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Attraction at first sight? Exploring and categorizing determinants that make scientific knowledge attractive to innovators

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Abstract

Innovators are met with substantial amount of information on new scientific discoveries that could potentially be of interest to them. But how do innovators select the piece of scientific knowledge they are ready to spend time on investigating further, potentially resulting into university-industry collaborations or patenting-licensing deals? This study explores the factors that determine whether scientific knowledge is attractive to innovators at first sight. Conceptually, innovators' early R&D decision processes are portrayed from a Stimulus-Organisms-Response (S-O-R) perspective using the effect model AIDA (Attention ? Interest ? Desire ? Action) as its point of departure. Based on this framework, interviews with a theoretical sample of innovators were conducted to identify and categorize determinants of innovators' perceived attractiveness of scientific knowledge at first sight. Overall, 56 determinants were identified and structured along six categories: source of knowledge, knowledge characteristics, transfer channel, recipients' characteristics, expected outcome, and context. By doing so, this paper provides a first overview of early-stage decision-making involved in the process of absorbing scientific knowledge for innovation. Understanding the innovators' perspective is essential for preparing scientific discoveries to be seized: by considering the factors identified in this study, policy makers and universities can contribute to better facilitating the successful transformation of scientific discoveries into innovations. The paper concludes by presenting implications for innovation studies and highlights avenues for further research. The applied categorization specifically outlines factors that could address the omitted variable bias in prior studies.

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Abstract

Innovators are met with substantial amount of information on new scientific discoveries that could potentially be of interest to them. But how do innovators select the piece of scientific knowledge they are ready to spend time on investigating further, potentially resulting into university-industry collaborations or patenting-licensing deals? This study explores the factors that determine whether scientific knowledge is attractive to innovators at first sight. Conceptually, innovators' early R&D decision processes are portrayed from a Stimulus-Organisms-Response (S-O-R) perspective using the effect model AIDA (Attention – Interest – Desire – Action) as its point of departure. Based on this framework, interviews with a theoretical sample of innovators were conducted to identify and categorize determinants of innovators' perceived attractiveness of scientific knowledge at first sight. Overall, 56 determinants were identified and structured along six categories: source of knowledge, knowledge characteristics, transfer channel, recipients' characteristics, expected outcome, and context. By doing so, this paper provides a first overview of early-stage decision-making involved in the process of absorbing scientific knowledge for innovation. Understanding the innovators' perspective is essential for preparing scientific discoveries to be seized: by considering the factors identified in this study, policy makers and universities can contribute to better facilitating the successful transformation of scientific discoveries into innovations. The paper concludes by presenting implications for innovation studies and highlights avenues for further research. The applied categorization specifically outlines factors that could address the omitted variable bias in prior studies.

Keywords:

Scientific knowledge transfer, innovator's perception, value capture, open innovation, science-based innovation

1. Introduction

Value from scientific knowledge is captured when it is used to create an innovation (Schumpeter, 1934; Teece, 1998). But for innovators to identify the right piece of scientific knowledge to seize is not an easy task, the amount of scientific discoveries is enormous. It has been estimated that a new scientific paper is published every minute (Hall, 2010) and the dissemination of research results through conferences and newspapers is increasing (Larsen, 2011). Facilitated by various search engines, open access policies and the fact that English has become the main language of science, innovators can more easily access (and potentially select from) a global supply of scientific knowledge than ever. Seizing scientific knowledge for innovation is also increasingly incentivized by policy making, funding schemes, specific awards and educational programs on both the national and the supranational level. It is therefore important to understand what makes scientific knowledge attractive to innovators at first sight, to get better insights into why some scientific discoveries are absorbed by innovators while others remain disregarded. The scientific knowledge transfer literature so far mainly investigates the transformation of knowledge into innovation by investigating outputs such as patents and licensing-deals (Larsen, 2011; Perkmann et al., 2013; Thursby & Thursby, 2011). This, however, leaves little attention to the early stages of the process, where the innovator decides to initiate further investigation of a particular piece of scientific knowledge. Despite the extensive literature on how scientific research from universities and other research organizations is transformed into valuable innovations for society (Agrawal, 2001; Miller, McAdam, & McAdam, 2018), there is remarkably little insight into what innovators find attractive in scientific knowledge at first sight. Hence, this study asks: *What determines innovators' perception of scientific knowledge as attractive for innovation?* By answering this question this study adds to two relevant research gaps. First, it looks at an early stage in the scientific knowledge transfer process that has so far widely been disregarded (research gap A). Second, determinants affecting the innovators' perception of scientific knowledge at this early stage are explored and structured (research gap B).

Addressing these gaps requires an understanding of the perceptions that influence innovators' decision making. Specifically since the drivers and barriers of transferring scientific research out of the ivory tower go beyond the pure access to particular findings (Bikard, 2012; Howe, Howe, Kaleita, & Raman, 2017). In this vein, we consider the perceived attractiveness of scientific knowledge as one important antecedent (i.e., as a filter or bottleneck) in the process of seizing scientific discoveries for innovation. We define scientific knowledge transfer as any form of transferring scientific knowledge from one knowledge-creating actor (i.e., the scientific researcher/s) to another innovating actor (i.e., the innovator) (Van Wijk, Jansen, & Lyles, 2008), including but not exclusively relating to university-industry collaborations and patenting-licensing activities (Bonakdar, Frankenberger, Bader, & Gassmann, 2017). Scientific knowledge is considered as new, previously unknown knowledge that results from rigorous research following scientific principles, independent of the research discipline (Nonaka & Von Krogh, 2009). Moreover, we understand innovators as economic actors who either create inventions based on scientific knowledge or seize inventions with the intention to exploit them. Innovations are further considered to be new product, process, and service inventions that are successfully marketed or being put to use (Fagerberg, Fosaas, & Sapprasert, 2012; Schumpeter, 1934).

To explore determinants of innovators' perceived attractiveness of scientific research we apply a qualitative approach. First, we review the literature on scientific knowledge transfer to identify factors that are shown or suggested to influence the occurrence and the successfulness of such transfer processes. These factors are then structured into six categories following the communication process: the source of the scientific knowledge, the knowledge itself, the channel, the recipient, the expected outcome, and the context (Lasswell, 1948). Since most existing research on scientific knowledge transfer focuses on phases in the innovation process when the decision to consider scientific knowledge as its starting point has already been made, this project specifically pays attention to identifying determinants that are relevant for decision making in the first place. Second, we use qualitative data from eleven in-depth interviews with theoretically sampled innovators from Austria, Denmark, Germany, and the US to deductively validate the factors identified in the literature review and inductively add novel factors that have not yet been investigated so far.

This paper yields three main contributions. First, we propose that paying attention to the early stages is essential for better understanding the drivers and barriers of successful scientific knowledge transfer processes. While research has primarily looked at the stages of the process where innovators have already decided which scientific discovery they want to seize (e.g., Bruneel, d'Este, & Salter, 2010), we focus on the steps prior to this decision is being made. As an underlying structure we suggest the AIDA (Attention – Interest – Desire – Action) model (Kotler & Keller, 2012; Strong, 1925) since it generally describes critical steps prior to making decisions for further actions. Second, building upon existing research on university-industry collaboration or scientists' willingness to commercialize their knowledge (e.g., D'este & Perkmann, 2011; Lam, 2015), this study identifies a set of 56 determinants that influence innovators' perceived attractiveness of scientific knowledge for the initiation of innovation processes, i.e., any action undertaken to build an innovation based on a particular scientific discovery.

Third, the identified factors are grouped into six categories along the communication process (Lasswell, 1948), allowing further studies to explore each of these categories in more detail, specifically also identifying related contingencies and consequences. By asking how innovators get interested in scientific knowledge in the first place, we discuss scientific knowledge transfer with a client-centric perspective as it is commonly used in marketing and communication research. This generally adds a new perspective to the ongoing discussion about universities' third mission and the wish to increase scientific knowledge transfer for the purpose of generating innovation, and more specifically contributes to better understanding markets for ideas and technology (Arora & Gambardella, 2010). Overall, this study adds to advancing our current insight into capturing value from scientific knowledge (e.g., Dedrick & Kraemer, 2015).

