

Doctoral School of Regional Sciences and Business Administration

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Selection of appropriate lead users for NPD in cocreation: further development of the lead user method in the context of medical device innovations

Doctoral dissertation

(short summary)

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1. Problem statements – research questions

Successfully innovating firms involve lead users in their new product development (NPD) process as these "leading-edge users" (von Hippel, 1986) are an important source of breakthrough and commercially attractive innovations.

Involving the right users in the NPD process is particularly challenging as the contribution of individuals varies strongly because their personal characteristics differ significantly (Lettl, 2007a; Füller *et al.*, 2012). While the lead user method aims to identify lead users based on their two general attributes of 'ahead of market trend' and 'high expected benefit', it does not consider explicitly the personal characteristics of the users. Consequently, the identification process of the method does not determine lead users' ability for successful co-creation with producer firms.

The question emerges: how to select appropriate lead users for a co-created NPD? **Hiba! A hivatkozási forrás nem található.**. demonstrates the research problem of the dissertation. The left side of the figure shows the principle of lead user identification based on the traditional lead user concept (available knowledge).



Source: own compilation

Figure 1. Demonstrating the available and new knowledge

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In our first paper, we performed a systematic literature review and concluded that the personal characteristics of lead users play a crucial role in achieving success in the NPD process. Based on the research results we had a strong argument to extend the lead user method with a partial method named "lead user cognition method".

In our second article, we identified six personal characteristics of lead users and their impact on the success of the co-created NPD process as well as on the technical and market success of the new product. We find that lead users need to be involved in the whole NPD process irrespective of the complexity of the new product.

Based on the research results we advanced the original lead user method by linking the identified six characteristics to the general attributes of lead users as "ahead of market trends" and "high expected benefit".

Our study reveals managerial implications by proposing signals for practices that facilitate the selection process of proper lead users in the fuzzy front end of the co-creation and therefore reduce uncertainty, cost, and time of the NPD.

1.1. Facing uncertainty in the selection process of proper lead users for co-creation

Scholars state that success in innovation "can only be achieved if the right number of the right people are prepared to collaborate with each other" (Boer, Kuhn and Gertsen, 2006, p. 9). "Selecting right user profiles, helps developers to set priorities and design with the most important groups of users in mind" (Abrell, Benker and Pihlajamaa, 2017, p. 9). Furthermore, studies stress the importance of selecting the right user profiles for product development (Gruner and Homburg, 2000; Schweitzer, Gassmann and Rau, 2014; Abrell *et al.*, 2016; Abrell, Benker and Pihlajamaa, 2017).

Scholars investigate lead users' personal characteristics in different industrial and consumer contexts and related to various products. They found various user characteristics such as imagination capabilities, openness to new technologies, high level of expertise and technological competencies (LaBahn and Krapfel, 2000; Lettl, 2007; Hoffman, Kopalle and Novak, 2010; Gürkan, 2014). (Schreier and Prügl, 2008) found that use knowledge, product familiarity, locus of control and innovativeness are important

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antecedents of lead userness. Other studies underline the importance of tacit ("local") knowledge (Lüthje, 2004; Lüthje, Herstatt and Von Hippel, 2005). (Füller, Jawecki and Mühlbacher, 2007) find a positive impact of willingness, task motivation, creativity components, and product-relevant knowledge. (Faullant *et al.*, 2012) state that individuals' creativity and personality play an important role in the determination of lead userness.

In other words, improper or ostensible customers with missing essential personal characteristics might lead to an unsuccessful new product development process (Schemmann, Chappin and Herrmann, 2017) and thus end up in failed innovation (Scaringella, 2017).

As the personal characteristics of lead users influence the success of the co-creation, therefore the proper understanding of lead users' characteristics and their impact on the success of the NPD process are essential to select appropriate lead users. The relevance of the problem is also underlined by the evidence that right lead users facilitate the successful collaboration between the external contributor and internal employees (engineers, product owners, etc.).

Even though published peer-reviewed papers investigate the human side of lead users the examinations are performed in different contexts (industrial and consumer), investigate various types of collaboration (idea exchange, partial involvement into NPD), and interpret co-creation in various senses. In order to gain a comprehensive overview of the existing knowledge related to the personal characteristics of lead users we carried out a systematic literature review (SLR) by answering the followings research question:

RQ1: What lead users' personal characteristics should be accounted by decision-makers in the selection process of lead users by considering each stage of the NPD process and the differences between the consumer and industrial segments?

