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A Conceptual Model of the Revised CAI-NPD-Systems Maturity

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Abstract

This article aims to turn the attention of researchers and practitioners in the innovation and engineering management field towards a more fine grained view on the influence of Information Technologies (IT) and New Product Development (NPD) capabilities on innovation outcomes in different stages of maturity. Computer Aided Innovation (CAI), as a specific but often overlooked category of IT-tools for innovation activities, is introduced as having the potential to positively influence the innovation supporting capabilities. Based on current and emerging developments in the fields of CAI and NPD, a revised version of the conceptual model of the CAI-NPD-systems maturity framework is proposed.

Keywords: computer aided innovation, maturity model, new product development

1. Introducation

Innovation generating activitites is also known as New Product Development (NPD). NPD could be definded independent of industry factors as an information processing activity where individuals and teams obtain interdisciplinary information about customer, technologies, competitors, and resources, and translate this information into product designs to be then transformed into new products or services (Kleinschmidt, De Brentani, & Salomo, 2010). Developing new products is a complex process that usually involves many functional groups within an organization as well as external groups in global markets, a setting that is often widely dispersed functionally, geographically, and culturally (Durmusoglu, Calantone, & Sambamurthy, 2006; Kleinschmidt et al., 2010). Thus, communication, collaboration, and coordination, both within the team and between the team, as functional departments and external parties are highly influential for the success of development efforts (Kleinschmidt et al., 2010). However, the success of NPD depends on a variety of factors, and many studies try to illuminate the variables influencing NPD outcomes (Durmusoglu et al., 2006; Cooper, 2001). One factor for potentially advancing NPD outcomes is seen in Information Technology (IT) tools (Nambisan, 2003; Durmuşoğlu & Barczak, 2011; Kawakami et al., 2014). For example, Nambisan (2003) proposes that IT use supports collaboration, coordination, and communication amongst NPD team members or enhances the base of knowledge available to an NPD team, such as computer-mediated communication technologies that facilitate, intensify, or expand the interaction of and communication between employees during NPD task executions such as planning, designing, decision making, or implementing (Song, Berends, van der Bij, & Weggeman, 2007).

However, only limited and partly contradictory empirical research is available concerning the positive effects of IT use on NPD outcomes (Barczak, Sultan, & Hultink, 2007; Durmusoglu et al., 2006; Durmuşoğlu & Barczak, 2011; Kleinschmidt et al., 2010; Nambisan, 2003; Massetti, 1996; Ozer, 2000; Song et al., 2007; Kawakami et al., 2014). Literature research on IT and NPD shows that only a few studies empirically test the relationship between IT and measures of innovation performance. In general the findings empirically support previous contentions that IT enables an innovation capability and yields significant value to firms (Durmuşoğlu & Barczak, 2011; Kleinschmidt et al., 2010). This would offer several implications for NDP practitioners because new product managers could use these results to advocate for greater investments in IT tools to build and extend their firm's innovation capability (Durmuşoğlu & Barczak, 2011). Nevertheless, the research so far largely fails to investigate the influence of specific IT tools such as Computer Aided Innovation (CAI) on new product performance. As Durmuşoğlu and Barczak (2011) indicate, due to the proliferation of IT tools available, it is important for managers to know which IT tools provide value and not that IT tools do so in general. Therefore, more detailed knowledge is needed about which category or class of particular IT tools can serve as levers for improving certain performance metrics of NPD.

In this paper, CAI is introduced as a specific but often overlooked category of IT-tools for innovation activities with the potential to positively influence the innovation capabilities of organizations. Therefore, the development and potential of CAI is outlined and examples are given. In combination with complementary NPD capabilities, a higher degree of innovation capability is expected. Based on current and emerging developments in the fields of CAI and NPD, a conceptual model of the revised CAI-NPD-systems maturity is proposed. This model specifies, combines, and augments existing maturity models in both literature streams and adds basic propositions to be tested in further empirical research. This might reveal if some of the hidden secret weapons in innovation such as TRIZ (Теория решения изобретательских задач or Theory of Inventive Problem Solving) based CAI tools, which firms such as Samsung are said to use frequently (Shpakovsky, Lenjashin, & Kim, 2002; Cascini & Russo, 2007; Altshuller, 1999), really live up to their promises.

