Disentangling the Value of Technological Platforms in Life Sciences: The Case of Enabling Technologies for R&D at Bayer

Bernhard Lingens[1] and Daniel Moser[2]

[1]bernhard.lingens@unisg.ch
[2]daniel.moser@unisg.ch
Both at the Institute for Technology Management, University of St.Gallen, Dufourstrasse 40a, CH-9000 St. Gallen, Switzerland

Recently, the management and innovation of technological platforms gains increasingly attention by both, practitioners as well as scholars. Moreover, technological platforms are important value drivers in R&D processes, especially in life sciences. Yet, research is lacking deeper understanding on how technological platforms in R&D create value. So far, the platform literature is barely addressing this crucial aspect and mentions certain patterns only incidentally. In this paper, we address this neglected topic while we contribute to research on technological platforms in general and improve the understanding of technological platforms applied in an R&D context in particular.

We first of all summarized the scarce literature on value creation of technological platforms. Subsequently, we analyzed five technological platforms that find application in life science R&D on their value creation for the handler of the platform. On this ground, we were able to describe two core value patterns. Thus, platforms create value by improving the R&D processes in terms of efficiency and effectivity leading towards time and cost savings. On the other hand, they can be the basis of the discovery of new compounds resulting in new products. By increasing the scope of the platform application, these values get multiplied boosting the overall value of the platform. Furthermore, we discovered additional value multiplication effects for external R&D platforms, which access an innovation ecosystem of various researchers and platform users. We aggregated our results in a framework being the first authors who describe different dimensions of value creation in life science R&D by technological platforms.

1. Introduction

Over the past decades, the continuously increasing costs of research and development (R&D) in the life science sector resulted in a significant reduction of its R&D efficiency (Cockburn, 2007; Scannell, Blanckley, Boldon, & Warrington, 2012). Consequently, life science firms have expanded significantly their efforts to develop and advance technologies, which increase productivity and reduce costs in R&D (Scannell et al., 2012). Moreover, life science firms are increasingly applying platform strategies for these technologies (Levy, 2013).

Therefore, technological platforms are important value drivers in life sciences, but are also of great significance for other industries (Boudreau, 2010; Eisenmann, Parker, & van Alstyne, 2008; Frattini, Bianchi, De Massis, & Sikimic, 2014; Gawer & Cusumano, 2014; Levy, 2013; Zhu & Iansiti, 2012). Especially in R&D, technological platforms are described as important enablers of innovation (Robinson, Rip, & Mangematin; 2007). However, research in this regard is still in its infancy. In general, research on technological platforms have mainly focused on metaphorical descriptions of industry trends, whilst empirical research and the development of theoretical foundations has just began to evolve (Thomas, Autio, & Gann, 2015). Prior works in this field have strongly focused on product family designs around platforms that are used for efficient development and production of product variants (Jiao, Simpson, & Siddique, 2007; Meyer

& Lehnerd, 1997; Simpson, 2005; Wheelwright & Clark, 1992). More recently published works have described platforms as market intermediaries, which connect different market participants and enable efficient interactions among them (Eisenmann, Parker, & Alstyne, 2006; Evans & Schmalensee, 2008; Zhu & Iansiti, 2012). More specifically, research on technological platforms in R&D is mostly lacking (Thomas et al., 2015) and, therefore, it is still not well understood how technological platforms in R&D can be managed and evaluated.

Based on a qualitative multi-case study with five cases, our paper aims to address the research gaps mentioned above. On this ground, we aim to contribute to literature on technological platforms in general and in life science R&D.

2. Literature Review

Platforms are a well-known principle in engineering and management and have been used to describe products as well as product systems (Thomas et al., 2015). Recently, even industry configurations, supply chains and certain market constellations have been defined as platforms (Gawer & Cusumano, 2014). Subsequently, different streams in the platform literature emerged.