1.2.Considering the level of lead users' involvement in the NPD process

The research result of our first article demonstrated that published articles investigate lead users' personal characteristics mainly related to the fuzzy front end of the NPD process. The findings of our review shed light on a research gap because co-creation is regarded as a process wherein users are the central and essential part of the new product development (Cooper 1993; O'Hern & Rindfleisch 2010). In such collaboration the participation of users is not limited only to the idea generation phase as they actively participate in the idea generation, concept formulation, product development and test, market diffusion and postlaunch activities (Hoyer et al, 2010).

The participation of lead users in the whole process is especially important to exploit their need-, and solution knowledge by considering the fact that lead users' knowledge is likely to be tacit (von Hippel, 1998; Dreyfus, 2004; Venesz, Dőry and Raišienė, 2022) and therefore "sticky" (Lüthje, Herstatt and Von Hippel, 2005), and in addition, the articulation of such "personal knowledge" is difficult (Polanyi, 1958). If the participation of lead users is restricted only to the idea generation phase, then it is very challenging or might be impossible to understand lead users' need-, and solution knowledge by the producer firm in the initial workshop (Churchill, von Hippel and Sonnack, 2009) or by applying different online tools (Franke and Hippel, 2003; Piller and Walcher, 2006). Our SLR demonstrated among other conclusions that a lack of academic literature is available that investigates the required level of lead users' involvement in various stages of the NPD, and additionally how different characteristics influence the success of the new product development. In order to fulfil this research gap, and improve our understanding of the impact of personal characteristics of lead users in different stages of the NPD process, we formulated the following research questions:

RQ2: How comprehensively does a lead user need to be involved in the co-created NPD process?

RQ3: How do the different personal characteristics of lead users impact the success of the NPD?

The research employed the results of our first article namely the lead user cognition method which refers to the cognition process of the innovation manager during the selection process of lead users. As the partial method required dedicated settings where the results can be interpreted, we applied it in the context of medical device innovations.

1.3. Difficulty in implementing into practice the two lead users' basic attributes of "ahead of market trend" and "high expected benefit"

Selecting lead users based on their first general characteristic of 'ahead of market trend' "one must identify the underlying trend on which these users have a leading position" (von Hippel, 1986, p. 798). von Hippel state in the same paper that the existence of formal methods ranging from the intuitive judgement of experts to simple trend extrapolations, the "trend identification and assessment remains something of art" and additionally "these perceptions may not be consistent over time" (ibid). Empirical studies emphasize also that it is difficult to select reliable information sources and prioritize pieces of information especially when the knowledge and experience of the experts are highly heterogeneous (Lüthje, Lettl and Herstatt, 2003; Lüthje and Herstatt, 2004). Furthermore, the identification of trends might mislead the management in case of radical innovations. This is based on the argument that in history there were no existing trends to identify in the case of radical innovations like the X-ray machine, statoscope, antibiotics, cardiac defibrillator etc.

Market researchers are familiar with existing trends by taking into account their experience collected in the past (facts), but they might face uncertainty in future market trend prediction (Figure 2.). Consequently, and in reference to the above reasoning, it might be difficult to predict market trends accurately and thus we concluded that it is uncertain to select lead users based on their general attribute of "ahead of market trend".





Source: own compilation

The second lead users' general characteristic of "high expected benefit" refers to the benefit by obtaining the solution. Despite the evidence that some users developed most of the commercially successful product innovations (von Hippel, 1986), empirical studies show that the identification process of lead users is rather weak (Lüthje and Herstatt, 2004) based on the unmeasurable manner of "high expected benefit".

In order to eliminate the weakness of the two general characteristics of lead users and additionally link our research results (new knowledge) to the two basic attributes of lead users (existing knowledge) we set the following research question:

RQ4: How can the identified personal characteristics elements be linked to the general attributes of lead users as "ahead of market trend" and "high expected benefit"?

2. Contribution

2.1. Selecting appropriate lead users: the lead user cognition method

Our first article answers RQ1 which is "what personal characteristics of lead users' managers need to consider in the selection process of lead users by considering each stage of the NPD process and the differences between the consumer and industrial segments?"