2. Computer Aided Innovation: Concept and Potential

2.1 Emergence and Concept of CAI

Computer Aided Innovation (CAI) has undergone significant developments in the past decades (Cascini & Russo, 2007; Hüsig & Kohn, 2009; Kohn & Hüsig, 2007; Leon, 2009; Hüsig & Kohn, 2011). The growing supply of related specific innovation process-supporting software, which helped to introduce new methods into the NPD, gave birth to the CAI category. Historically, CAI emerged from software tools that supported the use of Altschuller's TRIZ method (Schüler-Hainsch, Ulbrich, & Jost, 2006; Cascini & Russo, 2007). TRIZ, the Russian Theory of Inventive Problem Solving (Теория решения изобретательских задач), is gaining recognition, both as a systematic methodology for invention and as a powerful tool for technology forecasting (Cascini & Russo, 2007; Altshuller, 1999). From this perspective, CAI has mainly been associated with software tools such as Innovation Work Bench (Ideation International Inc.), TriSolver or Tech Optimizer (Invention Machine) (Schüler-Hainsch et al., 2006). These software products emerged in the USA in the early nineties and started a wave of software-supported invention methodologies that became increasingly sophisticated over time.

The development of CAI was started from the Fuzzy Front End (FFE) of the innovation process, especially the invention stage; and from an engineering perspective, associated with the IT support of these NPD activities to other CAx technologies (León-Rovira & Ovtcharova, 2007). However, this is not the sole source of the CAI concept and IT support in the innovation context. Other innovation methods such as synectics, mind mapping, and brain storming or innovation management concepts such as stage-gate systems, concurrent engineering, road mapping, and project portfolio methods have also been implemented in software tools. Others such as Waldmannstetter and Hüsig (2009) or Hüsig and Waldmannstetter (2013) have called this subcategory of CAI which addresses especially the innovation management activities IMS (Innovation Management Systems).

Furthermore, some scholars also discussed approaches such as TIM (Total Innovation Management) and ESS (Employee Suggestion Systems) and their relation to the CAI field (Chen, Shao, & Tang, 2009). These software tools basically help to facilitate Employee Suggestion Systems and idea management processes. A good example might be "HYPE Improve" by HYPE Softwaretechnik GmbH that is a comprehensive solution for the management of ideas targeting cost saving opportunities and process improvements. This CAI tool allows for engaging your entire workforce, whether blue or white collar, to participate in an improvement program. In this sense, CAI for ESS is essentially IT-supported Employee-Driven Innovation (EDI). The EDI approach develops research within the fields of learning, innovation and employees at work. It focuses on employees in relation to innovation and learning and vice versa, which distinguishes it from many other conceptualizations of and approaches to innovation, emphasizing an often overlooked driver of innovation, namely the employees and how they engage in various collaborative forms of innovation (Høyrup et al., 2012). Specific patent management software and strategic planning tools for the NPD process add to the growing complexity of the CAI field (Hüsig & Kohn, 2009; Kohn & Hüsig, 2007). Here the tools support patent and strategic management activities such as roadmapping, project or patent portfolio management. To add to this clouded picture, all development trajectories seem to strive for greater integration with their neighboring application and tool areas so that the borders of these development domains might become more blurred in the future.

This discussion and the development of CAI are ongoing and need to be understood better theoretically and empirically. Therefore, a theoretical or empirical conceptualization of CAI is difficult but is at the same time necessary for the integration of these emerging perspectives on CAI. Otherwise, a limited understanding of what kind of IT systems fall under the term CAI and what kind of benefits they can provide means that transparency and communication for CAI products, potential benefits for the users, and the further development of more sophisticated tools suffer.

In this context, specific software tools that support innovation methods and activities that streamline the entire NPD process and guide the project teams through the different information-generating and disseminating activities are defined as CAI. Although arising from the invention stage in the FFE of the NPD process, a comprehensive vision conceives CAI systems that integrate the full innovation process holistically. The final goal of CAI is therefore to support firms throughout the entire innovation process and integrate other IT systems, stakeholder and firm processes (Leon, 2009).

2.2 Potential Benefits of CAI

In order to improve the communication with potential users and support future research and development the potential benefits of CAI are outlined here. In the academic literature, the potential benefits of CAI can be categorized as follows: efficiency, effectiveness, competence, and creativity enhancing (Hüsig & Kohn, 2009).