Platforms in management were introduced by Wheelwright & Clark (1992) describing products satisfying the needs of a core group of customers but can be easily modified and adapted meeting different needs. Successively, early literature on platforms in the new product development (NPD) and operations literature is emphasizing the increased speed to market in fast product cycle industries paired with high model varieties and fast technological change as a main driver for platform strategies (Kim & Kogut, 1996; Meyer & Lehnerd, 1997; Sanderson & Uzumeri, 1995). However, the roots of this stream can be found in the engineering literature. Here, platforms are seen as a stable system architecture, whereas innovation and the evolvement of the platform happens on modules (Gawer, 2014). Another major stream in the platform literature are two-sided market platforms offering a place where different individuals are able to connect and exchange in an efficient way. Important aspects in this context are network effects and pricing strategies as two groups with different interests or goals, such as users and firms offering complementary applications or content, need to be addressed in an optimal way (Economides & Katsamakas, 2006; Hagiu & Hałaburda, 2014). Thus, a lot of attention lies on the business model of the platform deciding how the two parties and the platform itself profits of the constellation (Rochet & Tirole, 2003). This literature stream is mainly discussed in economics journals.

Subsequently, management research came up with different typologies trying to structure and unify different platform literature streams. Most recently, Gawer & Cusumano (2014) introduced their characterization of technological platforms bringing together engineering as well as economics literature streams using an organizational perspective. Thomas et al., (2015) are providing a similar classification after an excessive literature review on technological platforms. Both typologies differentiate between platforms with internal and external focus.

Gawer & Cusumano (2014) build on the platform definition of Meyer & Lehnerd (1997) and Muffatto & Roveda (2002) describing them as a set of assets which can be recombined in order to efficiently develop and produce derivate products. This somewhat vague definition is further specified by the authors by introducing the concept of internal (firm) platforms, supply-chain platforms, and industry platforms. Therefore, internal platforms are module based while their interfaces are shared either within a single firm or across the firm's supply-chain. Using platforms and subsystems allow firms to reduce production and inventory costs, increase product varieties and to introduce them faster to the market (Gawer & Cusumano, 2014). According to the authors, external or industry platforms are similar to internal platforms but do not rely on buyer-seller relationships. Moreover, industry platforms are a foundation, on which multiple independent firms can innovate and further develop the platform forming an innovation ecosystem (Adner, 2011; Gawer & Cusumano, 2014; Gawer, 2014). These platforms might also create network effects such as described in the economics literature stream. Gawer and Cusumano (2014) describe market intermediary platforms as a special case of industry platforms.

Thomas et al., (2015) subcategorize internal platforms in organizational and product platforms. The concept of organizational platforms is derived from the works of Prahalad & Hamel (1990) about core competencies, Kogut & Zander (1992) about organizational knowledge and Eisenhardt & Martin (2000) about dynamic capabilities. Therefore, the platform represents the resources and capabilities of a firm, which can be recombined in order to quickly and efficiently adapt in times of change. Product platforms refer to platforms with a core technology as well as modular subsystems in order to efficiently develop product families (Jiao et al., 2007; Meyer & Lehnerd, 1997; Wheelwright & Clark, 1992). Successively, external platforms can be subcategorized in market intermediary and ecosystem platforms. While intermediary platforms represent efficient marketplaces connecting two groups of market participants, ecosystem platforms share a common core technology and an ecosystem of specialized innovators is creating platform complements (Thomas et al., 2015). This differs from Gawer & Cusumano (2014) who describe both, intermediary platforms and platform ecosystems, as external industry platform with the intermediary platform as a special case. An overview of the two platform typologies can be found in table 1.

<<<<<<<Insert table 1 from appendix here >>>>>>>>

There are multiple reasons why companies pursue platform strategies in order to capture value. First of all, when it comes to the development and production of a

platform with various application possibilities (such as different products within a product family), firms are able to realize economies of scope (Boudreau & Lakhani, 2015; Eisenmann, 2011; Magnusson & Pasche, 2014). This phenomenon not only applies for the supply but also for the demand side of a platform as users might be able to deploy one platform for different purposes (Gawer, 2014). Taking an engineering and production perspective on a platform, also economies of scale create value as a core component can be manufactured for multiple products using the same production capacities (Baldwin & Woodard, 2009; Simpson, 2005). Moreover, rather intangible value is created by open, external platforms. Platforms working as intermediaries are connecting two parties and enable transactions between them while the transaction itself can be of value (Gawer, 2014). Furthermore, a platform firm might increase the value of an open platform by capturing the innovation capacity of the platform ecosystem that is contributing complements (Adner & Kapoor, 2010; Cennamo & Santalo, 2013; Tee & Gawer, 2009). Lastly, platform investments have been described as real options containing an optional value creation in the future (Baldwin & Woodard, 2009; Kulatilaka & Kogut, 1994). Especially in the case of a platform application in a R&D context, options on future R&D or the introduction of successful products are created (Robinson et al., 2007).

