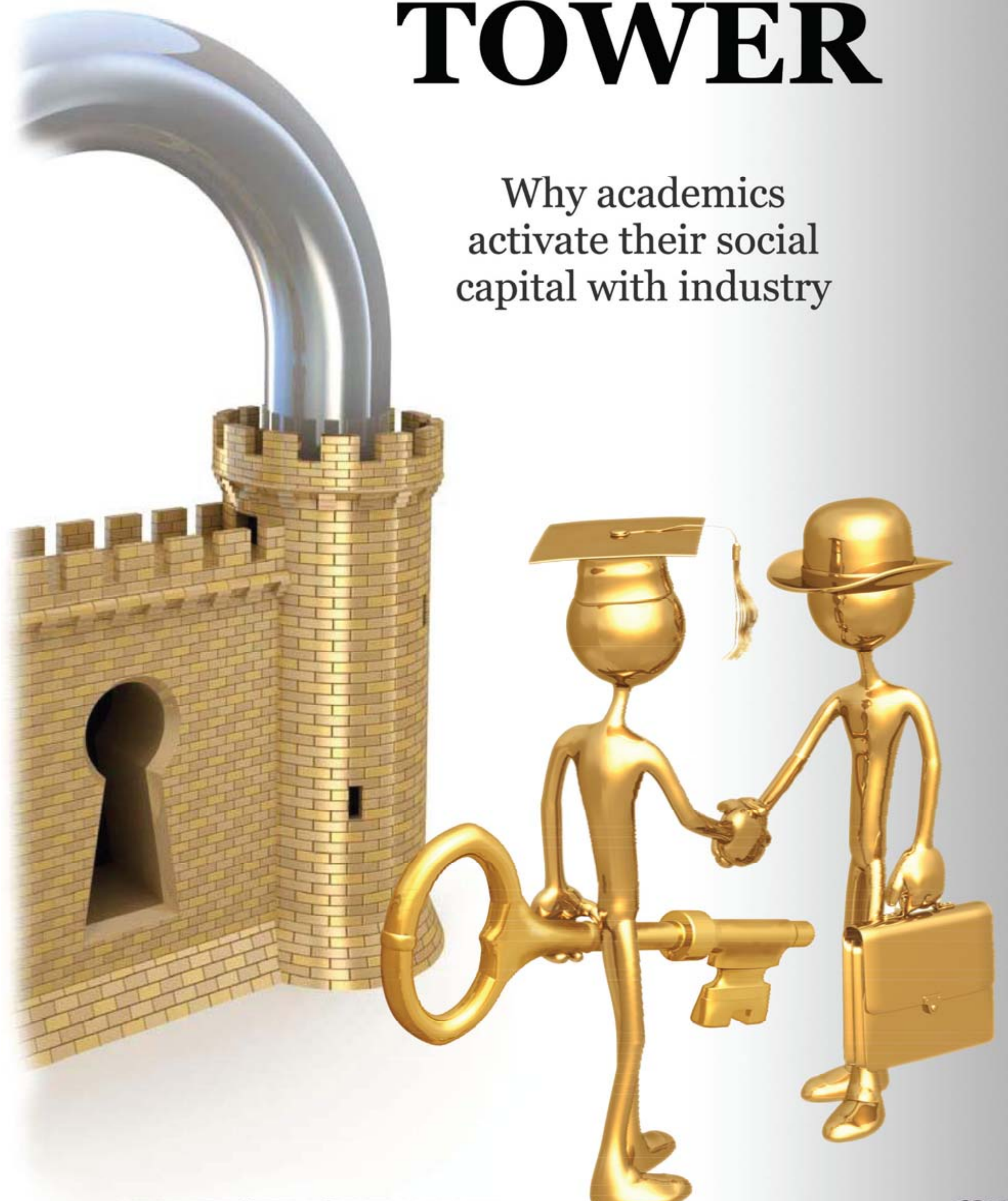
Kristina Dervojeda

DISSIDENTS OF THE IVORY TOWER

Why academics activate their social capital with industry



UNIVERSITY OF TWENTE.

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Why academics activate their social capital with industry

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Dissidents of the Ivory Tower: Why academics activate their social capital with industry

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DISSIDENTS OF THE IVORY TOWER
WHY ACADEMICS ACTIVATE THEIR SOCIAL CAPITAL WITH INDUSTRY

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1 Introduction

"Don't think you're on the right road just because it's a well-beaten path".
Unknown author

Dissidents of the Ivory Tower… These words are likely to evoke opposing images in the minds of various audiences. Some may envisage an image of rebellious anarchists spoiling an idyllic, noble and pure place. Others, on the contrary, may visualize valiant freethinkers who dare to go against an established set of rules and prefer to follow their own path. So how should the title of this work actually be interpreted?

In its original meaning, the term 'ivory tower' stands for a symbol of dignified beauty and purity. It first appeared in the Bible, in the Song of Solomon (7:4) ("*Your neck is like an ivory tower*") and was later included in the epithets for Mary in the sixteenth-century Litany of the Blessed Virgin Mary (Bull, 1999). However, in the nineteenth century, the term was picked up by Charles-Augustin Saint-Beuve, a French literary critic and poet, who gave ivory tower a new, far less noble flavor. In his poem called *Pensés d'Août* (Thoughts of August), Charles-Augustin describes Alfred de Vigny, a poet who was locked in his ivory tower remote from the cares and practicalities of daily life[1]. This work determined the way the term is used today. The modern ivory tower refers to a place or state of privileged isolation. Webster's Dictionary defines ivory tower as "a world or atmosphere where intellectuals engage in pursuits that are disconnected from the practical concerns of everyday life", "a secluded place that affords the means of treating practical issues with an impractical often escapist attitude; especially: a place of learning"[2]. The term 'ivory tower' is often applied to academia for its disconnectedness from practical matters, the implication being that academics who are so deeply drawn into their fields of study often can hardly find any linkages with activities outside their ivory towers.

However, while some use the Ivory Tower label as a metaphor for a degrading university, others, on the contrary, see it as an ultimate goal for the university to achieve. The latter idea is often associated with the notion of the so called Humboldtian University originally developed by the nineteenth-century Prussian Minister of Education Wilhelm von Humboldt. According to Humboldt, the

[1] For a complete explication of the term 'ivory tower' see M. Quinion (2001) "On Ivory Tower" WorldWideWords.org. http://www.worldwidewords.org/qa/qa-ivo1.htm
[2] http://www.websters-online-dictionary.org/definitions/

government must be convinced that it is in its own long-term interest to optimally support the expansion of scientific knowledge, and the latter can only be accomplished by securing the individual freedom of the scholar (Nybom, 2007). To enjoy extended freedom and autonomy, professors should refrain from the political and other 'external' ambitions, and the university should in general be separated from society…

Independent of whether one views the Ivory Tower as a symbol of nobleness and purity or as a metaphor for isolation and impracticality, as a matter of fact, not all academics prefer to stay disconnected from practical problems. Some of them depart from the sacred rules of the Ivory Tower and engage in interactions with industry, be it informal communication, collaborative research, consultancy work or other activities. Regardless of type of interactions, such academics commit themselves to connect their scientific activities to the practical matters and thereby per definition become dissidents[3] of the Ivory Tower. Consequently, the title of this work does not carry any judgmental touch.

'Dissidents of the Ivory Tower' or academics engaged in interaction with industry are the object of the current dissertation. In the introductory chapter, we first address the background of the phenomenon in question and thereby set the scene for the current research. We invoke the history of university-industry interactions and examine how the relationships between academia and industry emerged and evolved over time. We then move on to the economic effects of university-industry interactions and show that academics engaged in interactions with industry are considered a key driving force of the modern socio-economic development. We proceed to the essence of academics' interaction with industry and present it as a process of exploitation of existing social networks with industry or social capital activation. We then introduce the research problem and research questions. In the remainder of the chapter, we elaborate on the contribution of this study to research and practice, we present the research framework, the structure of the dissertation, as well as the delimitations of scope and key assumptions.

1.1 BACKGROUND TO THE RESEARCH

Nowadays, the main source of economic growth for developed nations is their capacity to innovate (Porter & Stern, 1999). Innovation is argued to be a key determinant of productivity improvement, competitive advantage and a nation's standard of living. The central role of innovation in economic growth has been

[3] Definition of 'dissident' in Webster's Dictionary: Disagreeing with an established political system, organization or belief

first emphasized by the contributions of Bush (1945), Schumpeter (1943), Solow (1956) and Abramovitz (1956), and since then has been confirmed by the work of various other scholars (for a detailed discussion on prior studies in the economics of innovation see, for example, Porter & Stern, 2000).

A nation's higher capacity to innovate, in turn, is argued to be influenced by knowledge transfer from university to industry resulting from university-industry interactions (Berman, 1990; D'Este & Patel, 2007b; Mitchell, 2008; Porter, 1998a; Romer, 1991; Rosenberg, 1963). Although historically, the industry sector has been the engine for innovation (Porter et al., 1999), companies often lack the necessary long-term in-house research capabilities that universities possess (Berman, 1990). Collaboration with universities, however, allows companies to get access to the university labs and to obtain the missing knowledge. Universities, in turn, get exposed to a wide range of practical problems thereby opening an array of research avenues that would not have emerged without university-industry interactions (D'Este et al., 2007b). University's advanced research combined with industry's downstream research activities and the understanding of user needs increases the probability of the actual application of the invention, i.e. innovation (Siegel, Waldman, & Link, 2003). This effect of university-industry collaborations on innovation has first been demonstrated by Rosenberg (see Rosenberg, 1963, 1982). Building on Rosenberg's early work, Romer (1991) confirmed the positive relationship between the "ideas" sector of the economy and the overall process of productivity growth in the economy (see Romer, 1991, 1996). Another significant contribution in this field refers to the work of Porter who showed the importance of clusters and their role in innovation and competitiveness (see Porter, 1998a; Porter, 1998b).

Existing research thus suggests that university-industry interaction is a key driver of innovation, and consequently also of economic growth. The current research, in turn, focuses on academics engaging in interactions with industry. Such academics represent the key agents of knowledge transfer from university to industry (OECD, 1996) and consequently are viewed as a driving force of the modern socio-economic development.

1.1.1 The emergence of 'dissidents' of the Ivory Tower

Academics' active engagement in interaction with industry is a relatively recent phenomenon. Historically, university and industry had distinct socio-economic missions and carried out non-converging tasks. Universities were supposed to contribute to general knowledge and had a primary mission of educating future scientific and technical workers. Industry, in turn, focused on product-oriented research and practical problems with more short-term horizon (Geisler &

Rubenstein, 1989). Interestingly, during the classical Industrial Revolution in the middle of the nineteenth century, the role of universities in developing technological breakthroughs (e.g., steam engines, textile, and wrought iron) was rather modest. Most of the inventions that changed the world came from the practical know how developed by engineers as a result of their trial and error approach (Viale & Etzkowitz, 2005b). At that time, there was hardly any collaboration between academics and engineers.

The situation slightly changed during the second Industrial Revolution that took place in the latter half of the nineteenth century and lasted until World War I. During that period, still dominated by engineers' trial and error approach, several inventions also emerged from the close collaboration between academia and industry (e.g., telegraphy, organic chemistry). This shift can be explained by the growing complexity of inventions and the need to integrate various 'micro-inventions' before a 'macro-invention' (e.g., the telegraph) can be created. Some of those 'micro-inventions' originated from the university (Viale et al., 2005b). As a result, the first academic revolution occurred, and a new mission of research was introduced into universities. The traditional task of teaching was expanded by the need "to include the methodologies for obtaining new knowledge as well as the passing on and reinterpretation of existing knowledge" (Etzkowitz, Webster, Gebhardt, & Terra, 2000). During that period, academics interacted with industry on an occasional, non-systematic basis (Etzkowitz & Webster, 1998; Jencks & Riesman, 1968).

In the early 1980s, the role of the university in the society was challenged again, this time by a new perspective suggesting that the university should play a central role in the process of innovation and making the university responsible for knowledge transfer to industry (Geuna, Llerena, Matt, & Savona, 2004). As a result, the second academic revolution occurred signifying the emergence of the 'entrepreneurial university' (Etzkowitz, 2008). The entrepreneurial university is responsible for "the translation of research findings into intellectual property, a marketable commodity, and economic development" (Etzkowitz et al., 1998). Via the development of 'third stream activities' or its 'third mission', the entrepreneurial university is expected to become a new engine of socio-economic growth (Etzkowitz, 2008; Geuna et al., 2004). Factors such as changing legislative environments (Mowery, Nelson, Sampat, & Ziedonis, 2004), increasing pressure on universities to help improve economic competitiveness (Greenaway, Haynes, & University of Nottingham. School of, 2000), as well as the growing number of policy initiatives to promote collaborative research (Zerhouni, 2003) and public-private research partnerships (Stiglitz & Wallsten, 1999) have contributed to a growing engagement of academia in interactions with industry (Fontana, Geuna, & Matt, 2006a; Perkmann, Walsh, & Campus, 2007).

Hence, in the last few decades, academic tasks have been redefined and expanded in response to the requirements of a new mission (Etzkowitz et al., 2000). The traditional task of teaching was expanded by the need to include in the curriculum 'real world' case studies and test students' academic knowledge in 'real life situations'. The task of research, in turn, was advanced by the need to spawn a wide range of local and regional linkages with companies and the shift from more traditional short-term contract research ties toward longer-term collaborations with industry and consequently stronger orientation toward applied research (Etzkowitz et al., 1998). Finally, the third task of commercialization of knowledge was added, including activities such as patenting, licensing and creation of spin-offs (Geuna et al., 2004).