2.2.1 Efficiency Enhancing

Great potential for improved efficiency can be created in the information and decision-making activities. One way to efficiency is the fast gathering and distribution of relevant information and knowledge in innovation processes. Usually, IT tools assist the integration, modification, and transmission of data and information more than non-computer-aided methods. Efficiency can be enhanced by CAI tools, wherever large amounts of data and information need to be processed in idea management processes or idea campaigns inside and outside of organizations (Hüsig & Kohn, 2011). Moreover, a highly skilled work force can be freed from routine work by delegating it to less expensive colleagues or is even delegated further to the user via crowdsourcing. Less experienced engineers might get faster results by the guidance of CAI supported method use such as TRIZ. Ideally, the input of data and information needs to be done digitally only once so that no media breaks occur. If integrated and centralized, the information in the innovation process is easier to update and is consistently and ubiquitously accessible, which potentially lowers the transaction costs and saves search time. If all information is stored digitally, the danger of disruptions in the media flow might be reduced and transmission errors are easier to avoid. Furthermore, the speed and scope of transmission might be greater. Furthermore, many CAI tools also offer functions to automate the generation of reports, documentations, or analysis, which increases the productivity of the user. Moreover, CAI products can support standardized decision procedures and decision gates, which help to structure the NPD process efficiently. This helps to formalize decision criteria once for all NPD-projects without much need to redefine them for each NPD-process individually.

2.2.2 Effectiveness Enhancing

Besides efficiency enhancing potentials, CAI has also the potential to enhance decision making by improving the quality, transparency, accuracy, and timeliness of the information provided. Different scenarios and more alternatives can be considered, which improves the richness of the information as well as the rationality of the decisions and further reduces uncertainty. Moreover, more advanced methods for inventing, idea generation, selection, evaluating, and analyzing technological, competitor, or customer information are facilitated by CAI tool support. Better management and methods—that rely on CAI support—might improve the quality of ideas, inventions, product concepts and business plans/cases. Less experienced engineers might get better invention results by the guidance of CAI supported method use such as TRIZ. Finally, effectiveness is enhanced by the capacity of several CAI tools to aggregate, structure, and visualize information, which contributes to the reduced complexity and clarity of large amounts of information.

2.2.3 Competence Enhancing

The NPD-processes become more understandable and accepted within the firm by the use of CAI tools since the transparency of processes is supported. Additionally, knowledge about innovation and management methodology within CAI suppliers can be transferred to the users. The implemented knowledge of many CAI-supported methods enables less proficient customers to apply more sophisticated methodology with less effort. E.g. less experienced engineers start to be enabled to use methods such as TRIZ by the guidance of CAI support. Some methods rely on the use of dedicated CAI tools to accumulate the collected data and perform the sometimes-complex calculations necessary. Characteristically, the knowledge transfer by the CAI suppliers is permanent since updates and new versions provide the latest advances in the specific knowledge area and foster individual and organizational learning. Additionally, the transfer of solution or need information and interaction with external stakeholders or communities can be supported by Open CAI 2.0 solutions that potentially improve the learning rate in the NPD (Awazu et al., 2009; Hüsig & Kohn, 2011).

2.2.4 Creativity Enhancing

CAI often specifically aims at improving the creativity in the FFE, which is a key to innovation success. Several studies have supported a positive effect of software support for creative activities such as idea generation by assisting in the recording, recalling, and reconstructing of knowledge in creative processes (Massetti, 1996; Marakas & Elam, 1997; Aiken & Vanjani, 1996). Beyond the stimulation of creativity, new information channels can be opened by lowering barriers for idea submission and simplifying the integration of external actors and institutions in the ideation process (Awazu et al., 2009).

2.2.5 Conclusion

These potential benefits of CAI need to be seen in context to be fully exploited and understood. In order to do so, the CAI-NPD-systems maturity model is further developed and used as theoretical underpinning for the development of a conceptual framework to further research the potential benefits of CAI.

3. The CAI-NPD-Systems Maturity Model Revised

Scholars in process management and information systems have developed a long tradition of analyzing the development of IT usage or process capabilities using what are known as maturity or stage models (Humphrey, 1989; Nolan, 1973). Maturity models typically consist of a structured collection of elements that describe certain aspects of maturity in an organization. A maturity model can be used as a benchmark to assess different organizations for comparison and is frequently organized in hierarchical stages or levels. In the area of NPD systems, similar approaches were proposed by Cooper (1994, 2001), McGrath (1996), Essman and Du Preez (2009), and Enkel, Bell, and Hogenkamp (2011). For the additional progress in the CAI field, these models could be essential for the formative stage of the knowledge formation in the CAI area in three ways: first, CAI-NPD maturity models could offer a direction for future strategies of both CAI suppliers and developers, and direct buying or implementing decisions by users. In this regard, these frameworks would allow forecasting the future development of CAI and NPD systems described by Hüsig (2011), Waldmannstetter and Hüsig (2009) or Hüsig and Kohn (2009). Second, these models are also interlinked with the process and management aspects of NPD, thus emphasizing a more holistic approach to CAI system development. And finally, these frameworks could be used as a common theoretical underpinning for additional investigations on CAI potential and evolution. In this section, a revised version of the CAI-NPD-systems maturity framework is proposed as theoretical underpinning for the development of a conceptual model of the CAI-NPD-systems maturity. In order to develop the CAI-NPD-systems maturity framework based on its theoreticial foundations, first the NPD maturity is described and then the CAI maturity is elaborated in the next sections.