In order to respond to the research question as well as fulfil a research gap, we performed a systematic literature review to provide an overview of lead users' personal characteristics in different stages of the NPD in the case of co-creation. 45 primary studies were found by employing automatic and manual search processes, applying inclusion and exclusion criteria, and conducting a quality assessment process (Figure 3.). The selected studies have been organized into two categories, e.g., consumer and industrial contexts, as they provided the key research settings of the studies. The findings were organised into each stage of the NPD process including 1. idea generation, 2. concept formulation, 3. prototype and product development and testing stages, and 4. market diffusion.



Figure 3. Flow diagram of the search and selection process

Source: own compilation

We found that most of the studies focus only on the idea generation stage of the NPD, and they discuss mainly the personal characteristics of lead users only in connection with the fuzzy-front-end phase of the new product development process. Consequently, a limited number of studies were found which discuss the characteristics of users at the later stages of NPD. Our finding indicated that firms generally rely on their own technical expertise and do not require any additional contributions from users or cooperate with users only with high technological competencies and involve them in the product development phase.

The identified 45 primary papers were highly heterogeneous in terms of the contexts of investigation (consumer or industrial), type of users (user or customer), level of users' involvement (only in the fuzzy front end of the process or subsequent stages of the NPD) and type of corresponding products like kite surfing (Franke, von Hippel and Schreirer, 2006), basketball shoes (Füller, Jawecki and Mühlbacher, 2007), mountain bikes (Lüthje, Herstatt and Von Hippel, 2005), industrial products (LaBahn and Krapfel, 2000). We found additionally that the characteristics of the external contributors strongly vary, and different user characteristics are needed in the different market contexts and additionally, different characteristics are needed at different stages of the NPD. No studies were found that investigate the needed elements at the market diffusion stage of the NPD.

The result of our first paper indicated that the personal characteristics of lead users play a crucial role in NPD process

of producer firms, but the level of users' involvement and the required characteristics vary in different stages of the NDP. We found additionally that the identification process (step III.) of the lead user method is not suitable to select the right lead users as it does not consider explicitly the personal characteristics of lead users. Therefore, we elaborated the lead user method and included an additional step that aims to select the right external contributors by considering their personal characteristics as enable factors of the successful co-creation process. The importance of the extension is based on the evidence that the proper selection of lead users for co-creation might reduce the innovation-related costs and the time-tomarket ratio besides increasing the quality of the new product.

Based on the above reasoning we made a contribution to the lead user method by extending it with a partial method called "lead user cognition" which is an additional step between the stages of "identification of lead users" and "concept design and start of co-creation as Figure 4. shows. The lead user cognition method refers to the cognition process of decisionmakers during the selection of lead users by taking into account their personal characteristics.





Source: own compilation

2.2. Identifying the impact of lead users' characteristics in each stage of the NPD process

To answer RQ2 (What personal characteristics can be associated with lead users and how do they impact at each stage of the NPD process?) we performed a case study at five medical device developers and manufacturer firms. We applied an abductive approach to eliminate the weaknesses of inductive and deductive reasoning by using both induction and deduction cyclically.

We employed theoretical sampling of companies to enable a clear pattern recognition of the focal phenomenon and that provides a strong base for theory building (Eisenhardt and Graebner, 2007). We selected five case companies that develop and manufacture medical devices, and are active participants in the global market, co-create with lead users in their NPD process and the new product fulfils our applied term of innovation. We used systematic combining where we evolved simultaneously the theoretical framework, fieldwork and case analysis. The outcome of our investigation might result in unexpected lead users' personal characteristics, leading in turn to the modification or extensions of our propositions. The process of systematic combining collaborated with the used abductive reasoning through a highly iterative process between theory and practice which co-evolved our initial propositions and conceptual framework (Dubois *et al.*, 2002). We conducted our interviews in three phases. In the first phase, we aimed to collect data, in the second step to verify our interpretations of the required characteristics of lead users and also identify their level of impact on different stages of the NPD, while in the third phase to embed our results in an existing theoretical framework of lead user cognition.

The main findings of our research refer to the relevance of six personal characteristics of lead users in achieving technical and market success of a new product and also their impact on each stage of the NPD process. In our analysis lead users were homogenous regarding their successful contribution to the new product development and concerning their characteristics including 1. expert level of domain related-knowledge, 2. high-level technical knowledge, 3. experimentation mindset, 4. social and professional connectedness, 5. status of formal authority, 6. high communication skills and collaborative attitude. Our study yields more specific insights to understand the level of lead users' knowledge by employing the "Novice to Expert" model (Dreyfus and Dreyfus, 1980; Dreyfus, 2004). We found that appropriate lead users are able to deal with complexity, able to determine and focus on significant aspects of the problem, able to create an innovative vision for a solution without effort and rely on their intuition to solve a problem without thinking of which principle, skill or theory to use.