These contributions also hold important practical implications for scientific researchers, university managers and policy maker. Scientific researchers are provided with an overview of factors that influence whether (or not) their scientific knowledge might get attention from innovators. Based on this, they may be able to increase the value captured from their scientific discoveries. Policy makers and university managers can use our results for optimizing contextual settings and facilitating the communication process between scientific researchers and innovators.

Finally, most of the existing research on scientific knowledge transfer and innovation has so far disregarded the early stages in the process of transforming scientific discoveries into innovation. Providing a framework of determinants in these early stages, will enable future studies to refrain from omitted variable bias.

The remainder of this manuscript is structured as follows. The theoretical framework (section 2) provides a discussion on the value of applying a process perspective to transferring scientific knowledge into innovation and introduces the AIDA model as a novel process framework for analyzing early-stage decisions in science-based innovation processes (2.2.). It furthermore presents a review of the existing literature on determinants of innovators' perception of scientific knowledge attractiveness using the Lasswell formula as its underlying framework for analysis

(2.3.). Section 3 describes the methodological approach to validating and extending the conceptual framework, section 4 covers the results that are then discussed to derive meaningful contributions and implications in section 5. A reflection on limitations and future research opportunities (section 6) closes this manuscript.

2. Theoretical framework

In the management literature, capturing value is defined as the distribution of created value among different involved actors (Pisano & Teece, 2007; Teece, 1986). Transforming scientific knowledge into innovation is one way to capture value from scientific research for society, the economy and the researchers themselves (Bowman & Ambrosini, 2000; Dasgupta & David, 1994; Lepak, Smith, & Taylor, 2007). Bowman and Ambrosini (2000) differentiate between use value and exchange value. While the second is the (monetary) price paid to obtain a good, the first is the buyer's surplus. The surplus describes the comparisons customers make between products, their needs and feasibility of other offerings as well comparisons that resource suppliers make between the deals with the firm and possible other deals. Value can be created by an organization as well as by a single individual via providing a contribution that is perceived to be valuable by a target group (Felin & Hesterly, 2007; Lepak et al., 2007). Therefore, the value created must exceed the perceived utility of any other alternative presented to the target group by either lowering the cost or creating a higher value. Following this definition, knowledge creation can be seen as one form of value creation (Dasgupta & David, 1994; Dedrick & Kraemer, 2015; Felin & Hesterly, 2007).

Capturing value can be assessed on an individual-, organizational-, and societal-level (Lepak et al., 2007). Pisano and Teece (2007) elaborated the idea based on Teece (1986) that the created value is distributed among, i.e., captured by different stakeholders. Value capturing describes the process of translating conjectured value into realized value (Pitelis, 2009). While the created knowledge still represents conjectured value for an innovator, value is captured if this knowledge is transformed into an innovation. In accordance, it is important that innovators perceive scientific knowledge as attractive to increase the value captured for all parties and the society (Felin & Hesterly, 2007; Lepak et al., 2007; Pisano & Teece, 2007). Consequently, the value of scientific knowledge cannot be assessed ex-ante, but only ex-post (Bozeman & Rogers, 2002). This is due to the dynamic nature of these processes referred to as generative appropriability that is the cumulative value capture from knowledge created based on previously created knowledge (Ahuja, Lampert, & Novelli, 2013).

However, scientific knowledge is challenged by losing its appeal to innovators (Arora, Belenzon, & Patacconi, 2018; Bikard, 2012). Bikard (2012), for example, shows that innovators prefer seizing knowledge developed in company-internal R&D teams although a research team from a university came up with the same scientific discovery at the same time. This indicates that despite the knowledge itself there seem to be other factors influencing whether a specific scientific knowledge is perceived as attractive by innovators, triggering them to engage in a deeper and more thorough analysis of whether the scientific knowledge could be absorbed to create an innovation (or not). In the following, we propose a theoretical framework for both, analyzing the early-stage process of seizing scientific knowledge for innovation (2.1.) and the factors which influence innovators' decision making in this early phase (2.2)

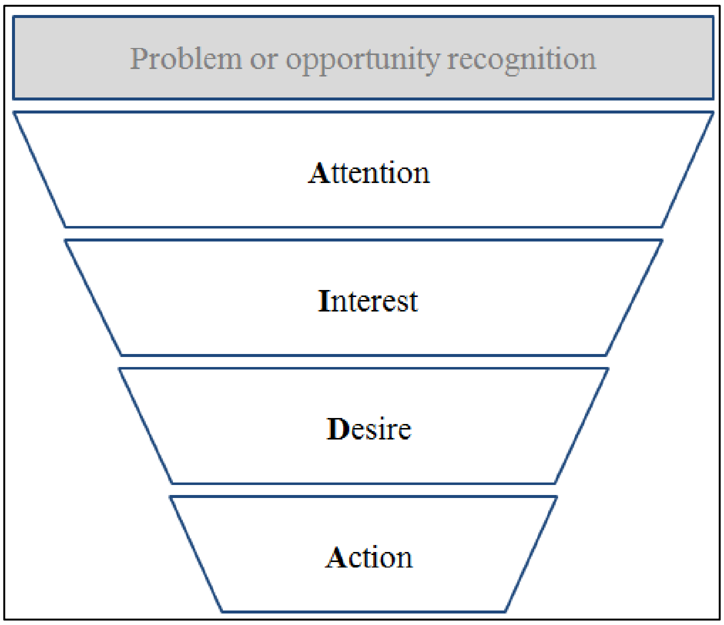
2.1. A process-perspective on translating scientific knowledge into innovation

In general, the existing literature differentiates between two main approaches to transferring scientific knowledge into innovation: either by university-industry collaboration or by means of commercialization science via patenting, licensing or academic entrepreneurship (Perkmann et al., 2013). The different mechanisms have received considerable attention by researchers regarding their antecedents, contingencies and consequences. Several authors undertook the challenge to describe generalizable processes of transferring scientific knowledge in more detail, especially regarding university-industry collaborations. Siegel, Waldman, Atwater, and Link (2004), for example, propose a process model of university-industry technology transfer where they highlight intervening organizational and managerial issues and point to the non-linearity of such processes as suggested by theory. Also Philbin (2008) derives a process-based model for collaboration from several best practice cases allowing for the identification of further relevant factors and circumstances. Bruneel et al. (2010) offer a process model to highlight barriers to university-industry collaboration, considering a wide array of orientation- and transaction-related aspects. All these processes focus on a specific type of transfer such as collaboration. One exception is Graham et al. (2006) who proposes an overarching knowledge-to-action process by conceptually differentiating knowledge transfer, translation, and exchange. Although this process is applicable to a wider array of different transfer mechanisms, it focuses on the negotiation stage, i.e., when the decision to seize a particular scientific knowledge had already been made. Independent of the type of knowledge transfer, little is known about what happens prior to the negotiation stage. To the best of our knowledge there is currently no process model available in innovation research that focuses on the time *before* negotiation processes for translating science into innovation can even start. Hence, we formulate research gap A: How does the process from innovators' first encounter with a particular scientific knowledge until the decision to follow-up on it to potentially initiate an innovation process look like?

Using the AIDA model for analyzing early stages in the process of in transferring scientific knowledge into innovation.

In line with a recent suggestion to see the knowledge transfer process from a Stimulus-Organisms-Response (S-O-R) perspective (Ting, Yahya, & Tan, 2017) we propose the use of the AIDA model (see Figure 1). AIDA is an acronym for Attention, Interest, Desire, and Action and describes the four phases of how an advertisement should activate the consumer's intention to buy the advertised product (Fredrickson & Branigan, 2005; Kotler & Keller, 2012; Rawal, 2013; Wijaya, 2015). This model belongs to the hierarchy of effects models and is commonly used in marketing education (e.g., Kotler & Keller, 2012; Meffert & Bruhn, 1979; Meffert, Burmann, & Koers, 2005) as well as in research beyond product marketing contexts such as advergames (Ghirvu, 2013), online and social media (Hassan, Nadzim, & Shiratuddin, 2015), or tourism research (Lin & Huang, 2006). Although such hierarchical phase models face justified criticisms (e.g., supposed linearity, lack of effects consideration) (see Barry & Howard, 1990 for a review) they are still considered as suitable due to their simplicity. For the endeavor to schematically depict the steps before an innovator decides (representing the last step: Action) to investigate a scientific knowledge for the purpose of initiating an innovation process, this model is considered suitable.

Figure 1: AIDA Model



Source: adapted from Strong (1925).
Note: The funnel indicates that with each step towards action the amount of people attracted decreases.