3.1 NPD Maturity

The NPD maturity concept assumes that the more elaborated the NPD methods and processes an organization is able to use successfully over time, the greater the NPD maturity of that organization will be. In the CAI-NPD-systems maturity model by Hüsig and Kohn (2009), the stage model of Cooper (1994; 2001) is used as an underlying framework that proposes different maturity stages that an organization's NPD system characteristically goes through. These stages are seen as an expected evolutionary path down which an organization has to go in its NPD capabilities. The stages are often also called "generations", and start at the lowest level with an unmanaged NPD process and ad hoc innovation activities followed by a first generation scheme named "phased review process". In this stage, the NPD process is focused on technical milestones only and fails to integrate other functions or customer inputs. In the next stage, firms use second-generation NPD processes such as stage-gate systems to overcome some of the limitations of the initial stage and include cross-functional mechanisms and stronger market orientation. The highest level is reached when firms implement a third generation NPD process that is faster, parallel, and more flexible than those from the second generation. However, this maturity concept is very focused on process aspects, closed innovation, and historical developments on a quite generic level. Therefore it needs to be enriched by further insights and more recent developments with other NPD maturity models such as McGrath (1996), Essman and Du Preez (2009), Hüsig (2011) or Enkel et al. (2011).

3.1.1 The "PACE" Framework

McGrath (1996) proposed the "Product and Cycle-time Excellence® (PACE) Evolution" framework, which is divided into Stages 0-4. The initial Stage 0, called "Informal Management", is characterized by small committed teams that rely on individual experience. In this stage, all NPD activities rely on a few individuals from the founding team with ineffective line structures and processes so that the business has problems growing. The "Functional Excellence" Stage 1 is typically dominated by strong functional competence, practices, ways of working, and roles in which functions manage effectively and can increase in size. Problems usually exist in the collaboration between functions, so project work is often serial, slow, unpredictable, and delayed. Stage 2 is called “Product and Project Excellence”, where line functions are aligned around customer and project needs for fast, collaborative concurrent project execution from concept to product availability. Typical drawbacks are that only priority products perform well, and it is hard for the organisation to manage many projects successfully, which ultimately leads to lower output as each project repeats development. In the “Portfolio and Platform Excellence” stage, the NPD maturity is already quite well developed. Portfolio and pipeline process aligns resources with needs, product strategies are aligned to meet customer needs and product architecture and platforms allow component re-use. However, processes are largely internally focused, and sub-optimize opportunities for creating competitive advantage through partners or suppliers. In the final maturity stage “Extended Enterprise Innovation”, solutions are created through a portfolio and pipeline that are agile, where the client controls and leverages partners. But the business and sources of value will change, and the firm needs to ensure its survival and drive radical change. Although this framework seems comprehensive, it lacks, to a large extent, the inclusion of the external perspective on NPD such as open innovation (Chesbrough, 2003, 2006).

3.1.2 ICMM: Innovation Capability Maturity Model

A more recent maturity model that comes closer to including the external perspective on NPD is the Innovation Capability Maturity Model (ICMM) by Essman and Du Preez (2009). The ICMM is a three-dimensional framework with dimensions including an innovation capability construct, an organizational construct, and capability maturity. The innovation capability construct identifies three areas: the innovation process, including practices, procedures and activities in the complete lifecycle of innovation of all NPD stages; knowledge and competency, and organizational support—including aspects such as resources, structures, strategy and leadership—needed to support the other areas of NPD. The second dimension ensures that the model addresses all the fundamental aspects of an organization, including customers and suppliers who are separated as an explicit external aspect. The third axis of the framework consolidates the other two dimensions into the maturity of innovation capability, which is divided into five levels of maturity (Essman & Du Preez, 2009):

1) Level—The organization is wholly consumed with day-to-day operations—maximizing short-term revenue and reducing cost. Individual attempts at being creative or “out-of-the ordinary” are often dismissed. Innovative outputs are inconsistent and unpredictable.

2) Level—The organization has identified the need to innovate. Innovation is clearly defined. A basic understanding has been established of the various factors that influence innovation. Innovative outputs are inconsistent, but traceable.