This shift in the university paradigm has led to the emergence of a new generation of academics: '*entrepreneurial academics*'. Entrepreneurial academics are academics who are able to integrate basic knowledge with the innovation goal by combining two distinct perspectives: the academic and the industrial one (Viale & Etzkowitz, 2005a). Such academics often are the driving force behind university spin-offs and other commercialization activities (Meyer, 2003); however, their entrepreneurial orientation goes beyond activities related to the capitalization of knowledge. In a broader sense, entrepreneurial academics refer to academics who look for entrepreneurial ways to pursue their teaching, research and commercialization interests, in particular by actively engaging in university-industry interactions (Gulbrandsen, 2005; Meyer, 2003). Examples of such interactions refer to informal communication, consultancy work, joint research, setting up spin-off companies etc. and imply activities with both low and high relational involvement (Perkmann et al., 2007).

1.1.2 The role of social capital

Academics' engagement in interaction with industry is possible due to the existence of social networks between academia and industry. Social networks represent a structure for relationships that bridges otherwise disconnected individuals (Burt, 2000; Grootaert, Narayan, Jones, & Woolcock, 2004; Putnam, 1993). However, the structure alone is not sufficient for interactions to occur, and the content is needed (Adler & Kwon, 2002; Lin, Cook, & Burt, 2001; Portes, 1998). The content here refers to the resources that academics are able to procure by virtue of their relationships with industry and vice versa (Grootaert et al., 2004). Structure and content together, in turn, form the foundation of *social capital* between academia and industry. Social capital can thus be defined as a durable network of more or less institutionalized relationships of mutual acquaintance and recognition in which actual or potential resources are embedded (based on the definition by Bourdieu, 1985). We will elaborate on the notion of social capital in the next section.

Besides enabling the very process of interaction, academics' social capital with industry leads to a series of benefits such as information; influence, control and power; and solidarity (Sandefur & Laumann, 1998). Firstly, social capital facilitates access to broader sources of information and improves information's quality, relevance and timeliness (Adler & Kwon, 2002). Academics engaging in interaction with industry are, for example, likely to keep abreast of industry problems (D'Este et al., 2010; Santoro & Gopalakrishnan, 2000; Thach, Gvozdiov, & Hull, 2005), get access to industry knowledge (Baldini et al., 2007; Lee, 2000; Meyer-Krahmer et al., 1998a; Perkmann et al., 2009) and obtain materials that would allow them to support their teaching duties (Belkhodja & Landry, 2007; Carayol, 2003; Gulbrandsen, 2005; Santoro & Chakrabarti, 1999). In case of the latter, academics may develop student assignments based on patents, they may organize field trips to spin-offs, they may include actual commercialization cases in their curriculum, and finally, they may regularly contact their industrial acquaintances to see if there are any practical problems suitable for student projects (Gulbrandsen, 2005). In some cases, information benefits gained by an academic lead to positive externalities for a broader group. Social capital enables brokering activities, and if those rely on a reciprocal outflow of information, the entire network will benefit from the diffusion of information initially obtained by a certain individual (Burt, 1997). When academics have frequent and regular contacts with industry, not only do they transit knowledge directly, but they become more familiar to thinking in terms of application and commercialization; they become more adept at seeing potential uses for their research. Furthermore, they build strategically valuable social networks in the marketplace (Mitchell, 2008).

The second benefit of social capital refers to influence, control and power (Adler & Kwon, 2002). Academics interacting with industry link otherwise disconnected worlds of university and business. Because these academics have a say in whose interests are served by the bridge, they can often negotiate the terms favorable to these interests, and thus become powerful actors (Burt, 1997). Burt also argued that individuals spanning structural holes are more powerful because they can control projects that connect other groups.

The third benefit of social capital is solidarity. Strong social norms and beliefs associated with a high degree of closure of the social network stimulate compliance with local rules and customs and therefore reduce the need for formal controls (Adler & Kwon, 2002). As a result, such 'trust' networks are likely to transmit more sensitive and richer information than other types of networks because of the solidarity aspect (Hanson & Krackhardt, 1993). Existing research suggests that both prior experience of working together and prior experience of collaboration in the broadest sense are important factors for the success of university–industry interaction (Barnes, Pashby, & Gibbons, 2002).

1.1.3 Conceptualization of social capital

The notion of social capital is central in examining the process of university-industry interactions. However its origins are to be found in other scientific domains. The first scientific attempts to conceptualize social capital date back to the nineteenth century work by Emil Durkheim and Karl Marx (Portes, 1998). The sense in which the term is used nowadays has been introduced by Hanifan (1916) who "invoked the concept of social capital to explain intangible assets [that] count most in the daily lives of people: goodwill, fellowship, sympathy and social intercourse among the individuals and families who make up a social unit (Productivity Commission, 2003, quoted in Batt, 2008, p. 487)". The latest wave of interest towards the concept has been caused by the work of Pierre Bourdieu (1980) who offered "the first systematic contemporary analysis of social capital" (Portes, 1998, p. 3). Consequently, social capital has been capturing the attention of social scientists for almost two centuries now, with a number of periodical flashes of interest that eventually resulted in "the most important movement in recent social history" (Bowey & Easton, 2007, p. 275).

Although the concept of social capital might presently experience its Renaissance period, the debates of scholars on the essence of social capital have resulted into actual paradigm wars and elusive definitions of the concept. As warned by Lin (2001, p. 48), "chances are that social capital would fade away as an intellectual enterprise for the ever broadening and confounding definitions and almost utopian expectations of its practical applications", or as Portes (1998, p. 2) has put it, "the point is approaching at which social capital comes to be applied to so many events and in so many different contexts as to lose any distinct meaning".

One of the main sources of disagreement among social capital scholars refers to the essence of social capital, and divides most of the current research into three branches. The first branch associates social capital with the formal structure of the ties that make up the social network. This approach is most closely associated with political scientist Robert Putnam and sociologist Ronald Burt (Grootaert et al., 2004). The second branch focuses on the content of the ties and "refers to the resources (such as information, ideas, support) that individuals are able to procure by virtue of their relationships with other people" (Grootaert, Narayan, Jones, & Woolcock, 2004, p. 3). The authors associated with this approach include, among others, Alejandro Portes and Nan Lin. The third stream of scholars, in turn, has attempted to integrate both approaches and suggested to view social capital as a combination of both structure and content (Adler et al., 2002; Bourdieu, 1980). In this research, we would like to support Weick (1999) and Adler and Kwon (2002) in their attempt to encourage dialogue across perspectives. We will thus view social capital as a combination of both structure and content of social networks.

Another source of disagreement refers to two different levels of analysis: the individual and the group level. Some scholars (for example, Fukuyama, 1995; Putnam, 1995) conceive social capital as a quality of groups, while others view social capital as individual's social relationships (Borgatti et al., 1998; Coleman, 1990). Some authors, however, have argued that social capital is formed at many different levels of societal organization (Turner, 2000), and therefore, there is no reason for conflict between individual-based and group-based view of social capital (Adler et al., 2002; Burt, 1982; Bourdieu & Wacquant, 1992; Lin, 2001; Nahapiet & Ghoshal, 1998). As Glaeser (2001, p. 5) suggested, "thinking about individual social capital is a prerequisite for thinking about the formation of community social capital". As a result, each level gives us somewhat different picture about social capital (Turner, 2000). Such approach is also in line with the theory of embeddedness by Granovetter (1985), who argued that since actual reality is not divided into levels, analysis at one level inevitably includes analysis at the other one. Therefore, in this study, we will analyze individual social capital while also taking into account group characteristics.

Along with the abovementioned paradigm wars, in the past three decades, the concept of social capital has penetrated a wide range of social science disciplines including sociology (Coleman, 1990; Lin, 2001; Portes, 1998), political science (Fukuyama, 1995; Putnam, 1995) and economics (Glaeser, 2001; Woolcock, 1998). Research in those disciplines has shown that social capital generates important effects on virtually every aspect of our lives, including areas like youth behavior, democracy and governance, public health, education and employment, career success, leadership and performance, creativity and innovation, as well as entrepreneurship and the creation of start-up companies (for overviews see Adler et al., 2002; Borgatti et al., 2003; Jackman & Miller, 1998; Portes & Sensenbrenner, 1993). Social capital is viewed as a powerful asset, and it is under close attention of management scholars, economists and policy makers (Portes, 1998).

1.1.4 Social capital activation

As described above, academics' social capital with industry represents a powerful asset and is an enabler of university-industry interactions. However, simply because an academic has social capital available for use does not mean that he or she will use it immediately (Foley & Edwards, 1999). Existing research suggests that there is a difference between the possession and the actual exploitation or 'activation' of social capital (Adler et al., 2002; Anderson, 2008; Burnett, 2006; Foley et al., 1999; Hebert, Lee, Sun, & Berti, 2003). Social capital activation can be defined as the point at which mobilizable resources are shared – "*when one or more actors provide instrumental or expressive aid to others, beginning or continuing a series of non-negotiated or reciprocal exchanges*" (Smith, 2005).

In the context of university-industry interactions, social capital activation is the point at which the first or sequential reciprocal exchange of (information) resources occurs between the academic and the industrial partner via the network of relationships. The current study exclusively focuses on information resources since those refer to the most popular means of exchange between interaction partners via networks of relationships, and often precede the exchange of other types of resources, e.g., economic or reputational resources (Bourdieu, 1985; Portes & Sensenbrenner, 1993). Social capital activation may take the form of face-to-face, phone, e-mail or other type of communication.

This view of social capital activation is consistent with social capital conceptualizations by Pierre Bourdieu (1985) and James Coleman (1988; 1990), both of whom emphasized the importance of reciprocal exchanges for social capital development and the facilitation of its activation. The reciprocal nature of such exchanges implies that both actors have an effect upon one another, and this idea of a two-way effect is essential in the concept of interaction (Pinar, Reynolds, Slattery, & Taubman, 2000). This effect can be of both short-term and long-term nature. Expected long-term effects refer to the notion of generalized reciprocity (Adler et al., 2002; Portes, 1998; Putnam, 1993; Uzzi, 1997) that implies the principle "I'll do this for you now, knowing that somewhere down the road you'll do something for me" (Putnam, 1993). The exchange of resources can occur either for the first time or it can be sequential, i.e., when interaction partners have already been engaged in social interaction with each other some time before.

Social capital can thus be viewed as a dynamic asset constantly switching between passive and active modes. The passive mode here refers to the possession of social capital without making use of it at a certain moment of time, while the active mode implies the actual exploitation of social networks at a certain moment of time. Furthermore, the way social capital is maintained in the past is likely to have a direct influence on social capital activation in the future (Adler et al., 2002).

Figure 1-1 illustrates the distinction between passive and activated social capitals. As can be seen from the figure, at moments when reciprocal exchange of resources does not occur between Actors A and B, social capital should be considered passive. In other words, passive social capital refers to networks that might be exploited (or activated) should the necessity arise. At moments when reciprocal exchange of resources does occur between Actors A and B, social capital should be considered activated.

We can speak of passive social capital if Actor A and Actor B already have an established social relationship, where an established social relationship implies the presence of an interpersonal tie (Friedkin, 1980; Granovetter, 1973; Henning & Lieberg, 1996). Nevertheless, the exchange of resources between Actors A and B can also happen for the first time for it to be called ‘social capital activation’. As a result, social capital activation per definition does not always have to be preceded by passive social capital. The notion of social capital activation implies that an individual’s social capital at a certain moment of time represents a sum of his or her passive and activated social capitals.

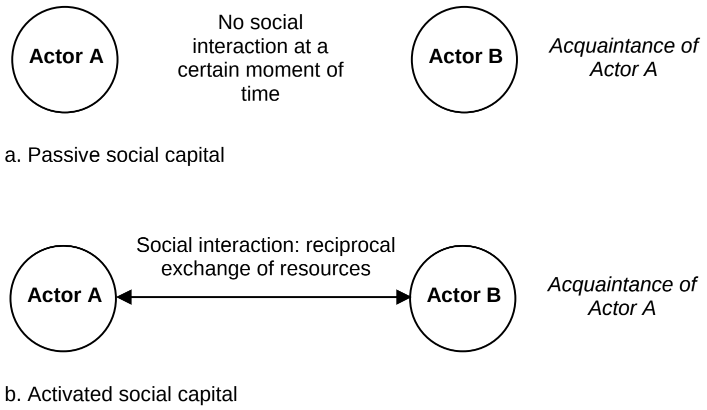

Figure 1-1: Passive (a) and activated (b) social capitals

Finally, social capital activation can result from both planned and unplanned behavior. For example, if an industry representative initiates an interaction with an academic researcher, and reciprocal exchange of (information) resources occurs between both actors, social capital of an academic can still be considered activated. In this example, academic’s behavior is unplanned.

1.1.5 The effects of social capital activation

Social capital activation represents the way of capturing potential benefits of social capital and is thus expected to produce various effects that can be of both positive and negative nature. The following effects are of particular relevance here.

First, continuous activation of social capital with a particular partner is likely to strengthen a social tie with that partner. On the contrary, if social capital does not get activated, social connections are likely to deteriorate over time (Adler et al., 2002). Consequently, social capital needs to be exploited in order not to lose existing connections. Figure 1-2 illustrates the evolution of a network tie depending on whether it is activated or not. For example, after an academic got acquainted with an industry representative during a networking event, a relationship was established and information was exchanged. The initial tie is weak, and its strength in the future depends on how often those individuals will interact with each other. Continuous exploitation of this contact is likely to strengthen the tie with time, whereas lack of activation of this tie is likely to lead to its deterioration. By deterioration we mean situations when people do not consider each other as acquaintances anymore (see the notion of "absent ties" in Granovetter, 1973). The weaker the tie, the less time is needed for that tie to deteriorate if it does not get activated. Consequently, a lifespan of a tie can vary from several weeks for extremely weak ties to decades for extremely strong ties.

Tie strength is, in turn, a direct predictor of a type of exchanged information (Adler et al., 2002; Granovetter, 1973, 2005; Hansen, 1999). By a type of exchanged information one should understand the novelty and the complexity of exchanged knowledge. The latter consists of the level of codification, i.e., explicit vs. tacit knowledge, and the extent to which these types of knowledge can be transferred independently. While explicit knowledge is revealed by its communication, tacit knowledge is revealed through its application (Grant, 1996). Consequently, the transfer of the latter is typically slow, costly and uncertain (for an extensive overview of the properties of tacit and explicit types of knowledge see, for example, Teece, 1986b; Winter, 1987; Zander & Kogut, 1995). Weak and strong social ties both have their strengths and weaknesses with regard to facilitating search for and transfer of different types of knowledge (Hansen, 1999). Consequently, by influencing the tie strength, social capital activation has an indirect effect on the type of information being exchanged in the future.