2.2. A recipients' perspective: The perception of scientific knowledge by innovators

To advance understanding and increase success of the scientific knowledge transfer process studies have recently investigated antecedents, contingencies, and outcomes. In general, the current literature is divided into two major research streams: a) Academic entrepreneurship / academic commercialization (Benassi, Landoni, & Rentocchini, 2017; Perkmann et al., 2013); and b) University-Industry collaboration (Bruneel et al., 2010; Lee, 2000; Perkmann et al., 2013). Both streams emphasize individual- and organizational-level determinants that affect *academics'* willingness to engage with industry (e.g., Bains, 2005; Bruneel et al., 2010; D'este & Perkmann, 2011; Lee, 1996; Marzocchi, Kitagawa, & Sánchez-Barrioluengo, 2018; Siegel et al., 2004; Tartari & Breschi, 2012). *Innovators'* willingness to engage with academia is thereby often assumed due to the general importance of science as a source of innovation (Beise & Stahl, 1999; Cohen & Levinthal, 1990; Mansfield, 1991) and has thus received far less attention. Hence, we formulate research gap B: What factors influence innovators' early stage decision to seize scientific knowledge for potentially translating it into innovation?

Using the Lasswell formula to analyze factors influencing innovators' decisions to seize scientific knowledge.

Both literature streams on scientific knowledge transfer were in a first step systematically analyzed for determinants (drivers and barriers) known to influence the likelihood and/or successfulness of transferring scientific knowledge into innovation. The identified factors are then structured along five categories: A) factors from the source of the scientific knowledge; B) characteristics of the knowledge itself; C) the transfer channel through which the innovator learns about the scientific discovery; D) factors from the innovator itself; E) the expected outcome; and F) the context. These categories are adapted from the Lasswell formula (Lasswell, 1948) used in communication research, which – despite its age – is still considered as relevant and applicable to today's communication (Sapienza, Iyer, & Veenstra, 2015). The Lasswell formula[1] postulates a communication process where a sender ("who?" here: source of knowledge), sends a message ("says what?" here: scientific knowledge) through a communication channel ("through which channel?" here: transfer channel) to a recipient ("to whom?" here: innovator) that provokes a certain outcome ("with what effect?" here: decision whether to seize a particular scientific knowledge). Due to the complexity of the communication process between source (scientific research) and innovator, F) context was added as 6th category in line with Lasswell's request to add categories depending on the contextual setting (Lasswell, 1948; Sapienza et al., 2015). The

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[1] Lasswell's five W-questions are formulated as follows: WHO says WHAT to WHOM through WHICH channel and with WHAT effect? (Lasswell, 1948).

use of this formula also conforms with recent findings, that it is more often the researchers who encourage an innovation process and hence, the transfer process (Goel, Göktepe-Hultén, & Grimpe, 2017), making researchers the starting point of the communication. These categories are therefore considered as providing a suitable structure for addressing both, research gap A (the process from encountering a scientific discovery until the decision to seize it and potentially initiate an innovation process) and research gap B (the determinants along this path). Please see Table 1 for a summary of the identified scholarly work.

Table 1: Literature overview of determinants affecting the likelihood to transform scientific knowledge into innovations

Category	No.	Attribute	Exemplary sources
A: Source of Knowledge	A _1	Scientist's Age	Haeussler and Colyvas (2011)
	A _2	Scientist's Gender	D'este and Perkmann (2011); Giuliani, Morrison, Pietrobelli, and Rabellotti (2010)
	A _3	Active engagement of academic researcher with the firm	(Murray, 2002)
	A _4	Level of recognition of the researcher	Zucker, Darby, and Armstrong (2002)
	A _5	Level of recognition of the university	Schartinger, Rammer, Fischer, and Fröhlich (2002)
	A _6	University vs. Company	Bikard (2012)
	A _7	Organizational standards	Argyres and Porter Liebeskind (1998)
	A _8	Social-contractual commitments	Argyres and Porter Liebeskind (1998)
B: Knowledge characteristics	B _1	Basic vs. applied research continuum	Dasgupta and David (1994); Nelson (1959)
	B _2	Incremental vs. disruptive innovation	Dasgupta and David (1994)
	B _3	Tacit vs. codified knowledge	Dasgupta and David (1994); Nonaka and Von Krogh (2009)
	B _4	Proof of Concept	Lee (2001)
	B _5	Interesting description	Crowd.science.com; zooniverse.org
	B _6	Attractive description	Lavis, Robertson, Woodside, McLeod, and Abelson (2003); Crowd.science.com; zooniverse.org
C: Transfer Channel	C_1	Patent vs. Scientific Journal Paper	Bikard (2012); Cohen, Nelson, and Walsh (2002); Murray and O'Mahony (2007)
	C_2	Conferences	Grigorov, Bayliss-Brown, Murphy, Thøgersen, and Mariani (2017) Laursen and Salter (2014)
	C_3	Collaborations	Grigorov et al. (2017);
	C_4	Active vs. Passive transfer	Grigorov et al. (2017) Laursen and Salter (2014)
	C_5	Degree of Openness / Accessibility	Cohen et al. (2002); Murray and O'Mahony (2007)

Table 1 (continued): Literature overview of determinants affecting the likelihood to transform scientific knowledge into innovations

Category	No.	Attribute	Exemplary sources
D: Recipient	D_1	Individual level absorptive capacity / Openness	Enkel, Heil, Hengstler, and Wirth (2017); Fontana, Geuna, and Matt (2006); Salter, Ter Wal, Criscuolo, and Alexy (2015)
	D_2	R&D time horizon of the innovator's position	Salter et al. (2015)
	D_3	Trust in science	Salter et al. (2015); Bikard (2012)
	D_4	Company size	Goel et al. (2017); Schartinger et al. (2002); Holgersson and Wallin (2017); Fontana et al. (2006)
	D_5	Sector	Bruneel et al. (2010); Schartinger et al. (2002)
	D_6	Degree of innovativeness	Community Innovation Survey
	D_7	Type of innovator	Community Innovation Survey
	D_8	Relative performance compared to competitors	Alexy, Bascavusoglu-Moreau, and Salter (2016)
	D_9	R&D investment	Alexy et al. (2016)
	D_10	Patenting activity / IP architypes	Alexy et al. (2016) Alkaersig, Beukel, and Reichstein (2015)
	D_11	Human capital (network size) / social capital within the organization	Alexy et al. (2016)
	D_12	Prior experience with scientific knowledge	Bruneel et al. (2010)
	D_13	Prior investment in external scientific knowledge – not own R&D	Bruneel et al. (2010)
E: Expected Outcome	E_1	Access to knowledge	Lee (2000)
	E_2	Networking	Lee (2000)
	E_3	Recruiting	Lee (2000)
	E_4	Risky "blue sky" research	Lee (2000)
F: Context	F_1	Spatial proximity	Arundel and Geuna (2004); Laursen, Reichstein, and Salter (2011); Mansfield and Lee (1996); Schartinger et al. (2002)
	F_2	Knowledge proximity	Schartinger et al. (2002)
	F_3	Social proximity	Alexy et al. (2016); Arundel and Geuna (2004); Boardman and Ponomariov (2009)

Source of Knowledge (Who…?)

Factors describing the source of knowledge can be differentiated in individual- and organizational-level factors. First, studies indicate that there is an effect of scientist's age (e.g., Haeussler & Colyvas, 2011), but with very mixed results (Perkmann et al., 2013). Regarding gender many studies reveal a higher ratio of male scientists to collaborate with innovators (e.g., D'este & Perkmann, 2011; Giuliani et al., 2010; Perkmann et al., 2013). However, to the best of our knowledge it remains unclear whether the scientist's age or gender is of relevance for the innovator or whether this is a spurious correlation. An individual-level factor that has been shown to influence the successfulness of scientific knowledge transfer is the university scientists' willingness to actively engage with the industry (Murray, 2002). She shows that spillovers arise from the co-mingling (founding, licensing, consulting and advising) instead of rather passive co-publication of the distinct science- and technology-networks. Furthermore, innovators willingness to seize knowledge from one or multiple researchers who came up with a scientific discovery seems also be influenced by the reputation of the researcher(s) as well as their host university (Zucker et al., 2002). The "Metthew-Effect" describes (simplified) that researchers that are already famous are more likely to be successful in terms of scientific rewards and collaborations compared to non-famous researchers (Merton, 1968). These researchers have a larger network triggering more co-publications from which they receive disproportionate credit independent of the nature of their true contribution. Furthermore, topics addressed by these researchers will be considered by outsiders as relevant because these researchers work on it. In line with that, Zucker et al. (2002) argue that only star researchers have tacit knowledge (vs. codified knowledge) that is even more valuable and thus, attractive for innovators to be seized.