3) Level—Innovation is supported and managed with appropriate practices, procedures, and tools. Individuals are encouraged to be innovative. Innovative outputs are consistent in nature and ensure sustained market share and positioning.

4) Level—Practices, procedures, and tools for integrating innovation activities are used. A deep understanding has been established of the internal innovation model and its relation to business requirements. Innovative outputs are consistent, diverse, and a source of differentiation.

5) Level—Innovation practices, procedures, and tools are institutional. Individuals are empowered to innovate. Synergy is achieved through the alignment of business and innovation strategy and the synchronization of activities. Innovative outputs provide sustained competitive advantage in existing and new markets.

This model of innovation maturity also focuses mainly on internal research and development although an external perspective is explicitly included.

3.1.3 Open Innovation and the “Open Innovation Maturity Framework”

The latest developments in NPD maturity are also enriched by open innovation and related concepts (Enkel et al., 2011; Hüsig & Kohn, 2011; Howe, 2008; Chesbrough, 2003, 2006). Open Innovation (OI) is defined as the use of purposive inflows and outflows of knowledge to accelerate internal innovation and expand the markets for external use of innovation, respectively (Chesbrough, 2003, 2006). This paradigm assumes that firms can and should use external as well as internal ideas and internal and external paths to the market, as they look to advance their technology. This concept was coined by Henry Chesbrough, based on his research on the innovation practices of large multinational companies. Open innovation is characterized by cooperation for innovation within wide horizontal and vertical networks of universities, start-ups, suppliers, spin-offs, and competitors. Companies can and should use external ideas as well as those from their own R & D departments, and both internal and external paths, such as spin-offs or licenses, to the market, in order to advance their technology. Since sources of external information for the innovation process are plentiful, including market actors such as customers, suppliers, competitors as well as the scientific system of university labs or research institutions, new methods and technologies are needed to tap into and manage these valuable innovation inputs. By applying these methods for open innovation, such as lead user method, toolkits for open innovation, or innovation contests, a firm can overcome its local search bias and acquire exactly the information required and therefore innovate more successfully and cost efficiently (Diener & Piller, 2010). A preliminary framework of open innovation maturity was developed by Enkel et al. (2011) based on the literature of three main areas: alliance management, innovation management, and software development that focuses on using external partners in order to develop and introduce valuable ideas in the FFE. By combining three core elements of open innovation (partnership capacity, climate for innovation, and internal processes) with five maturity levels (initial/arbitrary, repeatable, defined, managed, and optimizing) and using the ICMM as a reference point, a framework for open innovation maturity is proposed. However, here the focus of the maturity is exclusively on the FFE of OI and needs to be complemented with a comprehensive view on NPD maturity.

3.1.4 The Revised NPD-Maturity Stages

In the CAI-NPD-systems maturity model described by Hüsig and Kohn (2009), the aspect of NPD maturity is seen as too process-focused. The NPD maturity system proposed here follows the stages of McGrath (1996) to the fourth stage, which is slightly modified, and adds a fifth stage. Moreover, the model needs to be completed by the recent developments surrounding OI, as elaborated above. This leads to the following modified and new stages: the updated model is inspired by McGrath (1996) and Essman and Du Preez (2009) and focused on the closed innovation perspective with a strong market and customer orientation but with a limited focus on other stakeholder integration and OI. Therefore, the next evolutionary step in this model should be the introduction of OI methods in the NPD capabilities in the new maturity stages. As most firms will use their established close innovation NPD-processes in parallel, Stage 4 is complemented by OI methods, especially at the fuzzy front end of the innovation process, as proposed by Enkel et al. (2011). In this way, the fourth maturity stage develops: “Extended Enterprise Innovation with FFE-OI-Methods”. The dominant logic of the NPD-CAI-systems maturity model would suggest that both approaches (closed innovation NPD-systems and OI approaches) unite into a unified fifth maturity stage: “Holistic NPD System”, in which OI-methods and the firm-internal innovation processes would be united in a complementary manor as proposed by Hüsig (2011). The future NPD system would combine and integrate internal and external communities for the entire NPD process. The summary of the NPD maturity stages is shown in Figure 1.