Furthermore, social capital activation allows earning back one's investments with regard to social capital formation (i.e., the creation and maintenance of social capital). Like other forms of capital (e.g., economic, cultural), social capital is a long-lived asset into which other resources can be invested. These investments are expected to lead to a future flow of benefits such as superior access to information, power, and solidarity (Adler et al., 2002). Examples of such investments refer to time and financial resources spent by an individual on attending conferences or other networking events that may have led to formation of contacts with certain interaction partners. If no use will be made of those contacts in the future, the investments are not likely to lead to any results. Lack of social capital activation, therefore, implies low return on investment since the acquired asset is not used and thus is not likely to produce desired benefits.

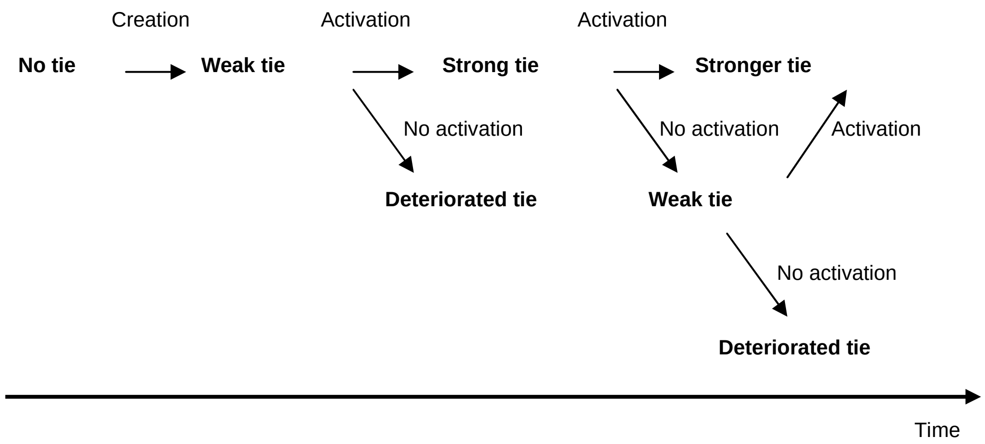

Figure 1-2: Evolution of a network tie as a result of (lack of) social capital activation

At the same time, too much activation of social capital or overinvestment can also create a negative effect and transform a potentially productive asset into a constraint and liability (Adler et al., 2002; Gabbay & Leenders, 1999; Gargiulo & Benassi, 1999; Hansen, Podolny, & Pfeffer, 1999). The opportunity costs of such investments may become too high; an individual may get distracted from other interactions, tasks and roles. Furthermore, similar to other forms of capital, when investing in social capital, the benefits are of potential nature, and there is no guarantee of success. Hence high investments do not necessarily imply high returns.

Consequently, while being a powerful asset, social capital is not an exogenous force; it is itself a consequence of other dynamic forces and requires constant maintenance. The distinction between passive and activated social capital and its constant switching between the two modes form the grounds of the current research.

1.2 RESEARCH PROBLEM AND RESEARCH QUESTIONS

In the previous section, we aimed to set the scene for the current research. We showed that being a key driver of innovation and economic growth, university-industry interaction represents a phenomenon of high practical importance. We also examined the essence of academics' interactions with industry, illustrated how such interactions emerged and evolved over time, and highlighted the central role of social capital in this process. Finally, we demonstrated the need to distinguish between the possession and the exploitation or activation of social capital. We showed that the actual interaction occurs only when social capital is activated. The objective of this section is to situate and diagnose the research problem and to derive the corresponding research questions.

1.2.1 Research problem

The evidence that economic growth is dependent on university-industry interactions has boosted the number of national and international policies and programs oriented towards promoting such interactions (Audretsch, Bönte, & Krabel, 2010; Branscomb, Kodama, & Florida, 1999; D'Este et al., 2007b; Jencks & Riesman, 2002; Perkmann et al., 2007). Given a central role of universities in this process (Balconi, Breschi, & Lissoni, 2004), a growing number of initiatives specifically targets academic institutions (Etzkowitz, 2004). Such initiatives often stress the necessity of building a large scale support system, e.g., a high-tech campus that includes shared laboratories, technology transfer offices, incubators and the like (Magnusson, McKelvey, & Versiglioni, 2009).

However, policies that are primarily targeted at institutions are likely to have a limited impact unless those take a better account of individual academics engaged in interactions with industry (D'Este et al., 2007b; Magnusson et al., 2009). As interaction with industry is not a compulsory task contrary to teaching, new incentive mechanisms are needed to specifically encourage academics to activate their social capital with industry (Geuna et al., 2004). The design of effective knowledge transfer policies and incentive systems, in turn, requires a good understanding of *why academics activate their social capital with industry at all* (Audretsch et al., 2010; D’Este & Perkmann, 2010; Lowe, 2006; Perkmann & Walsh, 2009).

Existing research on this issue is, however, fragmented and scarce (D'Este et al., 2007b; Fontana et al., 2006a; Geisler et al., 1989; Magnusson et al., 2009). Scientific studies that so far have contributed to the debate on university-industry interactions have mainly analyzed the determinants of those interactions either from the perspective of firms (Cohen, Nelson, & Walsh, 2002; Fontana et al., 2006a) or from the viewpoint of the university/department (Friedman & Silberman, 2003; Schartinger, Schibany, & Gassler, 2001; Tornquist & Kallsen, 1994). A few studies have examined the determinants of university-industry interactions taking individual academics as the unit of analysis (Agrawal & Henderson, 2002; Bercovitz & Feldman, 2003; D'Este et al., 2007b). The studies that do look at individual academics, in turn, follow heterogeneous and often non-converging approaches and typically exclusively focus on basic demographic variables (e.g., age, hierarchical position and gender of academics). Consequently, there is a clear need for the integration of various research streams and for the development of a comprehensive understanding of the phenomenon in question.

The following three main observations can be made regarding the existing research. Firstly, there is still lack of agreement in existing literature on what essentially drives academics to activate their social capital with industry. For example, one group of authors emphasizes the role of individual characteristics of academics (Cukierman, Fontana, Sarfatti, & Nuova, 2007), while other group suggests that it is mainly an interaction between the academics and their environment that enables them “to identify and act upon innovative opportunities” (Holmen, Magnusson, & McKelvey, 2007; Magnusson, McKelvey, & Versiglioni, 2008). Another possible explanation refers to the academics’ belief in their own abilities to interact with industry (Bandura, Adams & Beyer, 1977, Bandura, Adams, Hardy & Howells, 1980 quoted in Ajzen, 1991). Finally, some authors argue that academics’ future decisions to activate social capital with industry are based on their prior experiences (Audretsch et al., 2010; Hite, 2005). The current study aims to put these existing views next to each other and, by means of their reciprocal confrontation, to examine which of them explain larger variance in social capital activation.

Secondly, existing research suggests that there are only few academics actively engaged in university-industry interactions, while the majority of academics are much less ‘socially active’ in their relationships with industry (Agrawal et al., 2002; Balconi et al., 2004; Cukierman et al., 2007; D’Este & Patel, 2007b). For example, only few academics turn out to be involved in a wide range of university-industry interactions (Cukierman et al., 2007). Furthermore, certain academics collaborate with more than forty industrial partners, while the majority interacts with only one or two industrial acquaintances (Balconi et al., 2004). The same variance can be observed in the total time that academics spend on interactions with industry, as well as in the frequency of their interactions. The reasons behind this heterogeneity are, however, underexplored, both theoretically and empirically (D’Este et al., 2007b). This study aims to contribute by examining the differences between academics who are prominent in university-industry interactions and their more ‘traditional’ colleagues, thereby shedding light on the reasons for such heterogeneous behavior.

Finally, existing research lacks comprehensive explanations of who in academia activates social capital with industry and why (D'Este et al., 2007b; Magnusson et al., 2009). The latter is particularly important for the design of effective public policies (Bercovitz et al., 2003; D’Este et al., 2007b). It is the task of the scholars to provide policy makers with valid and reliable evidence suggesting a clear direction for measures to be taken. Policy makers and university administrators willing to boost university-industry interactions need to ensure that academics receive the necessary facilitation to encourage and enable them to engage in interaction with industry. The required adjustments may relate to incentive systems, organizational structures, administrative and process requirements, as well as provision of specific services and facilities. The design of effective policies and strategies requires a good understanding of factors that can and should be influenced in order to shape academics' behavior. The current study aims to contribute in this respect. After identifying the circumstances under which academics activate their social capital with industry, we aim at translating the research findings into a set of practical recommendations for policy makers and university administrators.

Figure 1-3 presents the structural logic of the research and contains the key questions this research aims to answer. We will elaborate on each of these questions in the next sub-section.

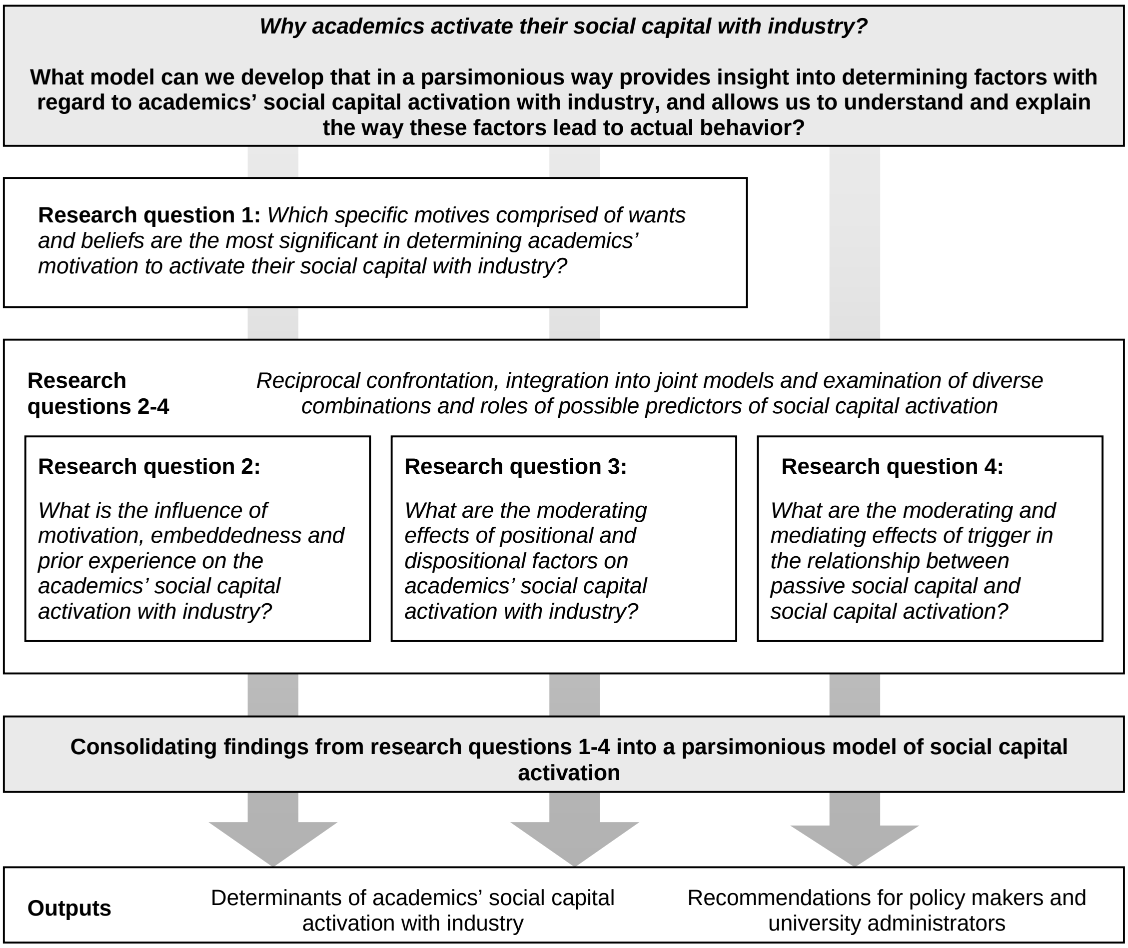

Figure 1-3: Structural logic of the research

1.2.2 Research questions

If existing social networks provide opportunities for interactions, it is crucial to understand the factors that influence the academic's decision to exploit those opportunities (Anderson, 2008; Burt, Jannotta, & Mahoney, 1998). It is reasonable to assume that a certain behavioral mechanism exists that determines when and to what extent academics activate their social capital with industry. By a mechanism here one should understand constellations of factors that are organized such that they regularly bring about a particular type of outcome (Hedström & Ylikoski, 2010), i.e., social capital activation. The key benefits of the understanding of the determinants of behavior refer to the ability to explain why it happens and thus to control/shape that behavior, if necessary. Such knowledge could better equip policy makers and university administrators to adjust their current strategies and measures with regard to university-industry interactions. It could also help scholars and practitioners learn how to influence the development of social capital of academics and how academics can get most out of its potential effects.

As mentioned above, so far, scholars were in search of factors that are best able to predict academics' behavior, such as the demographic characteristics of academics (e.g., hierarchical position, scientific orientation, gender, academic excellence) and university and departmental characteristics (e.g., the age and the breadth of a university, departmental income and staff) as the main proxies of engagement of academics in university-industry interactions (Bercovitz & Feldman, 2008; Cukierman et al., 2007; D'Este et al., 2007b). Although such approach enriches our knowledge on how actively academics will exploit their social networks with industry in the future, it also has a limitation. Such approach does not provide us with knowledge on factors that can be influenced, and how exactly the desired behavior can be stimulated, i.e., knowledge essential to the development of effective policies and measures. This limitation can be solved by improving our understanding of the antecedents of social capital activation and the relationships between them.