Second, on an organizational-level university reputation is also considered crucial as it signals expertise and experience with industry interactions (Schartinger et al., 2002). In line with this, university standards to collaborate with industry such as Technology-Transfer Office (TTOs) have been found to have mixed effects on innovation transfer (Argyres & Porter Liebeskind, 1998; Bruneel et al., 2010; Siegel, Veugelers, & Wright, 2007). Nevertheless, by showing that scientific knowledge is seized more often if created by a corporate research team versus a university's researchers team Bikard (2012) shows that the organizational source (university vs. company) matters despite the existence of TTOs regarding the perceived attractiveness of scientific knowledge. From a university's perspective, also the social-contractual commitment of university researchers should motivate them to disseminate their basic research to create innovations (Argyres & Porter Liebeskind, 1998). In line with Schartinger et al. (2002) Argyres and Porter Liebeskind (1998) argue that university standards such as technology-transfer offices are introduced to stimulate scientific knowledge transfer (Argyres & Porter Liebeskind, 1998).

Characteristics of Scientific Knowledge (Says What….?)

Considering the characteristics of scientific knowledge there are three main literature streams. First, the nature of the knowledge itself (basic vs. applied research, degree of newness); second, how far it is developed (i.e., tacit vs. codified knowledge, existence of a proof of concept); third, how the knowledge is presented (e.g., interesting description).

First, scientific knowledge can be the result of any type of research on the continuum of basic vs. applied research (Dasgupta & David, 1994; Nelson, 1959; Stokes, 2011). Nevertheless, for innovators the underlying type of research might have implications for their decision to innovate as results from basic research are said to be more disruptive compared to findings from applied research (Dasgupta & David, 1994). The type of innovation (incremental vs. disruptive) requires different organizational capabilities such as absorptive capacity, that is to recognize the value of new information, assimilate, and apply it (Cohen & Levinthal, 1990; Ritala & Hurmelinna-Laukkanen, 2013) as well as appropriability regimes (Hurmelinna-Laukkanen, Sainio, & Jauhiainen, 2008). Thus, these two factors might be influential for innovators decision to seize scientific knowledge.

Second, innovator's ultimate goal is to successfully commercialize an invention. However, the failure rate of newly introduced products is high although it varies substantially depending on the definition of innovation and failure (Crawford, 1977, 1987). Also the process until marketing an invention is very risky for the innovator (Cozijnsen, Vrakking, & van IJzerloo, 2000). In accordance, factors reducing the perceived risk associated with the scientific discovery are able to increase the likelihood of transferring scientific knowledge into innovation. In this vein, codified knowledge is less risky as it can be learned and compared to other knowledge (Dasgupta & David, 1994; Nonaka & Von Krogh, 2009). The further the scientific knowledge is developed, and findings have been validated the lower the risk of failure before marketing the invention. Therefore, the existence of a "proof of concepts" that is, an already advanced validation of the functionality of the invention is also assumed to reduce the perceived risk and thus increase scientific knowledge transfer into innovations (Lane & Flagg, 2010; Lee, 2001).

Lastly, the description of the knowledge matters. The same discovery can be presented differently and adapted towards a certain audience. Research on crowd science indicates that not all scientific projects appear similarly attractive to all target groups (Franzoni & Sauermann, 2014). Crowd science and scientific crowdfunding platforms provide researchers with guidelines and best practices for their communication strategy for their projects appropriately (e.g., crowd.science.com; zooniverse.org). As a consequence, the presentation of a scientific knowledge influences the participation rate (Franzoni & Sauermann, 2014). Also Lavis et al. (2003) found that a target-audience orientation is beneficial for a successful knowledge transfer. Hence, the perceived interestingness and attractiveness of a scientific knowledge is considered to affect the transferring process.

Transfer Channel (Through Which Channel…?)

The transfer channel describes the way by which innovators learn about the scientific knowledge. The most common channels used by scientists are scientific journal articles (Nicholas et al., 2017), patents (Murray & O'Mahony, 2007), conferences (Laursen & Salter, 2014), but also consulting or collaborations (Bains, 2005; Cohen et al., 2002; Georghiou, 2015). However, to the best of our knowledge it remains unclear which channels innovators prefer to get information about scientific knowledge. On a more general level, one can differentiate between active and passive transfer of knowledge towards the innovator, that is, do scientists actively contact relevant innovators to inform them about new discoveries or do innovators need to search for the knowledge (Grigorov et al., 2017; Laursen & Salter, 2014). Another distinction can be made along the accessibility continuum of the scientific knowledge (Antelman, 2004). To be able to capture value from their innovations firms must be consider appropriation strategies such as publishing, patenting or secrecy (Holgersson & Wallin, 2017; Teece, 1986). Therefore, how much is already (publicly) accessible matters to the decision whether to collaborate with scientists for a certain innovation (Murray & O'Mahony, 2007).

Recipient's characteristics (To Whom…?)

Most of the factors proposed by prior studies to influence the innovator's willingness to seize knowledge from researchers refer to the innovating company itself. Similar to the source's characteristics these factors can be grouped into individual-level and organizational-level factors. One individual-level factor is the individual absorptive capacity (Cohen & Levinthal, 1990; Enkel et al., 2017) and openness (Salter et al., 2015). This concept has been established and most often applied in an organizational context. However, it appears valuable to assess absorptive capacity on an individual-level as individual employees play a key role in the innovation process (Salter et al., 2015). Individual openness is thereby regarded as the openness towards external knowledge sources in the first place (Salter et al., 2015). Thereby, a longer R&D time horizon of the individual's position (Salter et al., 2015) was shown to positively moderate the influence of individual-level openness on ideation performance. The authors argue that a shorter time horizon would increase the perceived coordination costs hindering the engagement in complex research projects. Another individual-level factor might be trust in science as some innovators prefer to seize scientific knowledge from corporate research instead of university research as they have concerns regarding the quality and rigor of the findings (Bikard, 2012).

Many scholarly research studies in this field are case studies. As a consequence, many organizational-level descriptive variables are discussed to affect the knowledge transfer likelihood. Thus, recipients characteristics such as size (e.g., Fontana et al., 2006; Goel et al., 2017; Holgersson & Wallin, 2017; Schartinger et al., 2002), the sector (Bruneel et al., 2010), the type of innovator (e.g., start-up, incumbent, governmental institution, or service provider) and the innovators' degree of innovativeness (see Community Innovation Survey by EU science and technology statistics) are often considered as control variables. By exploring relative performance to their aspiration-levels as driver for searching knowledge from external sources, Alexy et al. (2016) found a moderating influence by R&D investment, human capital in terms of internal network size, and patenting activities. Patenting activities also serve Alkaersig et al. (2015) to define four different IP archetypes based on different strategic considerations and organizations' resources. The last organizational-level factor is prior experience with scientific knowledge transfer activities that helps to overcome orientation-related barriers but not transaction-related barriers such as IP or procedural conflicts (Bruneel et al., 2010).

Expected Outcome (With What Effect?)

Absorbing knowledge from scientist has long been considered as beneficial as it allows to enter the market faster and potentially secure a first-mover advantage, especially regarding disruptive innovations (Beise & Stahl, 1999; Mansfield, 1991). Some motivations and barriers for innovators to engage with scientists are identified by Lee (2000). In general the access to new research and discoveries (i.e., solve technical or design problems, new product and process development, new patents, improved product quality, reorientation of R&D agenda, access to seminars and workshops) are considered as greatest benefits. In addition, networking with university staff, risky research (e.g., "blue sky" research, fundamental research) and the recruitment of graduates, drives engagement with universities.

Context (In Which Context?)