3. Research Design

Our research uses a multi-case study design (Punch, 2005; Yin, 2004, 2014), which is ideal if a phenomenon is little known, existing aspects are incomplete or fragmented or a new perspective on an already researched topic is needed (Eisenhardt, 1989). Since we aim to explore the emergent phenomenon of technological platforms in R&D, we view an explorative multi case-study as a suitable methodology.

All cases we use are derived from Bayer Technology Services GmbH (Bayer). Each case describes one platform of this firm used as an enabling technology in R&D. Bayer Technology Services is a Bayer subsidiary that provides technologies for the Bayer sub-divisions, in particular Bayer HealthCare and Bayer CropScience. The subsidiary develops technologies along the whole research, development and production process of chemical and life science solutions. In order to maintain the position as a world-wide leading life science company, Bayer is also relying on its strong research divisions. Technological platforms from the external market as well as customized system solutions developed internally form the basis of Bayer's R&D.

The collection of the data took place in two phases, whereby mutual adjustments between data collection and analysis were possible (Eisenhardt, 1989). In the first phase, we conducted interviews with all R&D group leaders of the firm in order to gain an initial understanding of the platforms at hand. The results of this first stage were summarized and validated with the respondents. These small cases were supplemented with a literature review about technological platforms and life science R&D, which served as basis for the deeper analysis, conducted in stage two (Eisenhardt, 1989).

In stage two, we applied a semi-structured interview guideline based on the results of stage one. Open questions allowed the respondents to speak freely and provide additional information. We executed one to five in-depth interviews per case, which took between 30 and 60 minutes (Ø 50 minutes). The respondents were heads of innovation, project managers, R&D- and technology managers and the head of the business unit. We additionally conducted between two and three follow-up interviews per case. During the execution of all interviews, we constantly improved the questionnaire with new insights gained from the interviews.

All interviews were transcribed and independently coded by the researchers (Mayring, 2010). We triangulated our collected interview data with internal company data sources such as project reports and internal presentations (Davis & Eisenhardt, 2011). The resulting cases were summarized into detailed documentations and sent to the respondents for a final proof of correctness.

4. Findings

Case 1- Electron Microscopy (EM) Platform

The Electron Microscopy Platform enables investigations into the structure of biological and inorganic systems. The examined materials range from cells, microorganisms, large molecules, biopsy samples as well as metals, plastics, and crystals. The main application field of the platform includes several drug discovery processes. The platform enables the handler to image objects from millimeter nanometer scale. Within Bayer, the EM is used for the characterization of surfaces and emerging materials. However, the technology finds application in various fields, e.g. biology, physics, material science, and semiconductors.

The platform is formed by an electron beam source, optics, and the detector, which are the central components. Furthermore, there are several devices that serve as complements of the platform, e.g. a device for sample preparation that can be exchanged based on the specific needs. In order to process images of the EM, commercial software tools can be used that may be exchanged as well, if new innovations appear on the market.

Originally established in order to support the R&D function of material science in the characterization of new materials, the EM platform at Bayer has recently experienced an emergence of new applications in later stages of the drug discovery process. The possibility to apply the platform in various research fields enables the handler of the platform to realize economies of scope on a large scale. The characterization of substances nowadays plays a central role in recognizing and hence

preventing false positive results. The EM shows patterns of an open platform, as one may derive from the user base and the corresponding network effects. Users are spread across different companies as well as academia. Furthermore, the users are forming an ecosystem where information and innovations are exchanged on a frequent basis. In addition, users often collaborate with manufacturers in order to develop new innovations, leading to the expansion of the range of applications.

