol. 22, 1970.

[21] J.-P. Thommen, A.-K. Achleitner, D. U. Gilbert, D. Hachmeister, S. Jarchow, and G. Kaiser, *Allgemeine Betriebswirtschaftslehre: Umfassende Einführung aus managementorientierter Sicht*, 9th ed., Wiesbaden: Springer Fachmedien Wiesbaden GmbH; Springer Gabler, 2020.

[22] M. Bleider, *Gestaltungsmodell eines Energieinformationssystems im Internet of Production*, Apprimus Wissenschaftsverlag, 2019.

[23] P. Sahu, "Strategy-focused product innovation with product scorecard and product innovation scorecard," in *Proc. 2004 IEEE/UT Engineering Management Conference*, 2004, pp. 8–13.

[24] C. Stummer and M. GÜnther, "Die Balanced Scorecard (BSC) im innovationsmanagement," in *Digitalisierung und Innovation*, F. Keuper, K. Hamidian, E. Verwaayen, T. Kalinowski, and C. Kraijo, Eds., Wiesbaden: Springer Fachmedien Wiesbaden, 2013, pp. 471–484.

[25] A. Steiber, *The Google Model: Managing Continuous Innovation in a Rapidly Changing World*, Cham: Springer International Publishing, 2014.

[26] J. vom Brocke, A. Simons, B. Niehaves, K. Riemer, R. Plattfaut, and A. Cleven, *Reconstructing the Giant: On the Importance of Rigour in Documenting the Literature Search Process*, 2009.

[27] F. Borjesson and K. Hölttä-Otto, "Improved clustering algorithm for design structure matrix," *38th Design Automation Conference, Parts A and B*, Chicago, Illinois, USA, 08122012, vol. 3, pp. 921–930.

[28] M. Riesener, M. Kuhn, S. Perau, M. Mertens, and G. Schuh, "Fields of action for the realization of Continuous Innovations," in *Proc. the 10th International Conference on Mass Customization and Personalization - Community of Europe (MCP-CE 2022)*, pp. 138–146, 2022.

[29] J. Guo, L. Cui, S. L. Sun, and B. Zou, "How to innovate continuously? Conceptualizing generative capability," *Journal of Innovation & Knowledge*, vol. 7, no. 2, pp. 1–16, 2022. doi: 10.1016/j.jik.2022.100177

[30] M. A. Khan, S. Mittal, S. West, and T. Wuest, "Review on upgradability—a product lifetime extension strategy in the context of product service systems," *Journal of Cleaner Production*, vol. 204, pp. 1154–1168, 2018. doi: 10.1016/j.jclepro.2018.08.329

[31] G. Schuh *et al.*, "Always beta: DevOps für cyber-physische Produkte," in *Internet of Production - Turning Data into Value*, T. Bergs, C. Brecher, R. H. Schmitt, and G. Schuh, Eds., Aachen: Fraunhofer-Gesellschaft, 2020, pp. 114–136.

[32] P. Saksupapchon and K. W. Willoughby, "Contextual factors affecting decisions about intellectual property licensing provisions in collaboration agreements for open innovation projects of complex technological organizations," in *Proc. 2019 IEEE International Symposium on Innovation and Entrepreneurship (TEMS-ISIE)*, 2019, pp. 1–2.

[33] W.-H. Chung, G. E. O. Kremer, and R. A. Wysk, "A dynamic programming method for product upgrade planning incorporating technology development and end-of-life decisions," *Journal of Industrial and Production Engineering*, vol. 34, no. 1, pp. 30–41, 2017. doi: 10.1080/21681015.2016.1192067

[34] D. Brissaud and P. Zwolinski, "The Scientific challenges for a sustainable consumption and production scenario: The circular reuse of materials for the upgrading and repurposing of components," *Procedia CIRP*, vol. 61, pp. 663–666, 2017. doi: 10.1016/j.procir.2016.11.148