This category comprises all factors that are influential but either describe a relationship between categories (spatial, knowledge, and social proximity) or constitute the institutional environment of the potential knowledge transfer process (IP environment and country). Geographical proximity between the actors is still considered important for the successfulness of the knowledge transfer (Bikard & Marx, 2016; Laursen et al., 2011; Mansfield & Lee, 1996; Schartinger et al., 2002). Despite the improvement of communication channels spatial proximity is considered to ease tacit knowledge transfer (Arundel & Geuna, 2004). Knowledge proximity between the research discipline and the economic sector is regarded to allow for the mutual perceived interestingness of the interaction (Schartinger et al., 2002). Lastly, social proximity within the innovating organization (Alexy et al., 2016) and between the innovator and scientists has been shown in various contexts to positively affect the occurrence and the successfulness of absorbing scientific knowledge (Arundel & Geuna, 2004; Boardman & Ponomariov, 2009). However, Arundel and Geuna (2004) found that innovators stating a high importance of social proximity were less concerned about spatial distance.

In summary, these factors provide broad overview on determinants regarding the likelihood and successfulness to transfer scientific knowledge into innovations (see Figure 2). The following section qualitatively validates whether these factors are also considered by innovators to influence the decision to seize a certain scientific knowledge in the first place and second, whether and which factors remain disregarded.

Figure 2: Conceptual model based on literature review

Source of knowledge	Knowledge characteristics	Transfer channel	Recipient	Expected outcome	Context
Scientist's age	Basic vs. applied science	Patent vs. scientific journal paper	Individual level absorptive capacity	Networking	Spatial proximity
Scientist's gender	Incremental vs. disruptive innovation	Conferences	R&D time horizon of the innovator's position	Recruiting	Knowledge proximity
Active engagement of the researcher in the firm	Tacit vs. codified knowledge	Collaborations	Trust in science	Risky "blue sky" research	Social proximity
Level of researcher's recognition	Proof of concept	Active vs. passive transfer	Company size		
Level of university's recognition	Interesting description	Degree of openness / accessibility	Sector		
University's reputation	Attractive description		Degree of innovativeness		
University vs. Company			Type of innovator		
Organizational standards			Relative performance compared to competitors		
Social-contractual commitment			R&D investment		
			Patenting activity / IP architypes		
			Prior experience with scientific knowledge		
			Prior invest. in external scientific knowledge		

3. Methodology

This study follows a deductive-inductive qualitative approach aiming at validating and extending the conceptual model outlined in the previous section. Hence, we assess the relevance of the determinants of innovators' perceived attractiveness of scientific knowledge derived from existing literature and explore further factors. To do so, we conducted semi-structured in-depth interviews with different types of innovators and scholarly experts to explore what drives and hinders their decision to seize scientific knowledge for innovation purposes. Interviews are considered as most suitable approach to get an in-depth understanding about the opinions of the individual innovators (Crouch & McKenzie, 2006). Based on the results, we suggest a set of determinants that are then discussed in section 4.

3.1.1. Data Collection

To achieve a wide variety of different determinants we followed a theoretical sampling procedure (Coyne, 1997). Innovators selected for an interview needed to have experience with seizing scientific knowledge for innovation purposes. Furthermore, we strived for a heterogeneous background of the innovators. Hence, we aimed at having an equal distribution among the major types of innovators (start-ups, incumbents, service providers (e.g., consultancies), and public institutions). In addition, we interviewed two scholarly experts in the field of translating knowledge into innovation to enrich our data with further insights from prior research.

This resulted in a final sample of eleven interviews (female: 36%) with innovators from Denmark, Austria, US, and Germany (see Table 2). All interviews were conducted by the same interviewer to minimize interviewer biases (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). The interviews were conducted between May and November 2017 and took about 70 minutes on average. All interviews were audio-taped and transcribed.

Table 2: Description of interviewee sample

No.	Country	Type of innovator / *Expert*	Position of the Interviewee	Duration of interview (min)	Industry	Organization Size (employees)*	Founding year	Gender
1	Austria	Incumbent	Division Global Head R&D	65	Manufacturer	58,000	1852	Male
2	Austria	Start-up	CEO	69	Incubator	20	2003	Female
3	Denmark	Incumbent	Former CEO	64	Bio-Tech	6,500	2000	Female
4	Denmark	Expert	Professor	68	University	250	N/A	Male
5	Denmark	Service Provider	Head of Analysis	50	Consultancy / Policy Maker	25	2010	Female
6	Denmark	Incumbent	CEO	82	Bio-Tech		1987	Male
7	Denmark	Start-up	CEO	51	Pharma Bio-Tech	10	2006	Male
8	Denmark	Governmental institution	Head of Secretary	82	Politics Consultancy	10	2014	Female
9	Germany	Service Provider	CEO	30	Marketing consultancy	20	1979	Male
10	USA	Incumbent	Senior Researcher	93	Bio Materials	50	1973	Male
11	USA	Expert	Professor	60	University	30,000	N/A	Male

* Number of employees was rounded to assure anonymity.

3.1.2. Interview Guideline

The interview guideline is structured along five major sections (please see Appendix A for the complete guideline). First, interviewees were asked to think openly about where and how they search for scientific knowledge inputs to potential innovation processes. This initial question was followed by several sub-questions helping to guide respondents through their individual process to transform scientific knowledge into innovation. Second, interviewees were openly asked to think about the steps from hearing/learning about the scientific knowledge until their decision to seize it for innovation purposes (the initiation of the innovation process). Asking these questions allowed us to get more in-depth information about how innovators get aware of scientific knowledge, even if they do not necessarily absorb it for future innovations. Third, interviewees were shown the AIDA model and asked to what extend this model is applicable in the scientific knowledge transfer process. Fourth, they were shown the resulting table of categorized determinants from literature and asked to validate, comment and extend it. Fifth, respondents were asked eight questions about their professional skills, their position in the organization and the organization itself (only innovators, not experts). The guideline differed for scholarly experts only regarding the designation.

3.1.3. Data Analysis

All interviews were transcribed resulting in 207 pages of material. We followed an inductive-deductive approach searching for relevant determinants making scientific knowledge attractive to innovators. A Krippendorff procedure was applied for coding the data (Krippendorff, 2004). Therefore, a codebook with theory-driven codes (DeCuir-Gunby, Marshall, & McCulloch, 2011) was created by the research group. Then, all interviews were coded by two researchers independently, one from within the research group and one external research assistant. During the analysis both researchers followed two guiding questions: 1) where and how do innovators search for scientific knowledge? These codes indicated the different channels that researchers are using. 2) What factors make scientific knowledge attractive to innovators? The extracted codes indicate the determinants that were validated regarding the importance on the perceived attractiveness of scientific knowledge.

To extract the attributes and attribute levels, the results of both coders were compared and indicate an initial agreement of 82.3%. Disagreements (n=17) could be resolved quickly by discussing underlying reasons. After a second coding round a 100% agreement was achieved. A total list of 97 codes for determinants was extracted. These were then summarized into 56 distinct attributes in six categories: source of scientific knowledge, scientific knowledge characteristics, transfer channel, recipient, expected outcome, and context.

3.1.4. Results

In the following the results of the qualitative analyses are presented. First, the interviewees' evaluation of the AIDA model is depicted as suitable approach to address research gap A. Second, the validation and extension of the determinants presented in the conceptual model (see Figure 2) addresses research gap B.

The Process from Attention to Action

Regarding the AIDA model, interviewees expressed their agreement. Although most of them stated that they have not actively thought about that part of the transfer process. It further appears easy to understand for the interviewees. In general, they were quickly able to find their own processes in the model. For example, interviewee 7 stated: "If I understand correctly, some people in my little group or whatever they draw our attention to a given thing, a given observation, a given thing they've read, a given thing they've seen in our daytime that generates some interest. Out of that interest or research discussion, there can create a desire to go on and that will promote an action. If that's my understanding, then I think it's quite good". Likewise, interviewee 9 ("Looks like our pipeline."), interviewee 6 ("I think you can organize it in a similar manner."), interviewee 4 ("It seems very natural"), and interviewee 8 ("It's a very interesting idea.") find it appealing for their processes. Thereby, each step seems to be crucial as they are considered impossible to skip (Interviewee 7).