Social capital studies, in turn, have mainly focused on the structure of relationships between actors, and have only recently started considering the influence of characteristics of individual actors on the realization of social capital benefits (Anderson, 2008; Ibarra, 1995; Stevenson & Greenberg, 2000). To our knowledge, the only conceptual model of social capital activation that incorporates dispositional factors such as motivation or ability refers to the one by Adler and Kwon (2002). Despite its utility in explaining a complex causal process leading to the formation and development of social capital, the model is however inappropriate for empirical tests. Its very strength – providing a picture of complex configurations of causality – makes it too global to test as a whole.

Consequently, existing research lacks testable and, at the same time, comprehensive explanations of why academics actually activate their social capital with industry, which, in turn, makes it difficult for policy makers and university administrators to design effective policies and measures to support university-industry interactions. The current study aims to contribute in this respect. The overall objective of this research can be formulated as follows: *to develop a comprehensive but parsimonious model that provides insight into the key determinants of academics' social capital activation with industry, and to understand and explain the way these factors lead to actual behavior.*

In order to develop a parsimonious model of academics' social capital activation with industry, we will analyze the question of why academics activate their social capital with industry from the following perspectives (see also Figure 1-3):

- by examining the role of specific motives in forming the general motivation of academics to activate their social capital with industry;
- by examining the role of three key predictors of academics' engagement in interaction with industry suggested by the literature on university-industry interactions;
- by examining the moderating effects of dispositional factors (perceived social influence, motivation and perceived ability) on social capital activation, and the influence of positional factors (hierarchical position, scientific orientation, scientific domain) on this relationship, as well as by comparing these effects with each other;
- by examining the moderating and mediating roles of trigger in the relationship between passive social capital and social capital activation; *resulting in*
- consolidating findings into a parsimonious model of social capital activation.

When working with different perspectives, we will call upon a broad range of relevant theories some of which so far have been outside the scope of existing literature on university-industry interactions. For example, we will consult existing behavioral theories, including entrepreneurship theories (Ajzen's Theory of Planned Behavior (Ajzen, 1991); Shapero's Model of Entrepreneurial Event (Shapero, 1982) and more general models of behavior such as the MOA framework and other models (Adler et al., 2002; Argote, McEvily, & Reagans, 2003; Blumberg & Pringle, 1982; Boudreau, Hopp, McClain, & Thomas, 2003; Lawshe, 1945; MacInnis, Moorman, & Jaworski, 1991; Siemsen, Roth, & Balasubramanian, 2008; Wu, Balasubramanian, & Mahajan, 2004; Wyatt, Frost, & Stock, 1934). Building on a broad literature base and various empirical analyses, our objective is to identify the key factors that are likely to lead to social capital activation, as well as the most important relations between those factors.

By developing and integrating multiple perspectives, we aim to acquire a comprehensive understanding of the phenomenon in question. Such approach is likely to result in a stronger research design and more valid and reliable research findings. It minimizes the inadequacies of individual perspectives and addresses the threats to internal validity. Below we elaborate on each of the specific research questions in more detail.

Research question 1: Examining the role of specific motives

The success of university-industry interactions depends on the academics' willingness to engage in interaction with industry (Audretsch et al., 2010; D'Este et al., 2010; Lowe, 2006; Perkmann et al., 2009), as they are not obliged to do so, contrary to teaching. Consequently, policy makers and university administrators who want to promote university-industry interactions need a good understanding of motives that determine the academics' decision to activate their social capital with industry.

Several studies have already examined the academics' individual motivation associated with university-industry interactions (Agrawal et al., 2002; Bercovitz et al., 2003; D'Este & Fontana, 2007a; Glaser & Bero, 2005; Lee, 1996; Louis, Blumenthal, Gluck, & Soto, 1989). These studies offered a set of drivers or motives that were suggested to be the key determinants of academics' willingness to interact with industry. Such motives, among others, include the academics' desire to solve practical problems, as well as to get access to industry skills and facilities, to keep abreast of industry problems, and to obtain additional funding.

Academics' general feeling of willingness to engage in interaction with industry thus gets created from a set of specific motives. General willingness here refers to the academics' enthusiasm about interaction with industry, finding it professionally interesting and enjoyable, their interest in and openness towards interaction with industry. It is, however, reasonable to assume that not all motives are equally important for creating such feeling, and that some motives play a greater role than others. Understanding the significance of specific motives, in turn, is crucial for the design of effective public policies since measures building on different motives imply considerably different approaches (e.g., support and facilitation of the academics' desire to solve practical problems vs. incentive systems designed to reward the attraction of additional funding). The effectiveness of public policies can only be achieved if the efforts are focused on the motives that prove to be significant enough to determine the academic's decision to interact with industry.

Several studies have already attempted to measure the importance of academics' motives to interact with industry (Baldini, Grimaldi, & Sobrero, 2007; Goktepe-Hultan, 2008; Lee, 2000; Meyer-Krahmer & Schmoch, 1998b). These studies, however, have a number of common limitations. The importance of academics' motives is typically measured by asking them to select the most important items from a restricted list of options. Although such approach improves our knowledge of the popularity of certain motives among academics, it does not provide us with information on the relative weight of those motives with regard to the academics' actual motivation to engage in interaction with industry. What portion of the actual motivation to interact with industry can be explained by each of those motives, or by a selection of the most popular motives? The relative weights of specific motives would allow us to identify the actual determinants of academics' motivation to interact with industry and to find out to what extent the current public policies and measures build on the 'right' motives.

Furthermore, while in the motivation literature, individual motives are argued to have two distinctive components - individual beliefs and individual wants (Goldman, 1970; Shatz, 1987; Smedslund, 1997; Watson, 1975; Ajzen, 1991), existing studies on academics' motives to interact with industry tend to exclusively focus on the 'wants' (or 'attitudes') component of those motives (Glaser et al., 2005; Lee, 1996). Individual wants here refer to academics' desire to have or not to have a certain consequence of behavior. For example, an academic may want to obtain additional funding. Individual beliefs, in turn, refer to academics' beliefs with regard to the feasibility of those consequences, for example, the extent to what an academic actually believes that interaction with industry will lead to obtaining additional funding. Existing motivation theories suggest that if the want is strong, but the belief is weak (or the other way around), the actual behavior is less likely to occur than if they both are strong (for extensive discussions on wants and beliefs as basic building blocks of individual's motivation see, for example, Goldman, 1970; Smedslund, 1997). Consequently, although knowledge of academics' wants is crucial for understanding their motivation, it does not provide us with a complete picture of the drivers behind their behavior, and the notion of beliefs needs to be brought onto the stage. This study aims to contribute in this respect.

Research question 1: Which specific motives comprised of wants and beliefs are the most significant in determining academics' motivation to activate their social capital with industry?

Research question 2: Examining the role of three key predictors

Existing literature on university-industry interactions offers three key explanations of why academics interact with industry. As mentioned above, the first group stresses that academics actively collaborating with industry are primarily driven by a set of specific motives (Audretsch et al., 2010; Goktepe & Mahagaonkar, 2008; Hull, 1988; Lee, 2000; Mansfield, 1995; Meyer-Krahmer & Schmoch, 1998a; Stephan, 1996; Stephan & Levin, 2005; Stern, 2004; Stokes, 1997). Such motives create a general feeling of enthusiasm about doing something professionally interesting and enjoyable, interest in and openness towards engaging in interaction with industry.

The second group of authors suggests that academics' behavior is shaped by the environment in which they are embedded (Bercovitz et al., 2003; Cukierman et al., 2007; D'Este & Patel, 2007a; Kenney & Richard Goe, 2004; Magnusson et al., 2008). This perspective emphasizes the importance of local group norms and culture, by group meaning primarily the research department or laboratory within which academics are active (Becher & Kogan, 1992; Goktepe-Hultan, 2008; Kenney et al., 2004). It leads us to expect that academics embedded in research departments in which the traditional norms represent the consensus view are less likely to engage in interactions with industry than their colleagues from 'non-traditional' departments (Stuart & Ding, 2006). Existing research highlights the influence of both peer colleagues and chairs of departments on the academics' actual engagement in interaction with industry (Bercovitz et al., 2003; D'Este et al., 2007a).

The third group of authors argues that academics' engagement in interaction with industry depends on their prior experience with such interactions (Bruneel et al., 2010; Hagedoorn et al., 1994; Hertzfeld et al., 2006; Lin et al., 2006; Van Dierdonck et al., 1990). Academics' experience with industry is suggested to reduce the cultural differences which exist between both worlds (Van Dierdonck et al., 1990). Engagement in interaction with industry leads to the accumulation by academics of the individual skills required to make the integration between science and technology more effective and enduring (D'Este & Patel, 2007). Furthermore, experience with industrial collaborations may affect the attitude of the academic towards industry in a positive way and thereby shape his or her future behavior (Van Dierdonck et al., 1990). As a result, the past behavior of academics regarding their participation in university-industry interactions generates a strong imprint and increases the likelihood of these activities in the future (Bercovitz & Feldman, 2003; D'Este & Patel, 2007). The nature of academics' engagement in interaction with industry can therefore be thought of as 'inertia', i.e.., once a process of interaction with industry is set into motion and begins generating positive outcomes, this process tends to stay in motion and continue to generate those outcomes (Mahoney, 2000).

The distinct perspectives of motivation, embeddedness and prior experience are not mutually exclusive and complement each other. For example, an academic can be driven by certain motives, and at the same time, he or she can be encouraged to interact with industry by his or her research group. In addition, if the same academic was actively involved in interaction with industry in the past, he or she will be even more likely to continue doing so in the future. Consequently, all three factors represent complementary predictors of the actual academics' engagement in interactions with industry.

However, it is reasonable to assume that these factors are not equally important in determining the actual behavior of academics. To our knowledge, no attempt has yet been made to examine the relative weight of these factors on the actual academics' behavior and to compare the weights of these factors with each other. Such knowledge is essential for designing effective knowledge transfer policies and measures, as stimulating each of the three factors implies fundamentally different approaches. In this research, we thus aim to put different scholarly perspectives next to each other and challenge the significance of each of them. The current research sub-question exclusively focuses on factors from the existing literature on university-industry interactions.

Research question 2: What is the influence of motivation, embeddedness and prior experience on the academics' social capital activation with industry?

Research question 3: Examining moderating effects of positional and dispositional factors

As mentioned above, social capital constantly switches between passive and active modes. Therefore, in order to understand the antecedents of social capital activation, there is a need to examine the factors that are likely to influence this transition. Consequently, the moderating effects on the relationship between passive social capital and social capital activation need to be studied.

Existing research suggests that the presence of opportunities in the network increases the likelihood of the actual behavior in case an individual is inclined to this behavior (Ajzen, 1991; Burt, 1992; De Carolis & Saparito, 2006). Consequently, when searching for moderating effects on social capital activation, we need to examine the influence of factors that are likely to increase the academics' inclination to engage in interaction with industry. In this study, we examine the influence of two distinctive groups of such factors: dispositional and positional. Dispositional factors refer to the individual's feelings and abilities regarding the behavior in question (Ajzen, 1987; Chen, Greene, & Crick, 1998; Heider, 1982): the influence of academics' individual motivation to interact with industry, the influence of their direct social environment (i.e., research group or laboratory) and their perceived ability to interact with industrial partners. Positional factors, in turn, refer to the individual's current position in academia that can be expressed as the hierarchical position, scientific orientation (basic vs. applied) and scientific domain (Bercovitz & Feldman, 2008; D'Este & Patel, 2007b; Landry, Amara, & Ouimet, 2005; Lazega, Mounier, Jourda, & Stofer, 2006; Zucker & Darby, 1996).

When disentangling the influence of positional and dispositional factors on the relationship between passive social capital and social capital activation, it is reasonable to assume that the moderating effects of the two groups of factors are not equal. We therefore aim to explore which of the two groups proves to have a stronger moderation effect on the relationship in question, by comparing the moderating effects at different levels and in various combinations. By following this approach, we aim to obtain a broader view of factors influencing social capital activation.

Additionally, the academic's inclination to activate social capital with industry (i.e., dispositional factors) is likely to depend on his or her current position in academia, i.e., positional factors serve as a catalyst or retardant for dispositional factors to play a role in influencing the relationship in question. We therefore also aim to examine the presence of the moderating effect of positional factors on the role of dispositional factors in the relationship between passive social capital and social capital activation.

The results are expected to help entrepreneurial academics understand the causes of their behavior, as well as to provide insights for policy makers and university administrators for the design of effective knowledge transfer policies and measures.

Research question 3: What are the moderating effects of positional and dispositional factors on academics' social capital activation with industry?

Research question 4: Examining the role of trigger

Social capital activation is a specific type of behavior. For a behavior to happen, a person has to demonstrate certain readiness to engage in this behavior (Ajzen, 1991; Shapero, 1982). However, even exceptionally strong readiness does not necessarily have to lead to actual behavior (Triandis, 1967, Katz, 1989 quoted in

Krueger & Carsrud, 1993). Therefore, an additional set of factors needs to be considered that may ‘precipitate’ or trigger individual’s behavior (Krueger et al., 1993). The trigger here refers to an idea, event, action or occasion that serves as a reason for social capital activation to occur.

The notion of trigger is argued to be an imperative component of a broad range of entrepreneurial behaviors (Krueger, Reilly, & Carsrud, 2000; Shapero, 1982). The current study aims to empirically examine the role of the trigger in the process of academics’ social capital activation with industry. We will analyze two types of possible effects that the trigger can have on the relationship between passive social capital and social capital activation. We will first model the trigger as a moderator variable, and analyze how its presence influences the relationship in question for academics from various hierarchical positions, scientific domains and orientations. We will then model the trigger as a mediator variable partially resulting from passive social capital, and examine how much variance in social capital activation can be explained by this mediation. Also here we will compare the results of academics from various hierarchical positions, scientific domains and orientations.

By analyzing both the moderating and mediating roles of the trigger we aim to obtain a comprehensive answer to the question of what the role of the trigger in social capital activation actually is. Such knowledge is essential for improving our understanding of the antecedents of social capital activation. As the result of examining diverse roles of the trigger, we are thus more likely to obtain a robust explanation of the behavior in question than if we would not reconcile different approaches (Turner, 1988).