Case 2 – Mass Spectrometer (MS) Platform

The mass spectrometer is a device used to specify the amount and type of chemicals present in a sample. The basic applications in the industry context are R&D, product supply as well as areas of quality control and failure analysis. The platform can be used for various applications.

The core of the platform consists of the mass spectrometer with an ion-source, an analyzer as well as a detector. A liquid or gas chromatography (LC/GC) complements the core components in order to prepare and separate samples.

The LC-MS is used at Bayer in projects that include the analysis of small molecules and metabolites. Rapid characterizations of chemicals in GC pharmacokinetic studies in animal experiments are typical examples. The LC-MS is also used in preclinical development to check potentially attractive substances for safety and availability. MS within metabolomics and proteomics as well as the process of drug development are relatively new fields that were opened due to rapid progress in MS technology (especially for proteomics). The MS can be seen as an open platform, as various laboratories collaborate with manufacturers in order to improve the MS devices and technologies. Moreover, there are societies and congresses where an exchange over innovations and information takes place on a regular base with the goal to improve the overall quality of the platform.

Case 3 Zeptosens Platform

Zeptosens is a reverse phase protein array (RPPA) platform, which is used for proteomic profiling of tissue or in vitro cellular systems that can originate from humans, animals or plants. Generally spoken, the Zeptosens platform is applied to identify pathways inside cells, whereby information is transmitted. The technology enables the quantitative identification of thousands of protein molecules within one sample based on fluorescently labelled antibodies. The Zeptosens platform generates quantitative biological data that might be used to find answers to biological questions within the R&D process, e.g. in drug development. These questions can stem from very diverse fields and applications of Zeptosens and range from biomarker/drug target discovery and validation, mode of action identification and selective testing of a drug to applications in toxicology.

The technological basis of the platform is the Bayer proprietary planar wave guide (PWG) technology, which allows for ultrasensitive detection, which is performed with the ZeptoReader, a specialized, custom-built PWG-instrument. The ZeptoReader has been introduced to the market almost a decade ago and proved to be very robust. The core components are formed by optics, cameras, lasers and software that is all patent protected. Complements are spotting devices which apply the samples to be analyzed onto glass sides in an array format. They can be exchanged, for example when new innovative spotting technologies arise. Another complement is the glass slide or chip where samples are spotted onto. The chip consists of glass, an ultrathin film of tantalum pentoxide and an optical grating. They may be exchanged, e.g. when new materials become available. Furthermore, antibody labelling can be adapted to innovative labelling technologies, if available.

The Zeptosens platform is mainly used internally within the Bayer subgroups, but external application is not excluded. The platform has closed interfaces, which is exclusively shared within Bayer. New incremental innovations on the platform core itself are dependent on Bayer's own capabilities and are not triggered externally. Even if an opening of the platform for external innovators was possible, it is difficult to realize. The reason is mainly twofold. First of all, researchers working with this very sophisticated platform are not willing to share their knowledge, which was acquired over multiple years of work, with other researchers but prefer to work with the platform exclusively. Secondly, innovations cycles in life science in general but also with platform are long and a successful application cannot be guaranteed. There is a lack of interest of external innovators to contribute complements as the influence of them on a successful new product will be almost untraceable. However, there are certain trends of opening the platforms. For example, as spotting technology (complementary component), external commercial technologies are used and can be readily exchanged when new technologies become available in order to, e.g. sample volume to be used.

External exchange about the Zeptosens platform is limited to RPPA meetings where the technology itself is presented as well as workshops in the form of conference satellite meetings designed for a small number of external users. Bayer acquired Zeptosens in order to strengthen its technology portfolio in the fields of agro diagnostics, personalized medicine and drug discovery. The technology is provided to the HealthCare and CropScience divisions that apply it in the process of identifying new molecules, which may lead to the discovery of new products. As many possible applications may be served, the Zeptosens platform can lead to economies of scope.

Case 4 – PBPK/PD modelling software „PKSIM" Platform

Due to the massive expenses required to be spent by research-orientated pharmaceutical companies during drug discovery and development, there is an increased

need to streamline the R&D programs involved and to identify the most promising drug candidates at the earliest time point possible.