Besides the general agreement some critical statements challenged the model to overestimate the importance of a single scientific piece of research and that it oversimplifies the complexity of the knowledge transfer. In this vein, interviewee 3 stated about her experiences with companies: "They [companies] often describe it [a single piece of research] as one Lego brick of many and you often don't know if you're going to use it or not because there are so many bricks in play; so many potential avenues to choose; lots of uncertainty; lots of decisions to make along the way. So basically, you're trying to assemble a good set of Lego bricks. (…) maybe I'll use the brick in the final construction, maybe not. But you need to have the bricks so you know what have to work with". In addition, interviewee 3 and both experts in the sample added that the knowledge transfer process can take both ways – starting by the researchers (as indicated in the model) but also starting by the innovators actively searching systematically for information.

Determinants of Innovators' Perceived Attractiveness of Scientific Knowledge

Regarding the determinants influencing the innovators' perceived attractiveness of scientific knowledge we could not find validation for four determinants while 21 additional determinants could be added (see Table 3 for a list of adjustments made after the interviews to the factors extracted from the literature review). The categorization along the Laswell formula (Lasswell, 1948) was consistently considered as very suitable.

Table 3: List of adjustments compared to determinants

Category	Evaluation[a]	Attribute	Representative Statements (Interviewee No.)
A: Source of Knowledge	Not validated attributes	A_1 Scientist's age	"The scientists' age is absolutely irrelevant." (11)
		A_2 Scientist's gender	"Gender and Age is zero [important]." (7)
	New attributes	A_9 Scientist's academic title	"You need some professor who can stand up in front of anybody…and tell what the science looks like." (6)
		A_10 Institutional proximity	"The nationality of where that science originates, if it comes out of Sacre or it comes from Beijing, I would read that with some concern." (7)
		A_11 Entrepreneurial spirit	"if you want to start up a new company together, also personal characteristics are important, not only technical characteristics." (4)
B: Knowledge character-istics	Not validated attributes	B_3 Tacit vs. codified knowledge	"You need both" (6) "If we entered a phase where we actually base our advice to government and parliament or something, it would need to be written down. In the process of course, it's very interesting for us to talk with researchers and others who are working for the topic because it gives inspiration to us to write questions and we can say tendency." (8)
		B_6 Attractive description	"Obviously there's marketing and selling. The good entrepreneurs are no bullshit people. They really want to know the bottom line, and if you're very clear at explaining it, you're going to be more convincing." (10)
	New attributes	B_7 Novelty	"We have to find some new science, but I have to understand and meet by covering the new science with the market needs." (6)
		B_8 Scientific knowledge quality	"I'd be looking for things like, for example, if it's purely P-values and econometric studies, but no theory development ... Then I'll be interested but I'll be skeptical, because you don't really understand that ... Is it transparent where the data is coming from and how it's used and analyzed? That's also a criterion. So, there's something about the research integrity and link between empirical observations and theory development and the quality of that theory development, of course." (5)
C: Transfer Channel	New attributes	C_6 Tech-Transfer Offices (TTOs)	"The TTOs actually often makes it difficult to get easy access and set up a lot of constraints and definitions of areas where you're allowed to work, and where you cannot work together." (4)
		C_7 Consultancy	"In that respect, once in a while, it could be easier to have a consultancy bureau because they are very brave in drawing conclusions. Which might be good, which might also not be so good." (8)
		C_8 Reports	"So, when we buy consultancy reports, or we interact with a research group to finance that they're doing, report or some research, within an area, we always ensure that it's published or made public in a report." (8)
		C_9 Personal Network	"I mean, because I think that [person-to-person contract] has a lot to do with the technology transfer." (3)
		C_10 Coincidence	"Then we are kind of more searching really broadly and not really [systematically] you could say maybe a little by coincidence trying to [find knowledge]." (3)
		C_11 University websites	"So, if you start searching for something, it's pretty simple. You go into the annual report for the university, and you look at which research groups have published in Nature." (6)
		C_12 Social Media / Alerts	"Internet. Very important. Whether we are talking about social media or electronic databases or open access repositories, or online

Table 3 ***(continued)*****:** List of adjustments compared to determinants

D: Recipient	New attributes	D_14 Entrepreneurial Spirit	"The more dynamic entrepreneurship in an ecosystem the faster things are picked-up and transformed. The entrepreneurial spirit of the recipient is relevant. (2)
E: Expected Outcome	New attributes	E_5 Expected benefits for the innovator	"Another thing is, will it make our everyday easier? So, for example, it could be a technology you can't just commercialize. It won't be a product, but it can be researched to you will use to get more out of the hands you already have." (3)
		E_6 Expected market potential	"As I see my role has been for the last 20-plus years is to say, "How do we translate all this knowledge into something tangible, meaningful, that can be given to a patient?" Because, knowledge alone won't do." (6)
		E_7 Perceived uncertainty	"We consider feasibility very much. We evaluate the theoretical concept whether it can be implemented, what the risks are, and how implementation options look like. Because the technologies are premature." (1)
F: Context	New attributes	F_4 Organizational proximity	"I don't have PHD students but the professor I'm working with he has, postdocs and PHD students, and he's really, really important for us to have them highly motivated." (7)
		F_5 Number of innovators in the field / competition	"That's why we stay away from a competition with [other firms]. It's just not fruitful to compete at that level with your collaborator. So, it has that ... That's why a good, natural collaboration between an R&D firm like us and university counterparts are truly complimentary that something we're not really developing or going into their area." (11)
		F_6 Strategic fit	"I would add the scientific field or the application field, maybe. It's better to have the application field and whether it fits." (4)
		F_7 Timing	"It could be a really interesting technology, the thing is, you always have to be in line with what the business is doing right now, and what the budget is already for. So probably could be, "Wow, it's interesting but not right now." (3)
		F_8 Investor's preferences	„Where are the investors trends? Because investors also have their preferences changing in time. And some things are not initiated because of fear that something bad can happen. (…) And in this case, the technology can be extremely good, but if I do not get money to develop this further I simply cannot develop it." (2)

[a] After openly stating important factors they were presented a list of all factors derived from the literature and all of them were discussed. If none of the respondents claimed a factor as important or they claimed it to be less relevant, it was "not validated".

Source of Knowledge. In the first category, the characteristics of the source of the scientific knowledge, *scientist's age* and *gender* were emphasized to be irrelevant for the innovator's decision to follow up on a specific scientific knowledge. While the statements for gender were without any limitations, some interviewees mentioned that a researcher should not be too young due to a lack of track record (interviewee 2) or too old because "It's difficult if you have a scientist that's over 60… there's a perception that you get lazy" (interviewee 6). As new factors the *scientist's academic title* was mentioned. Interviewee 6 stated "Yes, it matters because it has to be professor somehow. (…) I'm sorry. No one wastes time". However, not all interviewees agree with this statement. Interviewee 11 argues that it's about whether they have the "knowledge and capacity to do what we're interested". Also, interviewee 5 summarizes: "In literature there's a correlation that if you're older; and or male; and or more senior; you're more likely to engage with industry. Presumably because you have the capacity to do it, because you have people helping you. (…) It's a signal that you know you can do something". *Institutional proximity* defined as shared norms and cultural values was mentioned by interviewee 7 stating: "We don't trust the Chinese" because "in our world, they cheat like hell". He further argues that it is not about the nationality of the researcher but of the university the science originates. "If it comes (…) from Beijing, I would read that with some concern". Also, interviewee 5 claims the lack of proximity dimensions besides spatial and knowledge proximity. *Entrepreneurial spirit* of the researcher was mentioned by interviewee 4 to increases the importance of researcher's individual characteristics.

Knowledge characteristics. Two factors were could not be validated. First, whether the scientific knowledge is *tacit or codified.* This seems to be less relevant for that stage as interviewee 5 states that it becomes relevant when they decide to collaborate because this is, when the tacit knowledge becomes relevant. Interviewee 6 argues that "you need both". Hence, whether the knowledge is tacit or codified seems not to be decisive for its perceived attractiveness. The *attractiveness* of the description has also been largely disregarded. Interviewee 1 argues that it is dependent on the topic what is considered as attractive. For example, modern technologies can be perceived as attractive provoking the wish to try them. However, the importance of an attractive display of the knowledge was consistently disregarded. The *degree of newness* was mentioned by several interviewees stating that on the one hand it helps them to "to get inspiration" (interviewee 8) but also that you have to cover unmet market needs with the innovation and that's why the knowledge must be really new (interviewee 3, 8, and 11). *Scientific knowledge quality* was emphasized by interviewees 5, 6 and 8. Especially the "transparency of the research data and methods" (5) is considered crucial along with the perception that the researchers really understand the phenomenon they are looking at including the theoretical foundation. Interviewee 6 concludes "I mean, it sounds ignorant or arrogant, best in class or first in class, or don't bother, but it is really true".