Research question 4: What are the moderating and mediating effects of trigger in the relationship between passive social capital and social capital activation?

Consolidating findings from research questions 1-4 into a parsimonious model of social capital activation

At the final stage of our research, we consolidate the findings from the abovementioned research questions into one model of social capital activation. By doing so we aim to obtain a comprehensive answer to the question of why academics activate their social capital with industry. Our approach seeks to break down barriers between various schools of thought and implies the selective use of ideas. We find these diverse perspectives compatible in the sense that they complement each other: each of them adds something that the others ignore or miss. As the result of their reciprocal confrontation, integration into joint models and examining diverse combinations and roles of those factors, we are more likely to obtain a robust explanation of the antecedents of social capital activation than if we would not reconcile different research streams (for detailed arguments in favor of such approach see Turner, 1988).

The current research focuses on *theory building* (i.e., constructing and modeling a theory) rather than theory testing. The research implies inductive reasoning. The inductive reasoning refers to the process of developing a model based on a broad literature base and on various empirical analyses conducted in the course of the current study. The inductive logic of the research is combined with the definition of research questions, and even a priori constructs. As emphasized by Eisenhardt (1989, p. 536), "*a priori specification of constructs can help to shape the initial design of theory building research. Although this type of specification is not common in theory building studies to date, it is valuable because it permits researchers to measure constructs more accurately*". Such approach is thus likely to result in a stronger research design and more valid and reliable research findings.

1.3 JUSTIFICATION FOR THE RESEARCH

To summarize the previous sections, the evidence that economic growth is dependent on university-industry collaboration has boosted the number of national and international policies and programs oriented towards promoting such collaborations (Jencks, 2002; D'Este, 2007; Branscomb, 1999; Perkmann, 2007; Audretsch, 2010). Given a central role of universities in this process (Balconi, 2004), a growing number of initiatives specifically address academic institutions (Etzkowitz, 2004). However, policies that are primarily targeted at institutions are likely to have a limited impact unless those take a better account of individual academics engaged in interactions with industry (D'Este, 2007). As interaction with industry is not a compulsory task contrary to teaching, new incentive mechanisms are needed to specifically encourage academics to activate their social capital with industry (Geuna, 2004). The design of effective knowledge transfer policies and incentive systems, in turn, requires a good understanding of why academics activate their social capital with industry at all (Audretsch, 2010; D'Este, 2010; Lowe, 2006; Perkmann, 2009). Existing research on this issue is fragmented and scarce (D'Este, 2007), and there is a clear need for the integration of various research streams and for the development of a comprehensive understanding of the phenomenon in question.

In the remainder of this section, we elaborate on the contribution of this study to research and practice in more detail.

1.3.1 Contribution to research

The current study represents an attempt to integrate various research streams in the field, thereby linking different scholarly perspectives and challenging the significance of each of them. Various existing theoretical models are brought together in order to undergo reciprocal confrontation. We address existing behavioral theories, including entrepreneurship theories (for example, Ajzen's Theory of Planned Behavior (Ajzen, 1991); Shapero's Model of Entrepreneurial Event (Shapero, 1982), a conceptual model of social capital by Adler and Kwon (2002), and more general models of behavior such as the MOA framework (Argote et al., 2003; Blumberg et al., 1982; Boudreau et al., 2003; Lawshe, 1945; MacInnis et al., 1991; Siemsen et al., 2008; Wu et al., 2004; Wyatt et al., 1934). Thereby we aim to extract the best out of each theory and construct a comprehensive framework for the phenomenon in question. In the first sections of this chapter, we have already partly mentioned possible contributions of this study to both research and practice in order to justify the selected research problem and research questions. In this section, we extend the list, and tailor the expected contributions to specific research streams and audiences of practitioners.

The study is likely to be of scientific relevance for university-industry interaction, social capital and entrepreneurship research.

Contribution to research on university-industry interactions

- *Addressing the need to focus on individual academics*. By this research we aim to contribute to a growing debate on the key drivers of academics' behavior with regard to social capital activation with industry and thereby to the 'humanization' of the research on university-industry interactions. Empirical studies in the field mainly look at the determinants of such interactions from either the perspective of firms (Cohen et al., 2002; Fontana, Geuna, & Matt, 2006b) or the university/department (Geuna, 1999; Tornquist et al., 1994), while the design of effective policy measures requires a good understanding of factors related to the key actors in the knowledge transfer process, i.e., academics themselves (D'Este et al., 2010; Magnusson et al., 2009; Zalewska-Kurek, Geurts, & Roosendaal, 2010). In this research, individual academics are in the central position.

- *Addressing the issue of heterogeneity of academics*. Existing research shows that academics represent a highly heterogeneous population (Balconi et al., 2004; D'Este et al., 2007b). This heterogeneity needs to be reflected in both policies and research on university-industry interactions. For example, factors like academic excellence, hierarchical position and scientific orientation (basic or applied) are reported to correlate directly with the inclination of researchers to engage in university-industry interactions (Bercovitz et al., 2008; D'Este et al., 2007b; Landry, Amara, & Ouimet, 2005; Lazega, Mounier, Jourda, & Stofer, 2006; Zucker & Darby, 1996). In the context of this research, we aim to take into account the following characteristics: hierarchical position, main scientific orientation, scientific domain, gender and country of origin. Instead of treating academics as a homogeneous population, we thus aim at tailoring the research findings to specific groups of academics at each level of the analysis. By this we aim to increase the added value of both the scientific outputs and policy recommendations stemming from this research, as different groups of academics are likely to require different types of policy measures and incentives. To make sure those measures and incentives are effective, robust and reliable scientific evidence is required that takes into account academics' heterogeneity.

- *Examining the role of specific motives*. By this research we aim to advance the way the role of specific motives to activate social capital with industry is measured. To our knowledge, the current study represents the first attempt to examine the relative weight of those motives with regard to the academics' general motivation to activate social capital with industry. Such knowledge would allow us to identify the actual determinants of academics' motivation, and thus to find out whether the existing research pays adequate attention to the motives that prove to be the most significant. Furthermore, when measuring specific motives, we aim to introduce a combination of the notions of 'wants' and 'beliefs' coming from the motivation literature (Goldman, 1970; Shatz, 1987; Smedslund, 1997; Watson, 1975; Ajzen, 1991) to the literature on university-industry interactions. We thereby aim to develop more comprehensive and reliable measures of specific motives as the current studies on academics' motivation to interact with industry exclusively focus on the 'want' component of motives.

- *Examining the significance of the key predictors from the literature*. Existing literature suggests that academics actively engaged in interaction with industry are driven by motivation, embeddedness and prior experience. To our knowledge, no attempt has yet been made to examine the relative weight of these predictors on the actual academics' behavior and compare the weights of these factors with each other. Such knowledge is essential for designing effective knowledge transfer policies and measures, as stimulation of each of the three factors implies fundamentally different approaches. The current research aims to contribute in this respect.

- *Combining multiple perspectives and introducing ideas from the literature streams beyond university-industry interactions*. The current research aims to approach the question of why academics activate their social capital with industry from different perspectives. Such multi-level approach is likely to result in a stronger research design and more valid and reliable research findings. It minimizes the inadequacies of individual perspectives and addresses the threats to internal validity. To our knowledge, the current research represents the first attempt to analyze the drivers of academics' social capital activation with industry from multiple perspectives. Our approach aims to integrate various schools of thought thereby allowing various ideas to complement each other. As the result of their reciprocal confrontation and integration into one model, we are more likely to obtain a robust explanation of the antecedents of social capital activation than if we would not reconcile different research streams (for detailed arguments in favor of such approach see Turner, 1988).

- *Developing valid and reliable measures for the level of academics' social capital activation with industry*. We aim to offer a structured approach towards measuring the level of academics' social capital activation with industry. We will be treating it as a complex multi-dimensional phenomenon that can hardly be expressed by one single characteristic. Existing literature on university-industry interactions lacks a clear agreement on such characteristics which leads to fragmented approaches.

Contribution to social capital research

- *Advancing knowledge on social capital activation and its antecedents*. Social capital researchers will benefit from a better understanding of the antecedents of social capital activation. By elucidating the notion of social capital activation, we aim to make an important step in social capital research which is currently dominated by studies on the effects of social capital (Glaeser, 2001). We see a number of advantages of employing the notion of social capital activation for further exploration of the antecedents and processes related to social capital. First, the concept emphasizes the dynamic nature of social capital that is constantly switching from passive to active mode. The main measures of social capital change with time depending on whether social capital was activated or not and to what extent. Second, the notion of social capital activation allows for analyzing the returns on investment related to social capital formation (i.e. creation and maintenance of social capital) and thus measure productivity of social networks, which might be of particular interest for scientists studying formal relations. Third, the understanding of the antecedents of social capital activation would allow predicting how social capital will be exploited in the future, and consequently also the corresponding effects of its exploitation in the future.

- *Developing measures to capture the dynamic nature of social capital*. In the past thirty years of social capital research, many attempts have been made to find valid and reliable measures of social capital (Blumstein & Kollock, 1988; Borgatti, Jones, & Everett, 1998; Burt, 1983, 1992; Marsden & Campbell, 1984; Petróczi, Nepusz, & Bazsó, 2006). However, little sustained attention has been paid to the development of measures that would allow capturing the dynamic nature of social capital, i.e., measures that would allow us to separately assess its passive and active modes. Such measures would allow social capital researchers to trace the development of social capital over time, i.e., to analyze how it is accumulated, maintained and changed. The current research develops a set of reflective measures for both passive and active modes of social capital.

- *Developing a parsimonious model of social capital activation*. If existing social networks provide opportunities for interactions, it is crucial for research to understand the factors that influence an individual's decision to exploit those opportunities (Anderson, 2008; Burt et al., 1998). It is reasonable to assume that a certain behavioral mechanism exists that determines when and to what extent individuals exploit their existing social networks. Understanding such mechanism would allow explaining why some people exploit their social networks more actively than others. The current study aims to contribute in this respect. We aim to develop an analytical model providing a picture of complex configurations of causality behind the process of social capital activation, i.e., a model containing the key factors leading to social capital activation and indicating the most important relations between them. We aim to build a model that allows for increased complexity, but does not abandon parsimony.

Contribution to entrepreneurship research

- *Advancing knowledge on a specific manifestation of entrepreneurial behavior*. Given the anticipated beneficial effects of social capital for upcoming and actual entrepreneurs (Audretsch, 2006), a model of social capital activation for entrepreneurial academics would also benefit entrepreneurship research. The proposed model aims to provide new insights into the processes by which entrepreneurial academics identify opportunities and how they formulate and implement resulting actions. We aim to develop a model of a specific manifestation of entrepreneurial behavior, i.e. the exploitation of social capital by entrepreneurial academics in the context of university-industry interactions. This behavior often precedes spin-off creation and various other forms of entrepreneurship, and thus can be helpful in spotting potential entrepreneurs, as well as in explaining why, when and how some academics and not others demonstrate entrepreneurial activity. This type of reasoning is also in line with the key sets of research questions about entrepreneurship proposed by Shane and Venkataraman (2000).

1.3.2 Contribution to practice

The current research aims to produce a number of practical benefits for academics, policy makers and university administrators, as well as broader publics of management practitioners.

Practical benefits for academics

- *Offering academics knowledge on the key drivers of their behavior*. We aim to find out what factors significantly distinguish ‘extremely active’ academics from their ‘less prominent’ colleagues, and to explore the ways in which academics exploit their networks of contacts with the current or potential users of their research. The lens provided to academics by this research thus offers an opportunity to understand why they made certain choices in their academic career (with regard to their engagement in interactions with industry) and how their career is likely to develop in the future.

Practical benefits for policy makers

- *Addressing the need to look at broader publics of academics*. We aim to help policy-makers to broaden their attention beyond the groups of academics that are actively engaged in university-industry interactions (that fit well with the description of “entrepreneurial academics” by Meyer, 2003) to thoughtfully consider other key types of publics: socially inactive academics with high potential, uninvolved but aware, and unaware academics (for detailed descriptions of different types of publics see Hallahan, 2000). These groups of academics have been largely overlooked by both theorists and practitioners, while they represent the majority of academics who are out there and who are also predisposed to interactions with industry, even if less actively involved in those.

- *Extracting policy recommendations*. The design of effective knowledge-transfer policies requires a good understanding of factors that can and should be influenced in order to shape academics' behavior. Therefore, after identifying the circumstances under which academics interact with industry and the differences between academics who are prominent in university-industry interactions and their more 'traditional' colleagues, we aim at translating the research findings into a set of practical recommendations for policy makers.

- *Advancing knowledge on the key sources of academics' motivation to interact with industry*. Such knowledge would allow policy makers to design more effective and better targeted knowledge transfer policies. Such policies, in turn, would be able to take into account the relative weights of specific motives, as well as the academics' perceived feasibility of achieving specific desires by means of interaction with industry.

- *Advancing knowledge on the role of the key predictors*. In this research, we examine the relative weights of motivation, embeddedness and prior experience on the actual academics' behavior and compare the weights of these factors with each other. Such knowledge is essential for designing effective knowledge transfer policies, as stimulation of each of the three factors implies fundamentally different approaches.

Practical benefits for university administrators

- *Extracting recommendations for university strategies and measures*. Universities willing to boost their collaboration with industry must be concerned with assuring that academics receive the necessary facilitation to encourage and enable them to engage in interaction with their industrial partners. The required adjustments may relate to incentive systems, organizational structures, administrative and process requirements, as well as provision of specific services and facilities. For effective strategies, it is important to know which factors actually make academics exploit their social contacts with industry, and the current research aims to contribute in this respect.

Practical benefits for broader publics of management practitioners

- *Developing a set of recommendations on how to manage one's social capital in order to maximize its return on investment.* Practitioners in general will benefit from a better understanding of what is likely to happen with their social connections in the future depending on how actively they exploit their social capital today. We aim to improve our knowledge on whether the investments made by practitioners in their social networks are likely to lead to any results. Practitioners will also benefit from knowing why they tend to engage in certain types of interactions while avoiding others.