[35] B. Kamrad, G. M. Schmidt, and S. Ulku, "Analyzing product architecture under technological change: Modular upgradeability tradeoffs," *IEEE Trans. Eng. Manage.*, vol. 60, no. 2, pp. 289–300, 2013. doi: 10.1109/TEM.2012.2211362

[36] G. Schuh, A. Gutzlaff, S. Cremer, J. Lammersmann, and Y. Liu, "Business model and organization: Interdependencies for customer-centric continuous innovation in subscription business," in *Proc. IEEE International Conference on Industrial Engineering and Engineering Management (IEEM)*, Singapore, Singapore, Dec. 2020, pp. 260–264.

[37] J. C. Barbieri and A. C. T. Álvares, "Sixth generation innovation model: description of a success model," *RAI Revista de Administração e Inovação*, vol. 13, no. 2, pp. 116–127, 2016. doi: 10.1016/j.rai.2016.04.004

[38] A. Karlsson and J. Björk, "Establishing and managing a network for continuous innovation: Invoking organizational pressure," *Creativity and Innovation Management*, vol. 26, no. 2, pp. 128–141, 2017. doi: 10.1111/caim.12215

[39] R. Khormaei, Capability life cycle tool to integrate external innovation," in *Proc. PICMET'11: Technology Management in the Energy Smart World (PICMET)*, IEEE, 2011, pp. 1–9.

[40] R. Chapman and C. O'Mara, "Product innovation in SMEs-key behaviours and performance measures," in *PICMET '01. Portland International Conference on Management of Engineering and Technology. Proceedings Vol.1: Book of Summaries (IEEE Cat. No.01CH37199)*, 2001, p. 47.

[41] R. L. Chapman and M. Corso, "From continuous improvement to collaborative innovation: the next challenge in supply chain management," *Production Planning & Control*, vol. 16, no. 4, pp. 339–344, 2005. doi: 10.1080/09537280500063269

[42] C. Ucler and K. Kristensen, "Context—a novel approach for collaborative virtual product realization and its disclosure using the business model canvas," in *Proc. 2016 International Conference on Engineering, Technology and Innovation/IEEE lnternational Technology Management Conference (ICE/ITMC)*, 2016, pp. 1–8.

[43] F. J. Forcadell and F. Guadamillas, "A case study on the implementation of a knowledge management strategy oriented to innovation," *Knowledge and Process Management*, vol. 9, no. 3, pp. 162–171, 2002. doi: 10.1002/kpm.143

[44] R. E. MILES, G. MILES, and C. C. SNOW, "Collaborative entrepreneurship: A business model for continuous innovation," *Organizational Dynamics*, vol. 35, no. 1, pp. 1–11, 2006. doi: 10.1016/j.orgdyn.2005.12.004

[45] T. Toivonen, "Continuous innovation—combining Toyota kata and TRIZ for sustained innovation," *Procedia Engineering*, vol. 131, pp. 963–974, 2015.

[46] N. S. Madonsela, S. C. Mukwakungu, and C. Mbohwa, "Continuous innovation as fundamental enabler for sustainable business practices," *Procedia Manufacturing*, vol. 8, pp. 278–283, 2017. doi: 10.1016/j.promfg.2017.02.035

[47] M. Corso, "From product development to Continuous Product Innovation: mapping the routes of corporate knowledge," *IJTM*, vol. 23, no. 4, p. 322, 2002. doi: 10.1504/IJTM.2002.003013

[48] C. Amirat and R. Reeps, "Continuous innovation through experimentation," in *Proc. 2018 IEEE Technology and Engineering Management Conference (TEMSCON)*, 2018, pp. 1–6.