Transfer Channel. Besides the channels already included as relevant for the perceived attractiveness, the interviewees added some further ways of how they get aware of scientific knowledge. These include *Technology-Transfer Offices* (TTOs) and *reports* by *consultancies* that even provide them with summaries of the current scientific literature in a rather plain language (interviewee 8). However, this was solely mentioned by one of the governmental service provider. The interviewees differed in their experiences with TTOs. Some described "smooth processes" (interviewee 8), while others struggle with this view: "The TTO is mainly what I would call a pain, when you want to establish collaboration with existing companies" (interviewee 4). Another important channel named by all interviewees is the *personal network.* As typical forms were mentioned the interaction with colleagues or team members (interviewee 10 and 11), experts from the network (interviewee 3, 4, 7), mentors (interviewee 10), pyramiding (interviewee 1) or personal contacts in general (4, 5, 8, 9). Related was the notion that very often it seems to be *coincidental* that an innovator gets aware of a scientific knowledge (interviewee 3, 4, 11). In addition, university websites were mentioned to be frequented to look for experts (interviewee 2, 6, 7, 8). Also, *social media* was mentioned as final channel although only by interviewee 5 but indicating an increasing importance.

Recipient. All determinants related to the recipient of the knowledge were considered relevant. One additional factor is the *entrepreneurial spirit* of the recipient as this influences the pace by which scientific knowledge is seized for further innovation processes (interviewee 2).

Expected Outcome. All four factors were validated. However, three interrelated market relevant determinants were mentioned. The decision whether to consider the scientific knowledge is influenced by the *benefits for the innovator* itself. This can be additional value for the company (interviewee 3) either by facilitating everyday processes (interviewee 3) or by solving problems (interviewee 1). The other two factors describe the *expected market potential* and the *perceived uncertainty* with the scientific knowledge in question. Considering the market potential commercialization potential (interviewee 3, 11) and applicability of the invention (interviewee 1, 6), the creation of a business model and in line with that the investors interests (interviewee 2) as well as the potential to fulfill market needs by solving problems (interviewee 6). Interviewee 1 also added that there must be a next possible step after this invention. In line with that, the risks associated with the scientific knowledge in terms of its feasibility are considered in the decision process (interviewee 1, 2).

Context. Again, all prior identified determinants are considered relevant for the perceived attractiveness of scientific knowledge. Three more factors were mentioned by the interviewees. First, despite the proximity dimensions already mentioned (spatial, knowledge, social, and institutional) also *organizational proximity* needs to be added, that is how close the two organizations (innovator and source of knowledge) work together. As interviewee 3 comments: “I think [getting] access to a group of people who actually do really good science is also important”.

Likewise, the *number of innovators in the field* and thus the competition is mentioned by interviewees 2, 3, and 11. According to them it is important how the knowledge fits into the own strategy to stay competitive. This is very close to the *strategic fit* and the *timing* when the innovator gets aware of the knowledge. Thereby, the strategic fit also refers to the appropriate application field (interviewee 2). Lastly, the investors' preferences are mentioned as highly influential on the perceived attractiveness of scientific research. Interviewee 2 points out that the further development of scientific knowledge is expensive and therefore requires financial investment. However, if investors do for some reason not like this development no financial resources can be used despite the interestingness of a certain discovery. Please see Figure 3 for a summary of the extracted determinants.

Figure 3: Validated conceptual model

Source of knowledge	Knowledge characteristics	Transfer channel	Recipient	Expected outcome	Context
Scientist's age	Basic vs. applied science	Patent vs. scientific journal paper	Individual level absorptive capacity	Networking	Spatial proximity
Scientist's gender	Incremental vs. disruptive innovation	Conferences	R&D time horizon of the innovator's position	Recruiting	Knowledge proximity
Active engagement of the researcher in the firm	Tacit vs. codified knowledge	Collaborations	Trust in science	Risky "blue sky" research	Social proximity
Level of researcher's recognition	Proof of concept	Active vs. passive transfer	Company size	Expected benefits for the innovator	Organizational proximity
Level of university's recognition	Interesting description	Degree of openness / accessibility	Sector	Expected market potential	Amount of innovators in the field / competition
University's reputation	Attractive description	Tech-Transfer Offices	Degree of innovativeness	Perceived uncertainty	Strategic fit
University vs. Company	Novelty	Consultancy	Type of innovator		Timing
Organizational standards	Scientific knowledge quality	Reports	Relative performance compared to competitors		Investor's preferences
Social-contractual commitment		Personal Network	R&D investment		
Scientist's academic title		Coincidence	Patenting activity / IP architypes		
Institutional proximity		University websites	Prior experience with scientific knowledge		
Entrepreneurial spirit		Social Media / Alerts	Prior invest. in external scientific knowledge		
			Entrepreneurial spirit		

Note: Grey dotted lines indicate non-validated attributes.

4. Discussion

This section first summarizes the major findings that lead to insightful contributions as well as practical implications. The results can be summarized to three major findings. First, the AIDA (attention – interest – desire – action) model is considered by the innovators and experts as suitable scheme to understand the "first-sight" steps, before the innovator's decision to seize scientific knowledge is made. However, according to the statements it is not applicable without restrictions if the innovator already knows what scientific knowledge to search for. This means, the identified factors do not compensate for a lack of fit between what the innovator is searching for and the scientific knowledge seen. But, if innovators' search is still unspecified the model provides insights on what they perceive as attractive. Thus, the AIDA model is suitable to schematically illustrate the process when innovators do not have any definite ideas what scientific knowledge they are looking for. This finding address research gap A that is the understanding of the process starting at the first encounter with the scientific discovery until the innovators' decision to seize it to potentially initiate an innovation process.

Second, most factors identified by prior studies that influence the successfulness of scientific knowledge transfer process also influence the perceived attractiveness of scientific knowledge. However, at this early stage of the process, our data indicates that new factors become important, while others are not validated. These are in the category "source of knowledge" (Scientist's age and gender) and "knowledge characteristics" (tacit vs. codified knowledge, attractive description). Regarding the supposed irrelevance of gender it has to be noted that the nature of this study does not allow to impose the existence of a social desirability bias, especially as the interviewer was female (Krumpal, 2013). However interesting is, that innovators and experts in this study claim that an appealing description of the scientific knowledge does not influence their perceived attractiveness of the knowledge and that it even might have a negative influence. By providing list of 56 relevant determinants this study adds to research gap B that is identification of determinants along the process until innovators decide to seize scientific knowledge for potential future innovation actions. Therefore, this list adds to the understanding of individual-level, perceptual factors that need to be considered when researching scientific knowledge transfer.

Third, the categorization of determinants along the Lasswell formula results appropriate to structure determinants influencing the innovator's perceived attractiveness of scientific knowledge. Applying this model from the communication and marketing discipline offers a new angle on the scientific knowledge transfer process. This finding is in line the individual-level perspective and further adds to the knowledge required to address research gap B.

Hence, this study crosses traditional disciplinary boundaries by discussing problems located in the research field of the organization of scientific knowledge with models from marketing research. By addressing both research gaps A and B the findings hold three meaningful contributions. First, we propose a necessity to see the transfer process more holistic. This allows to recognize the importance of factors that increase the probability that innovators pay attention to a scientific discovery. In line with the AIDA model (Strong, 1925), creating attention, interest, and desire on behave of the innovator is crucial before any further actions such as contacting the researcher will occur. Using this framework, the finer grained elements of the innovators' decisions are identified, contributing to what before has been a black-box in knowledge-transfer research. Hence, we shed light on how innovators select the piece of scientific knowledge they want to spend time on investigating for potential future innovation processes. Furthermore, showcasing how these elements exist and guide innovators search for scientific knowledge is core for proposing policy implication regarding the design of communication and dissemination efforts.

Second, the findings propose a set of 56 relevant determinants that influence the innovator's perceived attractiveness of scientific knowledge for the initiation of the innovation process. To the best of our knowledge, this is the first study considering a) the innovator's perception of scientific knowledge and b) at this early stage of scientific knowledge transfer *before* the decision to seize knowledge for potential innovation is made. These perspectives reveal that not all relevant determinants have been identified so far. New factors such as scientific knowledge quality or the academic title of the scientist are considered relevant determinants at this early stage. While prior studies on scientific knowledge transfer (e.g., university-industry collaborations or patenting-licensing deals) often mention to face an omitted variable bias, our insights help to address this issue. The determinants as well as their categorization serve researchers as extensive collection of control variables and contingencies necessary to be considered to draw precise conclusions from their data.