- *Elaborating in the importance of the maintenance of social capital*. By employing the notion of social capital activation we show that the added value of the social networks is derived from their use. If no use will be made of those networks in the future, the investments made by practitioners in those networks are not likely to lead to any results. Consequently, if a practitioner wants to keep a certain contact in his or her passive network, regular follow-ups of communication are required, otherwise that connection is likely to deteriorate with time. By deterioration we mean situations when people do not consider each other as acquaintances anymore. The weaker the connection, the less time is needed for that connection to deteriorate if it does not get used. Consequently, a lifespan of a social connection can vary from several weeks for extremely weak connections to decades for extremely strong connections. At the same time, too much activation of social capital or overinvestment can also create a negative effect by distracting from other interactions, tasks and roles. These implications may be of particular interest to management practitioners.

1.4 RESEARCH FRAMEWORK

Figure 1-4 presents a research framework of the current research. The research framework provides a schematic overview of the steps that have been taken to achieve the research objectives. The approach presented in the figure applies to each of the four aforementioned research blocks.

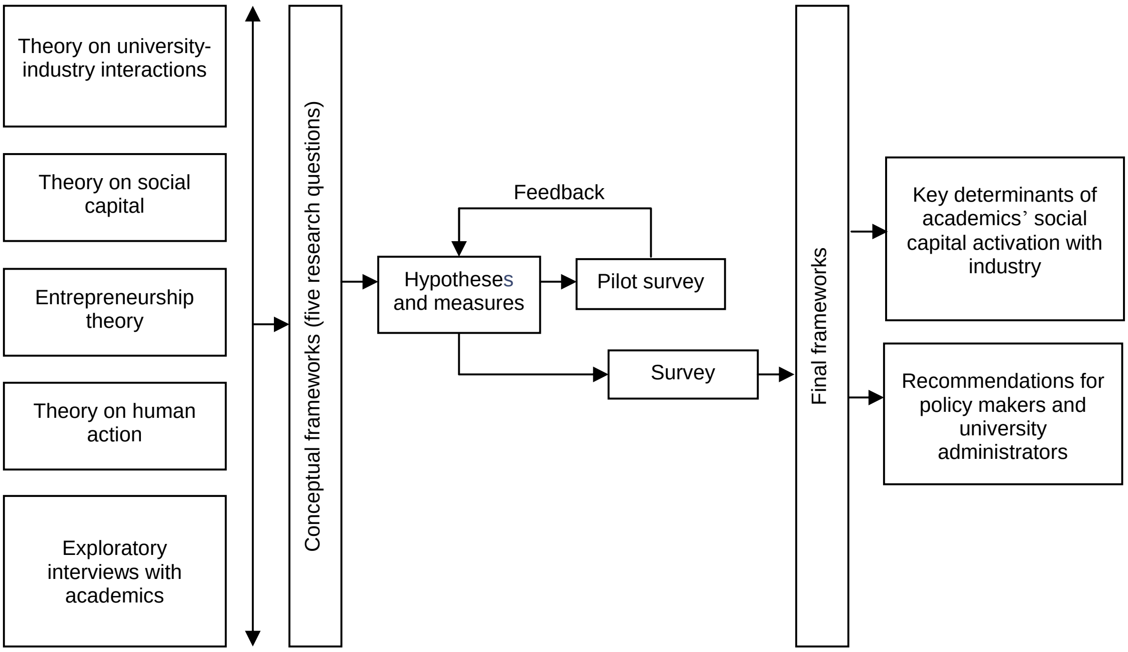

Figure 1-4: Research framework

We began with an extensive review of the literature relevant to the needs of the current research. The main literature fields that we consulted include university-industry interactions, social capital, entrepreneurship and human action. In total, more than 400 scientific publications were reviewed, and the key elements of the conceptual framework were extracted. Desk research was complemented by 10 exploratory interviews with academics. The objective of those interviews was to gather additional inputs on the potential elements of the conceptual frameworks for each research question and possible relationships between them. Based on the results of the literature review and interviews, the initial conceptual framework was developed. The next stage of the research involved the operationalization of the conceptual framework into a series of hypotheses to be empirically tested. Once the hypotheses were formulated, we launched a pilot survey. 45 respondents were asked to complete the survey and to provide their feedback on the included items. As a result of the pilot test, the final draft of the survey was developed. The main survey was then sent to 1386 academics from 12 Dutch universities and research centers. We targeted academics from bio- and nanotechnology fields. The survey was sent to the total population of academics from those fields based on the data from the Dutch Research Database (KNAW). After two reminders, 184 surveys were filled out corresponding to a response rate of 14.4%. The survey results were then analyzed by means of PLS path modeling, separately for each research sub-question. The analysis allowed for extracting the key determinants of academics' social capital activation with industry, as well as for developing a set of recommendations for policy makers and university administrators.

1.5 OUTLINE OF THE DISSERTATION

Figure 1-5 presents the outline of the dissertation. Chapters 2, 3, 8 and 9 address general issues relevant to the whole research. Chapters 4-7, in turn, focus on the specific research questions presented above. In this research, we aim to build on the synergy between abstract analytical models and testable hypotheses. The hypotheses state how we expect variation in one factor to be caused by variations in others, but they do not specify the process in which these relations operate. Unlike hypotheses, models do so, but those cannot state relations among factors with sufficient parsimony (Turner, 1988). By formulating hypotheses and then asking what processes are involved, we were able to create customized analytical models for each research question, and conversely, by developing models that depict configurations of causal processes, we were able to translate these into more parsimonious and testable propositions. To make it easier for the reader to follow, we have developed a separate chapter for each research question, where we present specific analytical models, hypotheses and analyses (Chapters 4-8).

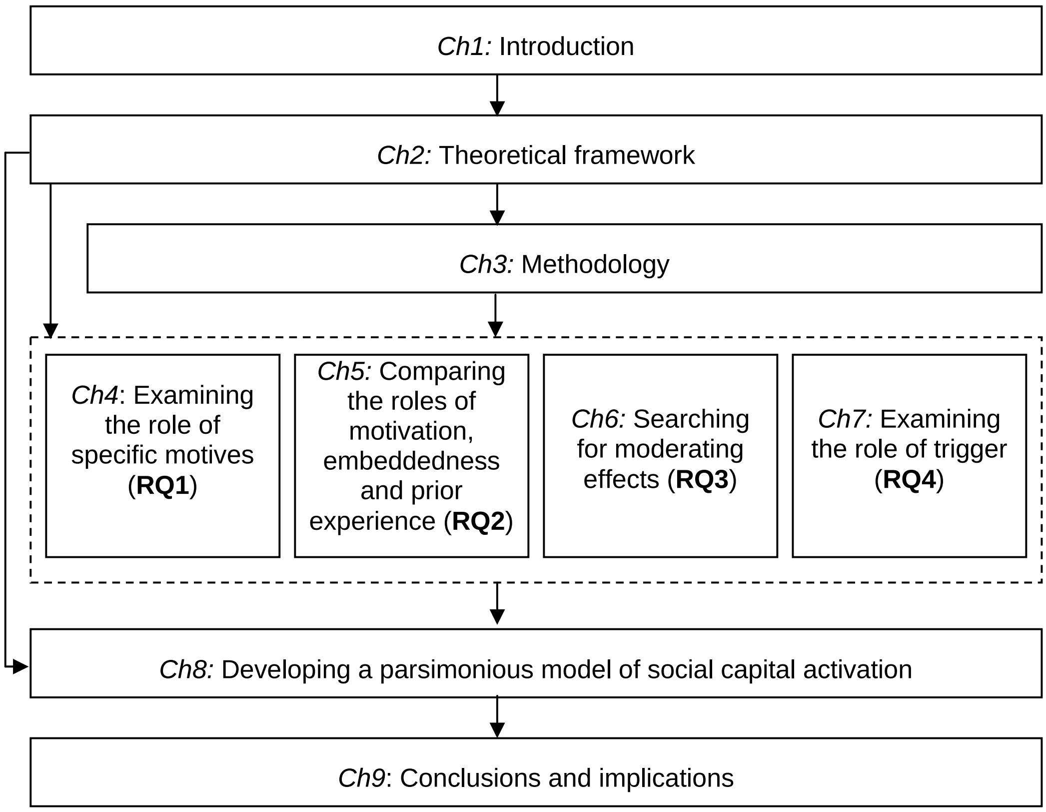

Figure 1-5: Outline of the dissertation

We begin by developing a general theoretical framework that aims to explain academics' social capital activation with industry (Chapter 2). We proceed by working out the main methodological steps including measurement models, data collection and data analysis (Chapter 3). We then zoom into specific research questions related to (1) examining of the role of specific motives (Chapter 4); (2) comparing the roles of motivation, embeddedness and prior experience (Chapter 5); and (3) searching for moderating effects (Chapter 6) and (4) examining the role of trigger (Chapter 7). We then move on to developing a parsimonious model of social capital activation (Chapter 8). Besides an empirical analysis, these chapters also contain specific aspects of theory and methodology that are relevant to those particular research questions. Finally, we compile the findings from the previous chapters and derive conclusions and implications for the whole research (Chapter 9). In the remainder of this section, we elaborate on each of the chapters in more detail.

Chapter 2: Theoretical framework

We begin by identifying the factors that are likely to influence social capital activation by means of an extensive literature review. We examine existing conceptual models and provide arguments on why a new conceptual model is needed and what would be its added value to the current research. We elaborate on the structural logic of the new model and on the causal relations between its elements. We then show that the proposed conceptual model represents a variance research model. Finally, we outline the key limitations of our approach and derive the key conclusions from the whole chapter.

Chapter 3: Methodology

In this chapter, we first operationalize each of the elements of the conceptual model into a set of measurable items. When possible, we develop a set of both reflective and formative measures. We then elaborate on the key procedures of data collection such as drawing a sample, launching an online survey, monitoring and increasing the response rate and systemizing the obtained data. We then proceed by examining the key procedures of data analysis including missing data analysis and PLS path modeling. Finally, we outline the key limitations of our approach and derive the key conclusions from the whole chapter.

Chapter 4: Examining the role of specific motives (Research question 1)

Based on the existing literature, in this chapter, we model academics' motivation to interact with industry as both reflective and formative constructs and formulate hypotheses. The reflective measures of motivation refer to its actual manifestation, i.e., a general feeling of motivation to interact with industry. The formative measures, in turn, refer to the specific motives derived from the literature and represent the building blocks of such motivation. For formative measures, we design composite variables representing an interaction of academics' wants and beliefs. Using the results of the survey, we regress the formative motivation index on its reflective measure. We examine to what extent the specific motives are able to explain the academics' actual willingness to engage in interaction with industry. We also examine the relative weight of each of those specific motives. Finally, we examine the differences in the role of those motives between academics from different hierarchical positions and scientific orientations, as well as between academics engaged in a few vs. many different types of interactions. We conclude with implications for research and practice, and set directions for future research.

Chapter 5: Comparing the roles of motivation, embeddedness and prior experience (Research question 2)

In this chapter, we model motivation, embeddedness and prior experience as latent variables expressed by a set of reflective measures. We regress these three factors on the actual engagement of academics in interactions with industry by means of PLS path modeling. The sample contains academics with different levels of prominence in university-industry interactions, and allows for the analysis of the relative contribution of each of the three factors into the actual behavior. Finally, we examine the differences in the role of those factors between academics from different hierarchical positions, scientific orientations and scientific domains, as well as gender and origin (Dutch vs. foreign).

Chapter 6: Searching for moderating effects (Research question 3)

In this chapter, we continue examining causal relationships between elements in the model. We analyze the moderating effects of dispositional and positional factors on social capital activation of entrepreneurial academics. Positional factors refer to the individual's current position in academia expressed as hierarchical position, scientific orientation and scientific domain. Dispositional factors refer to the academics' feelings and abilities such as individual motivation, perceived social influence and perceived ability. Using a sample of entrepreneurial academics, we analyze the proposed moderating effects by means of PLS path modeling.

Chapter 7: Examining the role of trigger (Research question 4)

In this chapter, we analyze how trigger influences the relationship between passive social capital and social capital activation. We develop and test two sets of hypotheses. The first set models the trigger as a moderator of the relationship in question, while the second set presents the trigger as a mediator in the same relationship. By analyzing both the moderating and mediating role of the trigger we aim to obtain a comprehensive answer to the question of what the role of the trigger in social capital activation actually is. Such knowledge is essential for improving our understanding of the antecedents of social capital activation. Using PLS path modeling, we test the hypotheses on the whole sample, as well as compare the results of academics from various hierarchical positions, scientific domains and orientations.

Chapter 8: Developing a comprehensive model of social capital activation
In this chapter, we first briefly recall the employed conceptual model of social capital activation. Based on the literature, we explain how we derived both the factors for the model and the causal relationships between them. We derive a series of hypotheses to be tested in the empirical part of this chapter. We then explain the main aspects of the employed methodology. We proceed to presenting the results of the PLS path modeling including the reliability and validity checks of the employed measures and the test of our hypotheses. We also analyze the differences between academics from different hierarchical positions, scientific orientations and scientific domains. Finally, by means of bootstrapping we examine to what extent the identified relationships are likely to be generalizable to the whole population.

Chapter 9: Conclusions and implications
In this chapter, we first evoke the research problem and the research questions. We then summarize the conclusions on each research sub-question. We proceed by integrating the research findings and drawing general conclusions. We highlight the key limitations of the current approach and elaborate on the implications for research and practice. We set directions for future research and develop a set of practical recommendations for policy makers and university administrators.

1.6 DELIMITATIONS OF SCOPE AND KEY ASSUMPTIONS

In this section, we set the boundaries of the scope for the current research and highlight the key assumptions.