To support decision making in drug development, Bayer Technology Services provides software products for predictive simulation of drug behavior and modelling of cellular pathways. The Systems Biology Software Suite (SB Suite) with its main tools PK-Sim® and MoBi® provides scientists and managers in R&D with the possibility to answer the most relevant questions required for judging development programs regarding the R&D key performance indicators like safety, efficacy and probability of success.

The unique combination of a comprehensive whole-body physiologically-based pharmacokinetic (PBPK) modelling toolkit (PK-Sim®) and an advanced biological modelling toolkit (MoBi®) with full access to all parameters and differential equations allows researchers to create mechanistic PBPK and PD (pharmacodynamics) models in a maximally flexible fashion. This unmatched flexibility is supported by built-in interfaces to mathematical modelling tools like MATLAB® and R®.

Furthermore, this full transparency facilitates acceptance of such models when communicating the corresponding results or submitting reports to regulatory agencies such as EMA and FDA.

Bayer licenses this platform to pharmaceutical industry customers and additionally provides related professional consulting in form of bespoke application projects from scope definition to reporting according to regulatory standards.

Following the idea of Open Innovation, for non-profit basic research purposes aiming at the advancement of general understanding of biological and pharmacological processes, Bayer Technology Services licenses the SB Suite to academic institutions free of charge. Like commercial customers, academic users are encouraged to participate in further improving the platform at regular workshops and via direct communication.

Case 5 – STED microscope Platform

The STED microscope is a super-resolution fluorescence microscope, which will guide to new paths in R&D, e.g. drug development. STED is an acronym standing for Stimulated Emission Depletion. Due to the fact that it is not limited in diffraction and that it can circumvent the Abbe diffraction limit, it is regarded as a breakthrough technology. It has therefore been awarded the Nobel Prize in Chemistry in 2014. The main advantage is a better resolution of biological entities down to single molecule applications. This enables more information to be extracted from the images. R&D.

The STED microscope is based on a fluorescence microscope, which, together with different lasers, forms the core component of the technological platform. It is complemented by sample preparation systems and especially fluorescent dyes and labelling systems. They are all easily exchangeable if new innovations arise on the market, e.g. new dyes or image processing software. As various applications for the platform, especially in cell biology, can be addressed, the STED microscope allows the handler to realize economies of scope by its acquisition. However, as the platform is very new, it is only used in a limited way while the exploration of new fields of applications is still going on.

However, Bayer has not implemented the platform yet in their businesses but is evaluating the use of the platforms and possible applications together with external experts. Therefore, the STED microscope represents an emerging technological platform, which stands at the very beginning of its life cycle in life science R&D. At the moment, this platform is mostly found in academic core facilities. As the technology gets increasingly affordable due to decline of costs for the individual parts, R&D usage will most likely increase. The current users form an ecosystem, e.g. PhotonicNet, a network between industry, academia and authorities. PhotonicNet provides a place for discussion and exchange of information (e.g. demand, ideas and new components) between users and manufacturers, leading to new innovations in the field of STED.

5. Discussion & Implications

In table 2, we highlight our main findings derived from our cases. The first two columns describe the core component forming the "heart" of the platform as well as complementing components, which further specify the application of the platform. The architecture of a platform and the separation between core and complementary components is one of the main defining characterizations of a platform (Baldwin & Woodard, 2009; Boudreau & Lakhani, 2009; Boudreau, 2012; Cusumano, 2010; Eisenmann, 2011; Frattini et al., 2014; Gawer, 2010; Tee & Gawer, 2009; Thomas et al., 2015). Thus, these two columns define the presented cases as platforms according to the literature. The third column outlines, how the platforms create value for the user. Column four specifies whether the value creation through complementary components takes place within the company or mainly stems from external innovators. Lastly, the fifth column describes the various applications of the platforms.