[49] N. Wiegand and M. Imschloss, "Do you like what you (can't) see? The differential effects of hardware and software upgrades on high-tech product evaluations," *Journal of Interactive Marketing*, vol. 56, pp. 18–40, 2021. doi: 10.1016/j.intmar.2021.03.004

[50] P. Zheng, X. Xu, and C.-H. Chen, "A data-driven cyber-physical approach for personalised smart, connected product co-development in a cloud-based environment," *Journal of Intelligent Manufacturing*, vol. 31, no. 1, pp. 3–18, 2020. doi: 10.1007/s10845-018-1430-y

[51] D. Mulligan and K. Cormican, "A customer centric process innovation toolkit for SMEs," in *Proc. 2006 IEEE International Technology Management Conference (ICE)*, 2006, pp. 1–8.

[52] A.-M. Wyk, J. H. C. Pretorius, and L. Pretorius, "Technical and non-technical enablers required for the design of a process- and product-innovation framework to enable a client-centric culture," in *Proc. 2022 Portland International Conference on Management of Engineering and Technology (PICMET)*, 2022, pp. 1–8.

[53] M. Terziovski, "Achieving performance excellence through an integrated strategy of radical innovation and continuous improvement," *Measuring Business Excellence*, vol. 6, no. 2, pp. 5–14, 2002. doi: 10.1108/13683040210431419

[54] W. Elfarmawi, "Correlation between customer relationship management system usage, product innovation, and customer satisfaction," *Foundations of Management*, vol. 11, no. 1, pp. 23–32, 2019.

[55] N. A. Aziz, D. A. Wahab, R. Ramli, and C. H. Azhari, "Modelling and optimisation of upgradability in the design of multiple life cycle products: a critical review," *Journal of Cleaner Production*, vol. 112, pp. 282–290, 2016. doi: 10.1016/j.jclepro.2015.08.076

[56] T. Murakami, M. Inoue, Y.-E. Nahm, and H. Ishikawa, "An upgrade design method for environmental issues based on the concept of set-based design," in *Design for Innovative Value Towards a Sustainable Society: Proceedings of EcoDesign 2011: 7th International Symposium on Environmentally Conscious Design and Inverse Manufacturing*, 2012, pp. 501–506.

[57] O. Pialot and D. Millet, "Why the upgradability is a present-day opportunity for designing sustainable systems?" *Procedia CIRP*, vol. 48, pp. 96–101, 2016. doi: 10.1016/j.procir.2016.03.246

[58] R. Garud and A. Kumaraswamy, "Technological and organizational designs for realizing economies of substitution," *Strat. Mgmt. J.*, vol. 16, S1, pp. 93–109, 1995, doi: 10.1002/smj.4250160919.

[59] M. Pellicelli, "Chapter five—managing the supply chain: Technologies for digitalization solutions," in *The Digital Transformation of Supply Chain Management*, M. Pellicelli, Ed.: Elsevier, 2023, pp. 101–152.

[60] F. Steiner, R. T. Tarman, J. C. Ihl, and F. T. Piller, "Learning from the customer: Identifying changing user needs during product usage through embedded toolkits for user innovation," in *PICMET '09 - 2009 Portland International Conference on Management of Engineering & Technology*, 2009, pp. 706–716.

[61] E. Permin, T. Vollmer, D. Grunert, and R. Schmitt, "Creating digital products in engineering companies—a practitioner's review," *Procedia CIRP*, vol. 100, pp. 205–210, 2021. doi: 10.1016/j.procir.2021.05.056

[62] A. Martini, B. T. Laugen, L. Gastaldi, and M. Corso, "Continuous innovation: towards a paradoxical, ambidextrous combination of exploration and exploitation," *IJTM*, vol. 61, no. 1, p. 1, 2013. doi: 10.1504/IJTM.2013.050246

[63] F. Guo, Y. Ding, W. Liu, C. Liu, and X. Zhang, "Can eye-tracking data be measured to assess product design?: Visual attention mechanism should be considered," *International Journal of Industrial Ergonomics*, vol. 53, pp. 229–235, 2016. doi: 10.1016/j.ergon.2015.12.001

[64] S. Denning, "Why Agile can be a game changer for managing continuous innovation in many industries," *Strategy & Leadership*, vol. 41, no. 2, pp. 5–11, 2013. doi: 10.1108/10878571311318187

[65] J. Lee and H.-A. Kao, "Dominant innovation design for smart Products-Service Systems (PSS): Strategies and case studies," in *Proc. 2014 Annual SRII Global Conference*, 2014, pp. 305–310.