3.2 CAI Maturity

CAI maturity is defined as the extent to which the potential benefits of CAI systems can be realized, depending on the level of CAI-category or CAI-stage and the ability to use a given CAI functionality effectively. Analog to the NPD-systems maturity stages, appropriate CAI system stages can be defined (Hüsig & Kohn, 2009; Hüsig, 2011). To do so, the CAI systems are also organized into a maturity model to match the two maturity frameworks. As seen in other areas of information systems, a tendency towards increasing system integration over formerly separated tools, processes and applications to achieve higher levels of ideality is also assumed in CAI, even if not accomplished in all aspects (Leon, 2009). According to the categorization of Hüsig and Kohn (2009), the maturity of CAI systems can be organized into the four stages. In Stage 0, the organization has no IT-enabled NPD process or doesn’t use generic software tools such as Excel or Email to support the NPD activities. In Stage 1, people in the organization are using focused tools for specific NPD tasks, e.g., ideas management or mind mapping tools. However, these CAI tools are not used in all parts of the innovation process but typically in the FFE of some parts of the organization. In Stage 2, firms have more integrated solutions that cover the whole NPD process and related activities. The NPD process is widely captured in the CAI system. Sopheons Accolade, ID, IntraPro Innovation by XWS, or Hype IMT offer integrated CAI solutions that fit into this category. Finally, in Stage 3 organizations integrated all relevant NPD processes across different business units and departments, and connected other firm process and systems such as suppliers with their CAI system. Unilevers Innovation Process Management System (IPM) or SAP with SAPxPD are said to have achieved this status. Along the lines of the NPD maturity, the CAI maturity concept also assumes that the higher the stage in the CAI development, the greater the CAI maturity of that organization will be. The stages in this maturity model can also be seen as a kind of natural evolution path along which an organization has to proceed. Therefore, this model suggests a staged introduction of CAI tools with respect to the actual stage.

3.2.1 Open CAI 2.0

In order to support the approaches resulting from the OI paradigm, specific IT-solutions are increasingly developed to enable firm-external participants to integrate more directly in the NPD process (Awazu et al., 2009; Diener & Piller, 2010; Hüsig & Kohn, 2011). This development expands the traditional CAI-concept towards the OI sphere. In parallel to the developments in the area of innovation management and theory described in the section above, parallel progress took place in the area of IT that is relevant to the area of CAI. The latter development is frequently described by the term web 2.0. However, the web 2.0 lacks a clear definition so far and many discussions about its real content and its future development are on-going (O'Reilly, 2004; O'Reilly & Battelle, 2009). Nevertheless, certain web technology developments in the last decade have led to a new breed of web services that have certain elements in common and that build the core web 2.0 elements. These core elements are cloud computing, desktop-like usability, interactivity, social media, user-generated content, virtual community, and the semantic web, which are also relevant for the emerging CAI maturity stages. Summing up, to integrate these new drivers (OI and web 2.0) a new concept, called "Open CAI 2.0", was developed (Hüsig & Kohn, 2011). Open CAI 2.0 is proposed as the next evolutionary step in the CAI development trajectory that can be defined as a category of CAI-tools that use technologies following the web 2.0-paradigm to facilitate OI methods to open organizations to a larger audience of external actors and enable them to interact in different activities of the NPD process. This evolution is also enforced by new players such as "Open Innovation Accelerators (OIA)", which are entering in the CAI-supplier-domain and pushing Open CAI 2.0 solutions to establish new CAI-based services on an outsourced basis, especially to support the FFE of the NPD process (Diener & Piller, 2010). OIAs typically offer one or several methods of OI and, partly, supporting and complementary services for the innovation process, such as start-ups like NineSigma, InnoCentive, Atizo or Brainfloor. Open CAI 2.0 leads to emerging stages which will be explained in the following section.

3.2.2 The Revised CAI Maturity Stages

As a result, the new fourth stage of the CAI maturity consists of enterprise CAI solutions complemented by "Open CAI 2.0" tools provided by OIA or self-developed solutions. The traditional CAI tools—in this context also called "Closed CAI 1.0"—further serve to support the internal innovation process while the Open CAI 2.0 tools typically support the FFE of the NPD process. Therefore Stage 4 is called: "Enterprise CAI & Open CAI 2.0". There are first collaborations between OIAs and providers of traditional CAI tools that show the relevance of this stage in the market place: E.g. Atizo, a Swiss OIA and HYPE Softwaretechnik GmbH, a German IMS/CAI provider joined together in order to complement Atzio's Crowdsourcing and Open Innovation services with a new Open CAI 2.0. tool called "HYPE GO!" (http://hypego.net/) that can be integrated with HYPE's holistic IMS system. The further development will also be reflected in Stage 5 with "Holistic CAI 2.0 Solutions" in which web2.0 technologies as well as integrated internal and external communities are fully incorporated in the firm's open and holistic internal innovation system. A seamless transition over firm and communities boundaries will be enabled by future CAI systems to optimize the full innovation process. Together with the modified NPD maturity stages, Figure 1 provides the revised CAI-NPD-systems maturity model. Finally, both maturity streams need to be interconnected by matching processes.