<<<<<<<Insert table 2 from appendix here>>>>>>>>

5.1. The value creation of R&D platforms in life science

Our cases reveal two value creation patterns by R&D platforms. Firstly, all platforms aim to increase the efficiency of the R&D process. The PKSIM modeling software for example, helps to avoid adverse negative results of tested compounds. This is the case when a drug causes harmful effects. Testing newly discovered drugs for official sales admission is a long and costly process. Therefore, platforms reducing the time to market and supporting prove of efficacy of a drug

that might reduce the costs in R&D significantly. Moreover, markets for blockbuster medicaments are typically characterized by "the winner takes it all" mechanisms. Thus, faster development can lead to major competitive advantages in the case of two or more companies working on the same drug at the same time. Being better and faster in the screening of compounds, the handler of the platform can realize direct and visible value in terms of saved time and economies of scale through higher amounts of compounds that are put through the platform. Even though it is almost impossible to calculate the monetary value share these platforms contribute to a final product, they certainly help to increase the efficiency and effectivity of the overall life science R&D process.

Zeptosens and the STED microscope show a different type of value creation. Even though they accelerate R&D processes and improve the outcomes of R&D, these platforms can facilitate their handler to discover completely new active substances, which might enable new products. Nevertheless, given the significant uncertainty in life science R&D, there is not guarantee that the use of such a platform will lead to a new substance. The platform solely offers the option to develop a new product. Thus, the value created by these platforms can be seen as a real option (Kulatilaka & Kogut; Street & Santhanakrishnan, 2011). Yet, we argue, that no platform creates purely one type of value, which can be even more or less equally spread such as in the cases of the electron microscope and mass spectrometer platforms.

Another core characteristic of a platform is the possibility to realize economies of scope (Gawer, 2014; Thomas et al., 2015), which can also be found in our cases. All platforms described in our sample have multiple applications. The electron microscope, for example, was initially established in a material science context before it became relevant in the pharmaceutical R&D. Also the STED microscope's full range of application is yet to be explored by Bayer and its partners. This leads to the conclusion, that R&D platforms' scope of application changes over the time while a new platform has a smaller range of applications than a mature platform. Furthermore, this has also implications on the value creation of the platform. Whether the value is direct or optional, the overall value of the platform grows with the scope of applications.

Consequently, the value creation of R&D platforms is twofold. Firstly, they create direct value by making the R&D process faster or reduce costs. Secondly, R&D platforms create an option value since they might facilitate the discovery of a new drug. In either case, the value of the platform increases with the number of applications.

5.2. The openness of R&D platforms in life science

According to the literature, platforms can be separated by their internal or external focus (Gawer & Cusumano, 2014; Gawer, 2014; Thomas et al., 2015). As our cases reveal, also R&D platforms in life science can be described as having an internal or external focus.

In four of our five cases, the platforms at hand can be classified as internal platforms, since core and complementary components are mainly developed and innovated within the focal firm. This counts, according to the typologies of Gawer & Cusumano (2014) and Thomas et al. (2015), for the Zeptosens as well as the PKSIM platform. First attempts in order to open the platforms for external innovators have been taken such as in the case of the PKSIM platform. A reason why the platform is not yet an external platform might be found in the protectionist attitude in the R&D context. Researchers often refuse to share their knowledge with other people. Moreover, given the very specific field of R&D Bayer platforms are used for, there is only a small community of experts and researchers being familiar with these platforms. In some cases there only exist around 60 experts for a certain platform globally, whilst 20 of them are developing the platform at Bayer. The other 40 experts are either employees of competitors or academics. Thus, a knowledge drain induced by an open platform might lead to a competitive disadvantage.

On the other hand, the electron microscope, the mass spectrometer and the STED microscope can be described as external platforms. Various independent innovators are advancing the mass spectrometer platform and share their achievements with the user community at congresses as well as with manufacturers of physical parts. The same applies for the electron and STED microscope where an ecosystem of innovators is working on enhancing the range of applications and to improve the functionality of the platform. External innovators independently working on the advancement of the platform is described by Gawer & Cusumano (2014) as industry platform or platform ecosystem by Thomas et al. (2015). However, while these authors highlight the intermediary character of the platform connecting component innovators with platform users, R&D platforms are special in terms of innovators and users who are commonly formed by the same group of people. Furthermore, R&D platforms do not always have a platform leader who coordinates the advancements of the platform. Different laboratories have own platform solutions tailored to their specific needs using own or ecosystem developments. Moreover, external platforms have been related to network effects (Eisenmann, 2011; Gawer & Cusumano, 2014; Zhu & Iansiti, 2012). In the context of R&D platforms, network effects cannot be fully unveiled as the usual user group is too small and the platforms are often forming isolated solutions for the specific firm neither attracting external innovators nor external users. However, network effects can be leveraged by partly opening the platform and including academics. Bayer for example, has constantly around 30 academic researchers at the Bayer Technology Services GmbH subsidiary, working with and on the advancement of the platforms. The gain of increasing the number of platform users in this academic context for Bayer is twofold. First of all, aca-