[66] M. A. Khan and T. Wuest, "Upgradable product-service systems: Implications for business model components," *Procedia CIRP*, vol. 80, pp. 768–773, 2019. doi: 10.1016/j.procir.2019.01.091

[67] S. S. Shang, S.-H. Wu, and C.-Y. Yao, Eds., *A Dynamic Innovation Model for Managing Capabilities of Continuous Innovation*, IEEE, 2008.

[68] R. E. Cole, "From Continuous Improvement to Continuous Innovation," *Quality Management Journal*, 2001, vol. 8, no. 4, pp. 7–21

[69] M. Inoue, S. Yamada, T. Yamada, and S. Bracke, "A design method for product upgradability with different customer demands," in *IFIP Advances in Information and Communication Technology, Product Lifecycle Management for a Global Market*, S. Fukuda, A. Bernard, B. Gurumoorthy, and A. Bouras, Eds., Berlin, Heidelberg: Springer Berlin Heidelberg, 2014, pp. 91–100.

[70] G. Schuh, M. Riesener, C. Doelle, and S. Brockmann, "Evaluation of the effects of activity deviations onto a development project's target dimensions," in *Proc. 2017 Portland International Conference on Management of Engineering and Technology (PICMET)*, 2017, pp. 1–6.

[71] F. M. Washko, "Segmented innovation to drive interdisciplinary design efforts," in *Proc. 2016 International Conference on Advanced Materials for Science and Engineering (ICAMSE)*, 2016, pp. 565–568.

[72] A. Brennan and L. Dooley, "Networked creativity: A structured management framework for stimulating innovation," *Technovation*, vol. 25, no. 12, pp. 1388–1399, 2005. doi: 10.1016/j.technovation.2004.08.001

[73] D. G. Broo and J. Schooling, "A framework for using data as an engineering tool for sustainable cyber-physical systems," *IEEE Access*, vol. 9, pp. 22876–22882, 2021. doi: 10.1109/ACCESS.2021.3055652

[74] N. Salim, A. Rahman, M. Nizam, D. A. Wahab, and A. A. Muhamed, "Influence of social media usage on the green product innovation of manufacturing firms through environmental collaboration," *Sustainability*, vol. 12, no. 20, p. 8685, 2020.

[75] S. Walker, "Object lessons: Enduring artifacts and sustainable solutions," *Design Issues*, vol. 22, no. 1, pp. 20–31, 2006. doi: 10.1162/074793606775247763

[76] L. Sun, L. Zhang, and Y. Li, "Sustainable decisions on product upgrade confrontations with remanufacturing operations," *Sustainability*, vol. 10, no. 11, p. 4090, 2018. doi: 10.3390/su10114090

[77] M. S. Jørgensen and A. Remmen, "A methodological approach to development of circular economy options in businesses," *Procedia CIRP*, vol. 69, pp. 816–821, 2018. doi: 10.1016/j.procir.2017.12.002

[78] C. J. Velte, K. Scheller, and R. Steinhilper, "Circular economy through objectives—development of a proceeding to understand and shape a circular economy using value-focused thinking," *Procedia CIRP*, vol. 69, pp. 775–780, 2018. doi: 10.1016/j.procir.2017.11.031

[79] S. Kondoh, Y. Umeda, and H. Yoshikawa, "Development of upgradable cellular machines for environmentally conscious

products," *CIRP Annals*, vol. 47, no. 1, pp. 381–384, 1998. doi: 10.1016/S0007-8506(07)62856-X

[80] M. Howard, P. Hopkinson, and J. Miemczyk, "The regenerative supply chain: A framework for developing circular economy indicators," *International Journal of Production Research*, vol. 57, no. 23, pp. 7300–7318, 2019.