Third, the interdisciplinary approach allows for new perspectives advancing current understanding of scientific knowledge transfer. By applying a client-centric perspective commonly used in market for technology and marketing research, the innovator is identified as client in the transfer process of scientific knowledge. In doing so, this study categorizes previously known and new determinants along the communication process in six categories. This provides a fruitful baseline for future studies to explore each of these categories in depth as well as contingencies and consequences. The application of this knowledge holds the potential to increase scientific knowledge transfer into innovations and thus, to increase value captured by scientific knowledge from university researchers for society.

Besides these theoretical implications, this study holds practical implications for researchers, policy makers, and university managers. Although factors from the categories “source of knowledge” are seldom adjustable by the researchers themselves, they can influence how the knowledge is presented (category “knowledge characteristics”) and through which channel it is disseminated. Being aware of different opportunities for making scientific knowledge attractive “at first sight” can increase the likelihood of the discovery to be transformed into an innovation. Likewise, the amount of scientific discoveries never being seized can be reduced. Thus, value can be captured more often form scientific knowledge transfer by researchers themselves and by society.

In the pursuit of this goal to increase the share of scientific knowledge being transformed into innovation, policy-makers and university managers can make use of this study’s findings. On the one hand they can run a discipline- or country-specific analysis of their “clients’” (i.e., innovators’) importance weights of the identified 56 determinants along six categories. This allows policy-makers and university managers to identify characteristics of a suitable environment for scientists to present their discoveries so that they are perceived by innovators as attractive “at the first sight”. On the other hand, the findings highlight the requirement of specialized support personnel and strategies to allow scientists to present their scientific knowledge appropriately. In line with this, these findings hold interesting insights for the evaluation of current and the design of future incentive structures that aim to foster science-based innovation rates.

5. Limitations and further research

This manuscript is the first part of a greater mixed-method project. The next steps include a quantitative study to test the proposed determinants. This will allow further conclusions about what types of innovators find what combination of determinants attractive when evaluating scientific knowledge. However, considering the manuscript at hand there are two major limitations opening avenues for future research.

First, although a heterogeneous sample of innovators was gathered some industries are not represented such as the agricultural or service sector. Nevertheless, by applying a theoretical sampling approach we were able to ask innovators with substantial experience. As in the first place the aim of an exploratory study is to get in-depth information, this is a prerequisite and strength of our sample. However, for future studies it would be of enormous value for practitioners and researchers to account for country and disciplinary differences. A quantitative study could be applied in several countries to see whether the preferred patterns of determinants hold despite cultural and legal differences (Sirmon & Lane, 2004).

Second, combining the AIDA model (process) and the six categories (determinants) provides insights on a general level. This requires, however, ignoring special circumstances (e.g., innovators, cultural and legal settings, research disciplines, and many more). However, this rather universal picture opens many opportunities for in-depth analysis. Therefore, an analysis of which determinants and categories are most important for each step to achieve innovators' attention, interest, desire, and finally the action holds a large potential for new insights. Overall, this paper hopefully provides a starting point for inspiring further empirical studies.

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Appendix A: Interview guideline

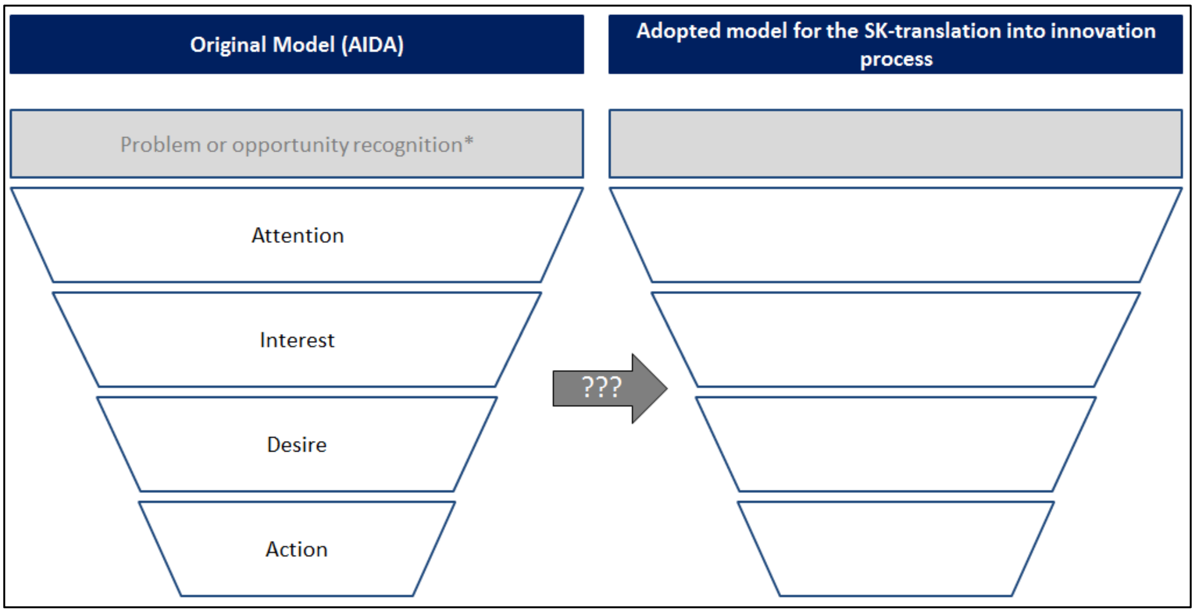
In the following I will ask you ten questions. Meanwhile, I'll send you a pdf file, but I would kindly ask you to not open it before question number 5.

At the end of the questionnaire we have some further short questions regarding your company. Your answers help us to further categorize your particular context.

Question [a]	Aim:
1. Where and how do you search for scientific knowledge that you can potentially use to create innovations?	Exploration of factors
2. In general, what factors makes scientific knowledge attractive to you? Are there any necessary conditions?	Exploration of factors
3. Think about the different steps within the process until initiating the transfer of scientific knowledge into innovations. What are these steps?	Exploration of transfer process
4. What factors influence your perceived attractiveness of scientific knowledge at each step? Please indicate the factors at each step.	Exploration of factors
5. Please have a look at the model. You see a stage-model (AIDA). Does such a process exist in the transfer of scientific knowledge into innovations? How would the steps look like and how would you call them?	Exploration of transfer process / test of AIDA
6. Please have a look at the following factors. You see four different categories of factors stated to affect the attractiveness of scientific knowledge. How would you personally rate the importance of each factor for the attractiveness of scientific research and why? Are there differences on the different steps within the process?	Validation of factors extracted from literature
7. Are there factors or categorizations missing that are important for your evaluation of scientific research to be attractive?	Exploration of factors
8. What do think about the structure (source, knowledge, channel, recipient, and context)? 8a. If yes, why? 8b. If not, what would be an alternative structure for factors influencing the attractiveness of scientific knowledge?	Validation of categories
9. Do you have any further comments regarding this topic that you could not share until now? Were you missing any question?	Further exploration

[a] For experts the formulation of the questions was slightly adopted: For example, question 1: "Where and how do innovators search for scientific knowledge that they can potentially use to create innovations?"

Figure accompanying Question 5:



Further Questions:

Question	Response Options
1. What is your position at your company?	[open]
2. How many full-time employees does your company currently comprise? [company size]	[open]
3. How would you personally rate the innovativeness of your company?	(1) Not innovative to (5) Very innovative
4. Has the company in the past picked-up scientific knowledge to create an innovation? 5. Has the company in the past invested in the external creation of scientific knowledge to create an innovation?	(1) No (2) Sometimes (3) Often (4) I don't know
Market performance: 6. If you think about your main competitor – would you say that you perform	(1) Worse; (2) Equal; (3) Better
Breadth of knowledge: 7. Considering your professional life, how would you describe your knowledge base?	(1) Very generalist (3) Both (5) very specialized
Mode of processing exploration input: 8. How is the exploration input being processed in your company?	(1) Rather in teams (2) Mixed (3) Rather individual (4) I don't know