demics working with the platform today might later join the industry and continue to work with the platform while promoting it in different companies or stay at universities and thus increase the platform's user base. On the other hand, by bringing the platform into universities, Bayer accesses up-to-date knowledge from the research front.

In terms of their value creation, external platforms offer an additional chance for value multiplication. Gathering an innovation ecosystem around the platform, developing new complementary components, which are creating additional value in their turn, is increasing the value of the whole platform. Moreover, as it is common for R&D platforms to unify innovators and users in one group, the advancement and the use of the platform could end in increased efficiencies of the R&D process outside the company as well as the discovery of new products. As a consequence, the chance to realize the optional value of a platform is growing.

5.3. A value framework for the classification of R&D platforms in life science

The specifics of R&D platforms as discussed in the prior sections are condensed in the framework, displayed by figure 1.

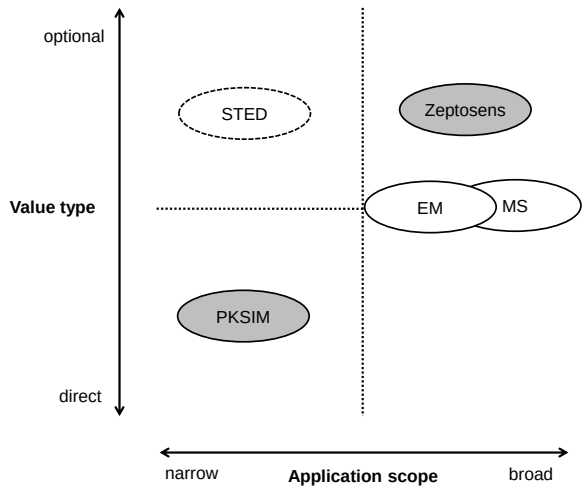


Figure 1: Characterization of value creating Bayer R&D platforms;
white: value origin mostly external
grey: value origin mostly internal
dashed line: not (yet) implemented at Bayer

As outlined in the previous sections, the value creation of the platform can be direct optional or combined value. This value can be multiplied with the number of applications, i.e. the scope of application of the platform as emphasized by the second dimension. The third dimension describes whether the platform is created internally or externally including the additional value multiplication effects at external platforms as explained in the previous section.

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Appendix

	Internal Platforms		External Platforms	
(Gawer & Cusumano, 2014)	Internal Platform	Supply Chain Platform	Industry Platform	
(Thomas et al., 2015)	Organizational Platform	Product Family Platform	Market Intermediary Platform	Platform Ecosystem

Table 1: Overview of platform typologies in the literature

Name of platform	Core component	Complement	Value creation through platform	Classification of platform	Scope of platform application
Electron Microscope (EM)	electron beam source, optics and detector	Devices for sample preparation, software for image processing	Characterization of substances in order to prevent adverse negative results = optional value	External Platform	Rather broad
Mass Spectrometer (MS)	Ion source, analyzer and detector	Sample preparation, sample separation	Faster and better characterization of = direct value	External Platform	Rather broad
Zeptosens	Bayer proprietary planar wave guide, ZeptoReader detection system	Spotting devices, glass slides or chips for sample application	Identification of new molecules that might lead to a new product = optional value	Internal Platform	Rather broad
Pharmacokinetic / pharmacodynamic modeling software PKSIM	Bayer proprietary software system PKSIM and MoBi as modeling and simulation platform in clinical sciences	Tools for visualization and modeling	Reducing negative adverse effects in clinical studies = direct value	Internal Platform	Rather narrow
STED microscope	Fluorescence microscope, different lasers	Sample preparation systems, labeling systems, fluorescent dyes, image processing software	Better analysis of biological entities = optional value	External Platform	Rather narrow

Table 2: Overview of cases