In contrast with the existing literature that concluded the various degree of lead user involvement in the NPD (von Hippel, 1986; Gruner and Homburg, 2000; Brockhoff, 2003; Enkel, Perez-Freije and Gassmann, 2005) our findings suggest that it is essential to involve lead users to each phase of new product development as each characteristic is essential in all stages of the NPD process to reach technical and market success of the new product.

Table 1. demonstrates how each characteristic contributes to the success of the NPD process. We set three impact levels of each characteristic at different stages of the NPD. We judged the impact of certain personal characteristics as *high* (green highlighted fields) when the average score was between four and five inclusive of both values; *moderate* (blue highlighted fields) when the average score was between three and four inclusive of both values; *low* (no highlight) below the score of three.

Our findings indicated a further novel insight as we found that there is no difference in the impact of the characteristics at different product complexities. It means that all characteristics of lead users are essential to achieve success of the NPD in the case of low as well as high-complexity products.

In order to ease the selection of proper lead users, we identified signals that enable innovation managers to apply our research results in their practice. We avoided applying unmeasurable signals like "tacit knowledge", "creativity" or "imagination capability" etc. which are not tangible, non-measurable and thus have no managerial implications. All signals shall be taken into consideration as a set of elements during the initial discussion with lead users.

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		A	4	4	4	4	5	2
IM PACT on the product development stage	AVG		2,8	2,4	3	2,8	2,1	3,5
	Firm	ш	3	3	4	4	2	4
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		C	4	2	3	2	1	2
		В	1	1	1	1	1	5
		A	4	4	4	4	5	2
IM PACT on the idea generation and concept formulation stage	AVG		4,8	3,2	4,4	4	2,6	4,5
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ess	AVG		4,2	3,2	3,2	3,7	4,6	4,6
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		Characteristics / scores by firms and average	xpert level of rofessional knowledge	ligh level technical n owledge	xperimenter mindset	ocial and professional onnectedness	ormal authority	ollaboration attitude nd communications

Table 1. Response sheet including the impact of each characteristic

Source: own compilation

2.3. Linking new knowledge to existing knowledge

In order to answer the RQ3 we proposed a different approach to identify and select proper lead users for co-creation by employing the following line of argumentation. According to Pham, Lee and Stephen (2012) the intuitive feelings of experts are better able to predict future market trends. Moreover, Hogarth (2005) states that the intuitive form of judgment outperforms the analytical processes where the analytical complexity is high, and where it is difficult to identify any single formal rule that has high predictive validity. Furthermore, individuals with expert level knowledge will more likely to discover an innovation opportunity than others (Shane, 2000).

Consequently, we state that lead users with 1. expert level of domain-related knowledge (need knowledge) and 2. highlevel technical knowledge (solution knowledge), and 3. market familiarity (derived from social and professional connectedness) are better able to predict market trends than traditional trend assessment methods or internal/external market researchers

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The second general characteristic of lead users is the "high expected benefit" which refers to the benefit by obtaining the solution (von Hippel, 1986). The expected benefit triggers users' motivation to develop early prototypes and perform cycles of experimentation. The tacit-to-tacit conversion of solution knowledge assumes a high level of willingness to collaborate with product engineers (learning by doing), while explicit-to-explicit knowledge conversion requires the personal effort to share ideas informally through personal discussions and storytelling (Collins, 2001). The status of formal authority and social and professional connectedness might be considered as a facilitator in the process of obtaining high expected benefits. Based on the above line of reasoning we conclude that the high expected benefit of lead users might be associated with their personal characteristics including 1. experimenter mindset. 2. professional social and connectedness, 3. status of formal authority, 4. collaboration attitude and communications skills (Figure 5.).

In order to increase the efficiency of the lead user concept, we elaborated the method by adapting the "lead user cognition" partial method in the context of medical device innovations and integrated our findings in the selection phases of the partial method and linked the characteristics to the general attributes of lead users as "ahead of market trends" and "high expected benefit".

In sum properly selected lead users fulfil both requirements of being "ahead of market trends" and fulfilling their "high expected benefit" besides providing a meaningful contribution to the success of an NPD process.