- *Looking at broader publics of academics*. Policy makers aiming to boost university-industry interactions need to broaden their attention beyond academics actively interacting with industry and also target academics with potential to interact with industry (Hallahan, 2000). These needs should be clearly reflected in research on university-industry interactions. Not only is the current research on individual academics in the context of university-industry interactions scarce (D'Este et al., 2007a; Goktepe, 2006; Goktepe et al., 2008), but it typically only examines so called "star scientists" (Zucker et al., 1996), "liminal scientists" (Gulbrandsen, 2005) or "extremely active" academic researchers (D'Este et al., 2007a). Although these studies increase our knowledge of academics that become prominent in interactions with industry, they overlook the majority of academics who are out there and who are also predisposed to interactions with industry, even if less actively involved in those. It is only possible to claim that we know what drives academics to interact with industry after we compared actively engaged academics with their less actively engaged colleagues. As a result, in this research, broader publics of academics are being addressed for both scientific and practical reasons.

- *Combining 'hard' and 'soft' factors leading to social capital activation*. The current research aims to explain the mechanism behind social capital activation by looking not only at network structure, but also at 'softer' factors leading to social capital activation. Studies that examine engagement in networks in terms of actor personalities and latent propensities, however, often clash with structuralism. The strong structuralist position seems to find explanations for all phenomena in the structure of networks, while personal characteristics are considered an absolute anathema (Borgatti & Foster, 2003). However, we argue that a theory that exclusively relies on network structure is hardly capable of explaining heterogeneous behavior of academics related to activation of social capital. As a result, when examining factors that lead towards activation of social capital, we propose to look at both 'hard' and 'soft' factors, and hope that structuralists will forgive us this free digression from their line of reasoning.

- *Focusing on the individual-level model of social capital activation*. The current study aims to develop a model of social capital activation at the individual level. Although social capital is usually defined as a collective variable (Fukuyama, 1995; Putnam, 1995), decisions to invest in social capital are made by individuals, not communities (Brehm & Rahn, 1997; Glaeser, 2001). As Glaeser (2001) has put it, thinking about individual social capital is a prerequisite for thinking about the formation of community social capital. As a result, analyzing social capital at the individual level is likely to provide insights into the dynamics that influence the key components of the social capital at the aggregate level (Brehm et al., 1997). Therefore, if we are ever going to understand the determinants of social capital formation, it is crucial to begin with some individual-level model of social capital activation (Glaeser, 2001). It is not our intention, however, to limit our scope only to individual characteristics of academics. Such approach would be one-sided and too simplified to adequately reflect the complex reality. We therefore aim to incorporate into the model also the key elements of the academics' direct social environment.

- *Focusing on the Dutch context*. The sample of academics that we address in this research exclusively refers to the representatives of Dutch universities and research centers. Consequently, the conclusions that we draw from this study refer to the Dutch context. Existing research suggests that university-industry interactions are highly context-dependent and subject to varying transaction costs, incentive structures, and cultural attitudes, themselves related to the rules and norms arbitrating public research in different countries (Goddard & Isabelle, 2006). Therefore, any generalization of research findings to other countries should be made with great caution.

The limitations and assumptions related to specific research questions will be addressed in the dedicated chapters.

1.7 SUMMARY

The key points from this chapter are as follows.

- The current research focuses on individual academics engaging in interactions with industry. Such academics represent the key agents of knowledge transfer from university to industry and are a key driving force of the modern socio-economic development.

- University-industry interactions are possible due to the existence of social networks between academia and industry. Social networks represent a structure for relationships in which (information) resources are embedded. Structure and content together form the foundation of social capital between academia and industry. University-industry interaction implies the actual exchange of resources embedded in the network structure between university and industry, and refers to social capital activation.

- Besides enabling the very process of interaction, academics' social capital with industry leads to a series of benefits such as information; influence, control and power; and solidarity.

- Social capital can be viewed as a dynamic asset constantly switching between passive and active modes. The passive mode here refers to the possession of social capital without making use of it at a certain moment of time, while the active mode implies the actual exploitation of social networks at a certain moment of time. Academics' interaction with industry occurs only when social capital is activated.

- The evidence that economic growth is dependent on university-industry interaction has recently boosted the number of national and international policies and programs oriented towards promoting such interactions. However, the growing number of such initiatives specifically addresses academic institutions and overlooks the role of individual academics. The design of effective knowledge transfer policies and incentive systems requires a good understanding of why academics activate their social capital with industry at all. Existing research on this issue is, however, fragmented and scarce.

- The current research aims to improve our knowledge on the circumstances that lead academics to activate their social capital with industry; the differences between academics who are prominent in university-industry interactions and their more 'traditional' colleagues; as well as the way policy-makers and university administrators can influence academics' engagement with industry.

- In order to minimize the disadvantages of previous studies related to fragmentation and narrow scope, in this research, we aim to develop and integrate various research perspectives. Such approach is likely to result in a stronger research design and more valid and reliable research findings. It minimizes the inadequacies of individual perspectives and addresses the threats to internal validity.

- The current research approaches the question of why academics interact with industry at all from the following four perspectives: (1) by examining the role of specific motives in forming the general motivation of academics to interact with industry; (2) by examining the role of three key predictors of academics' engagement in interaction with industry suggested by the literature; (3) by examining moderating effects of positional and dispositional factors; (4) by examining the role of trigger; and (5) by developing a parsimonious model of academics' social capital activation with industry.

- The study is likely to be of scientific relevance for university-industry interaction, social capital and entrepreneurship research. In addition, the current research aims to produce a number of practical benefits for academics, policy makers and university administrators, as well as broader publics of management practitioners.

- The key delimitations of the scope of the current research include looking at broader publics of academics, combining 'hard' and 'soft' factors leading to social capital activation, as well as focusing on the individual-level conceptual model and exclusively addressing the Dutch context.

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2 Theoretical framework

"It is theory that decides what can be observed".
Albert Einstein (1879-1955), German-Swiss-American scientist

The central objective of this chapter is to develop a plausible conceptual model for the antecedents of social capital activation. We begin by identifying the factors that are likely to influence social capital activation. We examine existing conceptual models and provide arguments on why a new conceptual model is needed and what would be its added value to the current research. We then briefly review the structural and causal logic of the new model, as more detailed descriptions will be provided in the empirical chapters dedicated to specific research questions. We also show that the proposed conceptual framework represents a variance research model. Finally, we outline the key limitations of our approach.

2.1 WHY A NEW CONCEPTUAL MODEL

In this section, we demonstrate that although existing models provide some valuable building blocks and highlight possible relationships among constructs, those models can only partially explain under what circumstances social capital gets activated. Consequently, a new conceptual model is needed.

2.1.1 Overview of existing conceptual models

To our knowledge, so far no comprehensive model exists that explains the antecedents of social capital activation. However, several existing theories have already touched upon some of the issues that might be relevant to the subject in question. The objective of this section is to make a selection of the relevant existing theories, to briefly review those theories and to extract the relevant elements and/or relations between those elements in order to construct a comprehensive conceptual model. The approach employed by the current research therefore partly corresponds to Schumpeter's definition of innovation, i.e., creating new combinations from familiar things (Schumpeter & Kilby, 1971).

We begin with the theories that aim to explain the antecedents of social capital. Although the research on this issue is scarce, two distinctive theories can be called upon: Glaeser's Theory on the Formation of Social Capital (Glaeser, 2001) and

Adler & Kwon's Conceptual Model of Social Capital (Adler et al., 2002). After reviewing these theories, we will move on to the next groups of relevant theories.

Glaeser's Theory on the Formation of Social Capital

In his article "The Formation of Social Capital", Edward Glaeser (2001) emphasized the need to focus on the causes of social capital and invited researchers to begin with an individual-based view of social capital formation. Glaeser suggested an economic model of investment in social capital, which can be partly considered as an alternative explanation for the question raised in the current study. It is important to point out, however, that Glaeser looked at the formation of social capital (i.e., both the creation and exploitation of social networks), while the current study exclusively focuses on social capital activation (i.e., the creation of social networks is beyond its scope).

Glaeser (2001) viewed social capital as a stock variable that in each period yields both market and non-market returns. Market returns refer to all social skills and connections that help an individual perform more effectively. Non-market returns refer to a wide range of social returns. Glaeser discussed the evidence that shows that time horizons are extremely important in social capital investment, i.e., individuals closer to the end of their life or having a high probability of mobility are less likely to invest in social capital. In addition, the model argues that individuals in occupations that are more social will invest more strongly in social capital. Finally, it was suggested that, when the opportunity cost of time rises, there would be less investment in social capital.

Glaeser emphasized that the formation of social capital is a crucial topic for both social science and for the policy agenda for improving the level and composition of social capital. Although Glaeser's economic model suggests the key factors that are likely to determine the formation of social capital, the model ignores a number of important issues. For example, the model does not take into account heterogeneity among networking behaviors of individuals in the same occupation. Furthermore, the model does not explain the reasons for individuals to invest in social capital. Finally, the model fails to adequately address both the structure and the content of interactions.

A contribution of the Glaeser's theory into the development of the conceptual model of the current research is as follows. The theory stresses the need to begin with an individual-level model if we want to reconstruct a comprehensive mechanism behind social capital activation. This proposition represents one of the cornerstones of the current research.

Adler and Kwon's Conceptual Model of Social Capital

In their conceptual paper called "Social capital: Prospects for a new concept", Adler and Kwon (2002) offered a comprehensive conceptual model of social capital. The model captures the nature of social capital, its sources, its benefits and risks and the contingencies that influence its value. Figure 2-1 presents the overall conceptual framework discussed by the authors.

The elements of the model that are of direct relevance to the current research refer to the 'sources' or antecedents of social capital. According to Adler and Kwon, the three main sources of social capital include opportunity, motivation and ability. The authors defined *opportunity* as the presence of certain structural configurations of a network of relationships allowing one to participate in a network. By *motivation* one should understand a set of reasons that determine one to engage in an interaction. *Ability* here refers to the competencies and skills needed to enable one to engage in networking.

The authors argued that it is important to differentiate between the potential opportunities that social networks provide and the realized opportunities. If network structure is viewed as providing opportunity, then a key research question should evolve from the need to understand the factors that affect actor's decision to realize this opportunity (Anderson, 2008; Burt et al., 1998). As suggested by Adler and Kwon (2002), part of the answer to this question involves factors like motivation and ability.

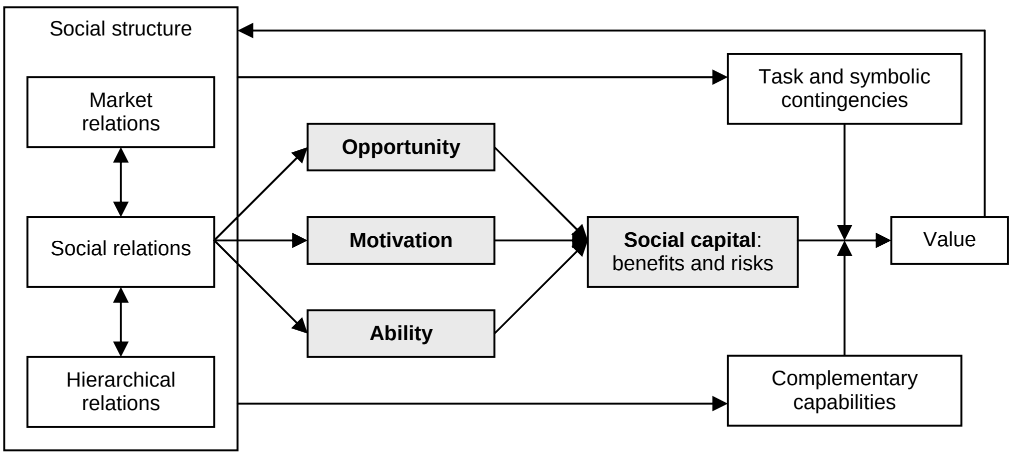

Figure 2-1: Conceptual Model of Social Capital (Adler and Kwon, 2002)

Adler and Kwon emphasized the need for all three sources to be present for social capital to be activated. For example, an individual might have access to certain networks (opportunity), but might be not motivated enough to engage in interaction; or even when being highly motivated, an individual might not possess skills necessary to be able to participate in this interaction (ability). Finally, an individual might be highly motivated and might have necessary skills; however, if there is no access to networks, an interaction will not occur. Consequently, Adler and Kwon argued that motivation, opportunity and ability are bonded by extreme complementarity, by this meaning that one variable has no effect unless the other variable is present (see also Siemsen et al., 2008).

A contribution of Adler and Kwon's model into the development of the conceptual model of the current research is as follows. According to their model, to construct a comprehensive mechanism of social capital activation, we need to include factors determining (1) the desire to activate social capital in return to certain benefits, (2) the skills necessary to activate social capital, and (3) the access to the certain structural network configurations.

Motivation – Opportunity – Ability (MOA) framework

The three sources of social capital suggested by Adler and Kwon correspond to the three constructs of the MOA (Motivation – Opportunity – Ability) framework. Although Adler and Kwon were the first ones to introduce the MOA framework to the social capital literature, the MOA framework itself is not new to the social science. The origins of the MOA framework lie in the theoretical discussion between industrial psychologists (Lawshe, 1945) and social psychologists (Wyatt et al., 1934). As pointed out by Siemsen et al. (2008), the MOA framework has been accepted as a well-established theoretical basis for the explanation of, among others, work performance (Blumberg et al., 1982; Boudreau et al., 2003), consumer choice (MacInnis et al., 1991), firm-level decision-making (Wu et al., 2004), and knowledge-management practices (Argote et al., 2003). Furthermore, theorists from different disciplines agree that motivation, opportunity and ability should play complementary roles in influencing behavior (Cummings & Schwab, 1973). From this view, without motivation or ability, opportunity alone should not lead to action.

In addition, motivation and ability have been introduced in some of the earliest models of human performance (Heider, 1958). In his review of the motivation literature, Pinder (1984) suggested that it might be that high levels of one component compensate for low levels of the other (O'Reilly III & Chatman, 1994). Motivation has been defined as a person's willingness to expand effort and persist at an activity, while ability has been defined as a person's capacity to perform certain tasks. As O'Reilly III and Chatman (1994) argued, motivation and ability are both necessary factors, but none of them alone may be sufficient for performing an action, let alone successful action (O'Reilly III et al., 1994). This statement supports the proposition of Siemsen et al. (2008) mentioned above.