[81] A. Lanzotti, P. Tarantino, and J. J. Dahlgaard, "Kansei engineering approach for total quality design and continuous innovation," *The TQM Journal*, vol. 20, no. 4, pp. 324–337, 2008. doi: 10.1108/17542730810881311

[82] P. Leitao *et al.*, "Integrating standardization in research and innovation projects: The GO0DMAN experience," in *Proc. 2022 IEEE 31st International Symposium on Industrial Electronics (ISIE)*, 2022, pp. 1147–1152.

[83] K. G. Grunert and H. C. M. Trijp, "Consumer-oriented new product development," in *Encyclopedia of Agriculture and Food Systems*, N. K. van Alfen, Ed., Oxford: Academic Press, 2014, pp. 375–386.

[84] J. Matthews and S. Bucolo, "Continuous innovation in SMES: How design innovation shapes business performance through doing more with less," in *Proc. 12th International CINet Conference-Continuous Innovation: Doing More with Less*, 2011, pp. 696–708, 2011.

[85] J. Lin, "Creativity engineering for continuous and discontinuous innovation," in *Proc. 2006 Technology Management for the Global Future - PICMET 2006 Conference*, Istanbul, Turkey, 2006, pp. 767–777.

[86] C. Hepperle, F. Lachner, M. Mortl, and U. Lindemann, "Compatibility evaluation of future product concepts," in *Proc. 2012 18th International ICE Conference on Engineering, Technology and Innovation*, 2012, pp. 1–10.

[87] S. S. Durmuşoğlu, R. J. Calantone, and R. C. McNally, "Ordered to innovate: A longitudinal examination of the early periods of a new product development process implementation in a manufacturing firm: Examination of early-period NPD process implementation," *J Prod Innov Manag*, vol. 30, no. 4, pp. 712–731, 2013. doi: 10.1111/jpim.12016

[88] V. Salminenl and J. Tammela, "Leadership for Life Cycle Business Transition by Hybrid Innovation," in *Proc. 2007 IEEE International Technology Management Conference (ICE)*, IEEE, 2007, pp. 1–6.

[89] G. Fantoni, A. Bifulco, and R. Santoro, "Problem classes and collaborative methods: A new approach to product innovation," in *Proc. 2006 IEEE International Technology Management Conference (ICE)*, 2006, pp. 1–8.

[90] J. F. Gieskes and P. W. Hyland, "Learning barriers in continuous product innovation," *IJTM*, vol. 26, no. 8, p. 857, 2003. doi: 10.1504/IJTM.2003.003394

[91] C. Fuchs and T. Gutmann, "How technical market segmentation can help build products your customers really need," *IEEE Engineering Management Review*, vol. 50, no. 1, pp. 17–19, 2022. doi: 10.1109/EMR.2022.3140715

[92] C. Berggren, "The cumulative power of incremental innovation and the role of project sequence management," *International Journal of Project Management*, vol. 37, no. 3, pp. 461–472, 2019. doi: 10.1016/j.ijproman.2019.01.014

[93] B. Lianto, M. Dachyar, and T. P. Soemardi, "Modelling the continuous innovation capability enablers in Indonesia's manufacturing industry," *Journal of Modelling in Management*, vol. 17, no. 1, pp. 66–99, 2022. doi: 10.1108/JM2-04-2020-0103

[94] K. Hribernik, W. F. Vegte, D. Kiritsis, and K.-D. Thoben, "Towards a methodology for selecting product usage information sources for the (re-)design of product service systems," in *Proc. 2016 International Conference on Engineering, Technology and Innovation/IEEE lnternational Technology Management Conference (ICE/ITMC)*, 2016, pp. 1–6.