Figure 5. Elaboration of the lead user method

Source: own compilation

2.4. Key results and thesis

The key results of the dissertation are summarized in the following points. The key results (thesis) of the Dissertation are considered as the overall conclusion of the Dissertation and also the corresponding answers to each research question (RQ1-RQ4).

Key results:

The overall conclusion of the Dissertation is described in the first and second points, while the main findings related to each research question are summarized afterwards in points 4, 5 and 6.

- 1. The personal characteristics of lead users have an impact on the technical and market success of the cocreated NPD process therefore they shall be considered during the selection process of lead users for the co-created NPD.
- 2. As the lead user method does not consider the personal characteristics of lead users in the identification process, the *"lead user cognition method"* aims to resolve this weakness by proposing a partial method

which is embedded as an additional step in the lead user method. The *lead user cognition method* refers to the cognition process of the decision maker during the selection process of appropriate lead users for the cocreated NPD process.

As the lead user cognition method shall be interpreted in a dedicated context, the results of the second paper (the characteristic set of an appropriate lead user) shall be understood in the context of medical device innovations.

3. Diverse characteristics are required at different stages of the co-created NDP and the required characteristics vary in the consumer and industrial context.

The key result No. 3 answeres RQ1 as "What lead users' personal characteristics should be accounted by a decision maker in the selection process of lead users by considering each stage of the NPD process and the differences between the consumer and industrial segments?" The identified characteristic elements are demonstrated in Figure 4.4. and Table 4.7. and the differences between the industrial and consumer segments are shown in Table 4.8. The systematic literature review through the resulting 45 primary studies

provided a great overview of the required personal characteristics elements at different phases of the NPD and the results also emphasized that firms involve lead users mainly in the ideation phase of the NPD.

4. Lead users must be involved in each stage of the cocreated NPD process regardless of the complexity of the new products.

The key result of No. 2 answers RQ2 as "*How* comprehensively does a lead user need to be involved in the co-created NPD process?" The findings are shown in Table 6.2. which belongs to the results of the second research paper.

5. Each of the identified six personal characteristics of lead users makes a diverse impact at different stages of the co-created NPD in the process of reaching the technical and market success of the new product.

The above key result answers RQ3 as "How do the different personal characteristics of lead users impact the success of the NPD?" The identified characteristics are discussed in the second research paper and the results are shown in Figure 5.1. The results are crucial for decision-makers to consider the intensity of lead user involvement in the NPD.

6. The first general attribute of "ahead of market trend" can be determined by the following characteristics elements of lead users 1. expert level of domain-related knowledge (need knowledge), 2. high-level technical knowledge (solution knowledge), 3. market familiarity (derived from social and professional connectedness). These elements make lead users capable of being "ahead of market trend" and demonstrate their *capability for innovation*.

The second general attribute of "high expected benefit" can be determined by characteristic elements of 1. experimenter mindset, 2. social and professional connectedness, 3. status of formal authority, and 4. collaboration attitude and communications skills. These elements demonstrate lead users' "high expected benefit" and demonstrate their *motivation for innovation*.

The key results No. 4 and No. 5 answer RQ4 as "How can the identified personal elements be linked to the

general characteristics of lead users as "ahead of market trend" and "high expected benefit"?" The reference between the original two attributes and the identified characteristics demonstrates how the new knowledge (research results) advances the existing knowledge (lead user concept and method).

2.5. Limitations and future research

Our study is subject to limitations that might impact the research findings. In our case study, we employed a qualitative research method. We have not examined the case when multiple lead users participate in the NPD process as it sets up a different situation and might require other or additional characteristics elements from the participants. Another limitation is that we performed our investigation in the dedicated context of medical device innovations. In our research, we examined the selection problem from the perspective of the innovation manager.

Further research might apply quantitative research methods and other approaches in order to confirm our findings. The investigation of multiple lead users in the same lead users involved in NDP might open new research opportunities. The different contexts might require a different set of personal characteristics, which proposes an interesting future research agenda. Further research might examine the perspective of lead users by answering the question: how to select an appropriate firm for co-created NPD?

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- Venesz, B., Dőry, T. and Raišienė, A.G. (2022) 'Characteristics of Lead Users in Different Stages of the New Product Development Process: A Systematic Review in the Context of Open Innovation', *Journal of Open Innovation: Technology, Market, and Complexity*, 8(1). doi:https://doi.org/10.3390/joitmc8010024.
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- Venesz, B. and Dőry, T. (2021) 'Essential Characteristics of Lead Users at Different Stages of the New Product Development Process', in. 18th International Open and

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