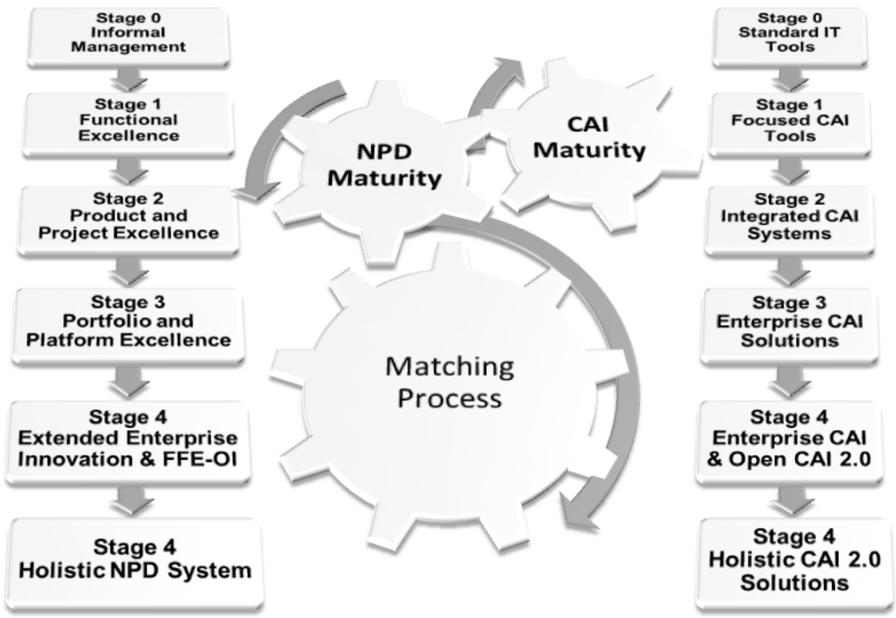

Figure 1. The Revised CAI-NPD-Systems Maturity Model

4. Development of a Conceptual Model for the Revised CAI-NPD-Systems Maturity

The basic propositions of the revised CAI-NPD-systems maturity model are based on the idea that the need for improvement of the organizational innovation system can be described by the distinctive benefits of the IT-support and the NPD methods used. However, the so-called "model" is still in the state of a theoretical framework, and these basic propositions of the framework have not been explicitly stated or formalized so far. The potential benefits of CAI tools are the starting point for doing so. These can be categorized as efficiency, effectiveness, competence, and creativity enhancing, as elaborated above. These potential benefits of CAI can be summarized as the "Innovation Supporting Capability" (ISC) that in the end increases the Innovation Success (IS) of firms. This forms Proposition 1:

P1: A higher innovation supporting capability increases the innovation success of the firm.

The degree to which the possible benefits of CAI systems can be realized depends positively on the level of the CAI-maturity stage and the capability to use the functionality effectively. The technological CAI-maturity stage and the organizational capacity to utilize the functionality of CAI systems effectively are defined as "CAI Maturity" (CAI-M). Therefore, this is shown in Proposition 2:

P2: A higher CAI maturity increases the innovation supporting capability of the organization.

Along the lines of the CAI maturity, the "NPD Maturity" (NPD-M) construct also assumes that the more elaborated the NPD methods an organization is able to utilize productively, the greater the NPD maturity stage of that organization will be. Therefore, a greater NPD maturity would translate into a greater innovation supporting capability for the ultimate innovation success. This is summed up in Proposition 3:

P3: A higher NPD maturity increases the innovation supporting capability of the organization.

And as a final point, since the majority CAI tools are targeted at an specific NPD task or a process phase, it is assumed that it is essential to carefully choose and match the right tool with the adequate method for the right task and stage of the NPD process, as long as the CAI tool is not a holistic solution. Still, in the case of a holistic solution, a comprehensive NPD-system would also be required to effectively support and utilize it. Moreover, even in this case, the maturity level of the NPD system must be analyzed to provide a sufficient match between

CAI and NPD capabilities. Unless CAI or NPD methods are sufficiently embedded in people's working routine, it will not be used, and their potential benefits will not be realized. Therefore, the fit between the CAI and the NPD maturity influences the combined "CAI-NPD-systems maturity fit" (CAI-NPD FIT), which increases the innovation supporting capability and, finally, the innovation success of the organization. The reasoning and findings of Kawakami et al. (2014) on complementary organizational resources that influence IT capabilities, which in turn affect NPD outcomes such as NPD task proficiency and NPD performance go in a similar direction. The CAI-NPD-systems maturity fit's influence is described in Proposition 4:

P4: A higher CAI-NPD-systems maturity fit increases the positive effect of a higher CAI maturity and NPD maturity on the innovation supporting capability of the organization.