[95] Y. Xu, D. E. Ribeiro-Soriano, and J. Gonzalez-Garcia, "Crowdsourcing, innovation and firm performance," *Management Decision*, vol. 53, no. 6, pp. 1158–1169, 2015. doi: 10.1108/MD-06-2014-0408

[96] I. Nonaka, K. Sasaki, and M. Ahmed, "Continuous innovation in Japan: the power of tacit knowledge**this chapter is an extended version of an article originally published in Ark group's knowledge management magazine," *The International Handbook on Innovation*, Oxford: Pergamon, 2003, pp. 882–889.

[97] M. Corso and L. Pellegrini, "Continuous and discontinuous innovation: Overcoming the innovator dilemma," *Creativity and Innovation Management*, vol. 16, no. 4, pp. 333–347, 2007. doi: 10.1111/j.1467-8691.2007.00459.x

[98] G. Schuh, S. Schmitz, G. Lukas, L. Niwar, M. Welsing, and R. Calchera, "Ordnungsrahmen für eine zirkuläre Produktionswirtschaft," in *Empower Green Production: Tagungsband Aachener Werkzeugmaschinen Kolloqium (AWK)*, T. Bergs, C. Brecher, R. Schmitt, and G. Schuh, Eds., Aachen, 2023, pp. 306–335.

[99] E. Chierici, G. Copani, T. Tolio, S. Cavalieri, G. Pezzotta, and E. Ceretti, "Remanufacturing with upgrade PSS for new sustainable business models," *Procedia CIRP*, vol. 47, 2016. doi: 10.1016/j.procir.2016.03.055

[100] S. Yamada, T. Yamada, S. Bracke, and M. Inoue, "Upgradable design for sustainable manufacturer performance and profitability and reduction of environmental load," *International Journal of Automation Technology*, vol. 10, no. 5, pp. 690–698, 2016. doi: 10.20965/ijat.2016.p0690

[101] V. V. Agrawal, A. Atasu, and S. Ülkü, "Modular Upgradability in consumer electronics: Economic and environmental implications," *Journal of Industrial Ecology*, vol. 20, no. 5, pp. 1018–1024, 2016. doi: 10.1111/jiec.12360

[102] A. Martensen and J. J. Dahlgaard, "Strategy and planning for innovation management-supported by creative and learning organisations," *Int J Qual & Reliability Mgmt*, vol. 16, no. 9, pp. 878–891, 1999. doi: 10.1108/02656719910289177

[103] H. Latan, C. J. C. Jabbour, A. B. L. S. Jabbour, P. C. Fiorini, and C. Foropon, "Innovative efforts of ISO 9001-certified manufacturing firms: Evidence of links between determinants of innovation, continuous innovation and firm performance," *International Journal of Production Economics*, vol. 223, p. 107526, 2020.

[104] G. Schuh, A. Gützlaff, S. Cremer, J. Lammersmann, and Y. Liu, "Business model and organization—interdependencies for customer-centric continuous innovation in subscription business," in *Proc. 2020 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM)*, 2020, pp. 260–264.

[105] S. Tyagi, X. Cai, K. Yang, and T. Chambers, "Lean tools and methods to support efficient knowledge creation," *International Journal of Information Management*, vol. 35, no. 2, pp. 204–214, 2015. doi: 10.1016/j.ijinfomgt.2014.12.007

[106] N. Casalino, B. Borin, G. Pizzolo, and S. Cavallini, "Automation, technology transfer and managerial practices for organizational growth of SMEs. A smart curriculum for competitiveness," in *Proc. 2019 IEEE Global Engineering Education Conference (EDUCON)*, 2019, pp. 1534–1541.

[107] B. Nicoletti, "Lean and digitized innovation," in *Proc. 2014 International Conference on Engineering, Technology and Innovation (ICE)*, 2014, pp. 1–7.