A conceptual model of the basic propositions of the CAI-NPD-systems maturity framework is presented in Figure 2.

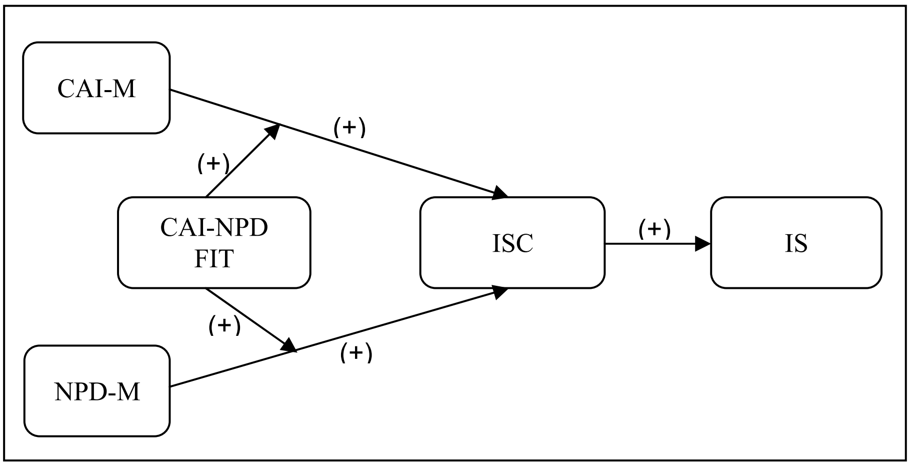

Figure 2. A Conceptual Model of the Revised CAI-NPD-Systems Maturity

5. Conclusions and Further Research Agenda

This article puts forward a more fine grained view on the influence of specific IT and NPD capabilities on innovation success in different stages of maturity. Since the research so far in the NPD area largely fails to investigate the influence of specific IT tools on new product performance, CAI as a specific but often overlooked category of IT-tools for innovation activities is introduced as a potential for positively influencing the innovation supporting capabilities of firms. As Durmuşoğlu and Barczak (2011) indicate, it is important for managers to know which IT tools provide value and not that IT tools in general do so. Therefore, more detailed knowledge is needed about which category or class of particular IT tools can serve as levers for improving certain performance metrics of NPD. Therefore, future research should incorporate the maturity stages when assessing the impact of IT tool use—such as CAI—on innovation performance. By using the revised version of the CAI-NPD-systems maturity model, this paper develops a conceptual model and propositions for further empirical research on how the different generations of CAI could influence NPD success. This approach goes beyond the often generic empirical research about the positive effects of IT use on NPD outcomes (Kawakami et al., 2014; Barczak et al., 2007; Durmusoglu et al., 2006; Durmuşoğlu & Barczak, 2011; Kleinschmidt et al., 2010; Nambisan, 2003; Massetti, 1996; Ozer, 2000; Song et al., 2007).

Based on current and emerging developments in the fields of CAI and NPD, an revised CAI-NPD-systems maturity model is proposed. As a result, new stages of the CAI maturity consist of enterprise CAI solutions complemented by "Open CAI 2.0" tools provided by OIA or self-developed solutions in the FFE of the NPD process. The further development will also be reflected in which web 2.0 technologies as well as integrated internal and external communities are fully incorporated in the firm's open and holistic internal innovation system. At the same time, the OI paradigm shifted the attention of companies from employees as main suppliers of new ideas to customers and other users outside the company. So far, the processes for these developments have often not been properly aligned with the existing NPD processes but are handled as separate projects. The integration of OI activities with the internal NPD system and the development of holistic CAI 2.0 solutions will be major tasks for the companies involved. As shown above, there are already firms that go into the proposed direction. This revised framework specifies, combines, and augments existing maturity models in both literature streams (NPD & CAI) and adds basic propositions to be studied in further empirical research.

Future research should focus on the further development of the concepts and solutions outlined in this paper. In particular, more empirical based inquiries are needed on if and how the revised CAI-NPD-systems maturity framework and the propositions conceptual model can be supported or if alternative approaches are a more fruitful avenue for research.

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