Except the model by Adler and Kwon, existing social capital literature, however, fails to adequately incorporate individual actors, motivation and ability (Adler et al., 2002; Anderson, 2008; Burt, 2000; Emirbayer & Goodwin, 1994; Stevenson & Greenberg, 2000). Social capital studies have mainly focused on the structure of relationships between actors (opportunity), and have only recently started considering the influence of characteristics of individual actors on the realization of social capital benefits (Anderson, 2008; Ibarra, 1995; Stevenson et al., 2000). An integrated analysis of all three factors (i.e., motivation, ability and opportunity) is important to provide a solid base for answering the key question on why actors with desirable social network structures do not benefit equally and why some are more adept at capturing the social capital embedded in their networks than others (Anderson, 2008).

Consequently, the MOA framework stresses that to construct a comprehensive mechanism of social capital activation, we need to include factors determining the desire to activate social capital in return to certain benefits, the skills necessary to activate social capital, and the access to the certain structural network configurations.

Given that social capital activation is an immediate effect of behavior, we now proceed to examining the theories on human behavior. Theories of human behavior focus on a set of inherent distinguishing characteristics that humans tend to have including the ways of thinking, feeling and acting. For the purpose of this study, we have selected one general and one more specific theory of human behavior, i.e., one theory looking at general patterns of human behavior, and another one focusing on behaviors that are planned. The first one refers to Goldman's Theory of Human Action, while the second one is Ajzen's Theory of Planned Behavior. As mentioned above, the behavior in question implies both planned and unplanned nature. Therefore, including only a theory on planned behavior would provide a one-sided perspective.

Goldman's Theory of Human Action

Goldman's book, 'A Theory of Human Action' (1970), presents a systematic way of classifying and relating general human actions. Goldman suggested to divide factors that are causally relevant to an individual's action into three main groups: (1) individual's wants or aversions; (2) individual's beliefs; and (3) individual's abilities, including both his or her basic act repertoire and operational conditions (Goldman, 1970). Wants and beliefs of an individual form his or her motivation.

As a result, Goldman argued that planned behavior of an individual can be explained by interaction of two main factors: motivation and ability (which correspond to two out of three MOA constructs). In addition, Goldman distinguished between two types of motivation: acting from duty and acting from desire. He argued that the agent's ability to perform and act depends on (1) his or her basic act repertoire; (2) generational conditions; and (3) his or her beliefs (Goldman, 1970).

In addition, Goldman suggested that the factors determining human action should be analyzed through the prism of the individuals perceptions since the individual's attempted behavior is not a function of the way the world actually is, but the way the individual believes it to be (Goldman, 1970). Therefore, knowledge of an individual's beliefs is valuable in determining his or her wants.

Goldman also emphasized that the picture of a human agent as of "someone whose action flows from his desires, beliefs, and primitive abilities (basic act-types)" represents an exceptionally limited perspective (1970). The scope of an individual's action is also affected by the environment, "which provides generational conditions for the performance of further acts". This statement is in line with other personality and organizational researchers who widely agree that behavior is a function of both individual and situational factors. As Schneider (1987) argued, situations may influence people, while people may influence situations and maintain distinctive personal styles across situations (O'Reilly III et al., 1994). It is crucial to understand the critical importance of situational effects, the existence of stable individual differences, and their interaction as causes of behavior (O'Reilly III et al., 1994; Wright & Mischel, 1987). Therefore, if we aim to understand the antecedents of social capital activation, then the consideration of additional factors such as environmental or group's influences is unavoidable.

A contribution of Goldman's theory into the development of the conceptual model of the current research is as follows. To construct a comprehensive mechanism of social capital activation, we need to view motivation as a combination of wants and beliefs. Furthermore, we need to analyze the factors determining social capital activation through the prism of the individual's perceptions. Those perceptions should refer to both individual and group factors.

Ajzen's Theory of Planned Behavior

According to the Ajzen's theory of planned behavior (1991), human action is guided by three kinds of considerations:

(1) *behavioral beliefs*, or beliefs about the likely outcomes of the behavior and the evaluations of these outcomes;

(2) *normative beliefs*, or beliefs about the normative expectations of others and motivation to comply with these expectations; and
(3) *control beliefs*, or beliefs about the presence of factors that may facilitate or impede performance of the behavior and the perceived power of these factors.

In their respective aggregates, behavioral beliefs produce a favorable or unfavorable *attitude toward the behavior*; normative beliefs lead to *subjective norm* or perceived social pressure; and control beliefs result in *perceived behavioral control*. These three kinds of considerations are likely to be interrelated. Ajzen argued that in combination, attitude toward the behavior, subjective norm and perceived behavioral control lead to the formation of behavioral *intention*.

The theory of planned behavior suggests that the more favorable the attitude and subjective norm, and the greater the perceived behavioral control, the stronger should be the person's intention to perform the behavior in question. According to Ajzen, given a sufficient degree of *actual control* over the behavior, people are expected to carry out their intentions when the opportunity arises. Figure 2-4 is a schematic representation of the theory.

Behavioral beliefs of the model correspond to the individual's own motivation to engage in targeted behavior, while normative beliefs represent individual's perception with regard to group's motivation. Control beliefs, in turn, support the abovementioned notions of ability (skills) and opportunity (access to networks) that enable an individual to activate social capital.

The model, however, does not explain under what circumstances intentions result into actual behavior. Interestingly, relatively low intention – behavior correlations are often related to a tendency for intentions to overestimate readiness to perform (socially) desirable behaviors (see Ajzen, Brown, & Carvajal, 2004, Sheeran, 2002 quoted in Ajzen, Czasch, & Flood, 2009). This bias produces unrealistically high estimates of intentions to engage in behavior as well as inconsistencies between intentions and actions. Given that engagement of researchers in interaction with industry is likely to be viewed as socially desirable behavior, inclusion of intentions in our model might jeopardize its predictive power with regard to the actual behavior. Furthermore, intentions are likely to play a role in cases when the behavior is planned. Given that social capital activation refers to both planned and unplanned behaviors, inclusion of intentions would put too much emphasis on the planned side of behavior. Consequently, we will not include intentions in the proposed model of social capital activation.

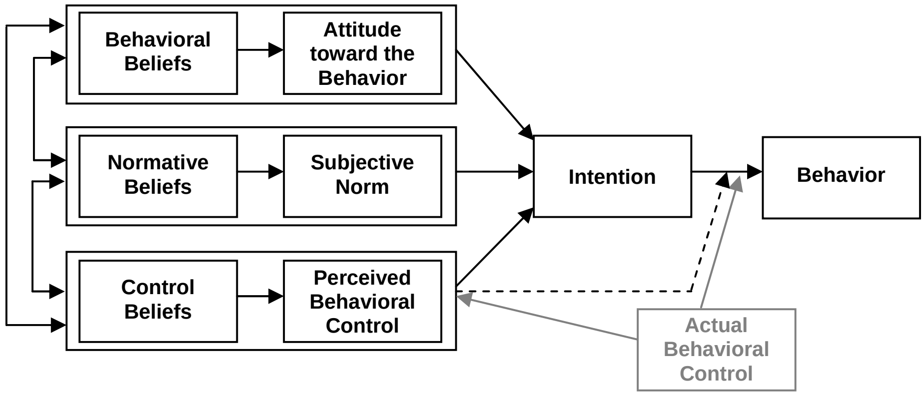

Figure 2-2: Ajzen's Theory of Planned Behavior (Ajzen, 1991; 2006)

A key contribution of Ajzen's theory into the development of the conceptual model of the current research is as follows. To construct a comprehensive mechanism of social capital activation, we need to split motivation to activate social capital into two parts: academic's own motivation and academic's perceptions with regard to group's motivation.

Academics examined in this study can be considered as ones demonstrating entrepreneurial behavior since they are looking for entrepreneurial ways to pursue their teaching, research and commercialization interests, in particular by actively engaging in university-industry interactions (Gulbrandsen, 2005; Meyer, 2003). Within the scope of this research, we therefore aim to look at those aspects of social capital that may be conductive to entrepreneurial activity of academic researchers. Audretsch (2006) labeled this sub-set of social capital as social factors of entrepreneurship capital. Consequently, to complete the picture, there is a need to examine the relevant entrepreneurship theories.

Shapero's Model of Entrepreneurial Event

Shapero's Model of Entrepreneurial Event represents one of the few existing models of entrepreneurial behavior (Krueger, Reilly, & Carsrud, 2000). Shapero's perceived desirability corresponds to Ajzen's attitude toward the behavior; perceived feasibility corresponds to perceived behavioral control. Shapero's propensity to act adds a volition-based attitude (Krueger et al., 2000).

Shapero also included exogenous factors in his model (see Figure 2-5). Exogenous factors refer to either personal variables (traits, demographics) or situational variables; and their effects on intentions or behavior are likely to be indirect. Nevertheless, Shapero argued that the exogenous factors are likely to influence the determinants of intentions, i.e., attitudes or perceived desirability and perceived feasibility (Krueger et al., 2000), and therefore should be taken into account.

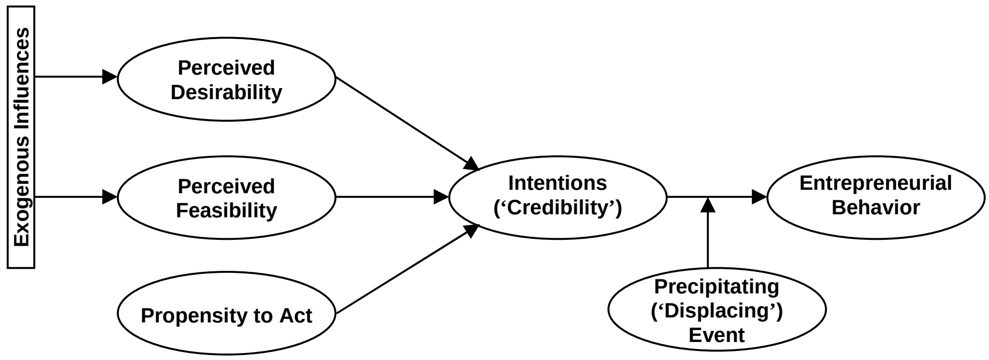

Figure 2-3: Shapero's model of the Entrepreneurial Event (Krueger et al., 2000; Shapero, 1982)

Another specific feature of Shapero's model refers to 'displacement', a precipitating event that triggers the actual intended behavior. Even exceptionally strong intentions do not necessarily have to lead to actual behavior (Triandis, 1967, Katz, 1989 quoted in Krueger & Carsrud, 1993). Therefore, an extra set of factors needs to be considered that may 'precipitate' or trigger individual's behavior (Krueger et al., 1993). The trigger here refers to an event, action or occasion that serves as a reason for behavior to occur.

A contribution of Shapero's model into the development of the conceptual model of the current research is as follows. We need to take into consideration exogenous factors such as the relevant demographic characteristics of academics. Furthermore, we need to include a precipitating event that triggers the actual behavior.

2.1.2 Added value of a new model

In the previous sub-section, we reviewed several exiting theories that have a direct relevance to the subject in question. We examined theories related to social capital (Adler et al., 2002; Glaeser, 2001), as well as general behavioral theories (Ajzen, 1991; Goldman, 1970), including MOA framework, and theories specifically related to entrepreneurial behavior (Shapero, 1982).

Although these models provide some valuable building blocks and highlight possible relationships among constructs, we argue that those models can only partially be employed for explaining a mechanism behind social capital activation. Consequently, there is a clear need to develop a new conceptual model that would capitalize on existing knowledge and at the same time reduce the limitations of existing theories. Table 2-1 provides an overview of the theories we consulted, as well as the limitations of those theories and the added value for a model of social capital activation.

Table 2-1: Overview of existing theories

Theory	Limitations	Added value for a new model
Glaeser's Theory on the Formation of Social Capital (Glaeser, 2001)	• the model does not take into account heterogeneity among networking behaviors of individuals in the same occupation; • the model does not explain the reasons for individuals to invest in social capital; • the model fails to adequately address both the structure and the content of interactions.	• the model demonstrates the need to begin with an individual-level model of social capital activation; • the model demonstrates the need to distinguish between the influence of individual and group characteristics in explaining social capital activation at the individual level.
Adler and Kwon's Conceptual Model of Social Capital (Adler & Kwon, 2002)	• despite its utility in explaining a complex causal process leading to the formation and development of social capital, the model is inappropriate for empirical tests. Its very strength – providing a picture of complex configurations of causality – makes it too global to test as a whole.	• the model demonstrates the need to put the key constructs of MOA (Motivation – Opportunity – Ability) framework as central in the explanation of social capital activation
Motivation – Opportunity – Ability (MOA) framework (Lawshe, 1945; Wyatt et al., 1934)	• the model is of universal nature and is applied to a broad range of behaviors without taking into account the specifics of a particular type of behavior (in this case, social capital activation) • the model does not take into account the influence of group characteristics	• the model demonstrates the need to take into account factors that (1) determine the desire to activate social capital in return to certain benefits (motivation), (2) the skills necessary to activate social capital (ability), and (3) the access to the certain structural network configurations (opportunity).
Goldman's Theory of Human Action (Goldman, 1970)	• the theory is of universal nature and is applied to a broad range of human	• the theory emphasizes the distinction between wants and beliefs within the construct of

Theory	Limitations	Added value for a new model
	behaviors without taking into account the specifics of a particular type of behavior (in this case, social capital activation)	motivation, and that looking at wants only represents a one-sided approach • the theory emphasizes that factors determining human action should be analyzed through the prism of the individuals perceptions • the theory emphasizes the critical importance of situational effects, the existence of stable individual differences, and their interaction as causes of behavior
Ajzen's Theory of Planned Behavior (Ajzen, 1991)	• the model focuses on predicting intentions rather than actual behavior, and does not explain under what circumstances intentions result into actual behavior; • the model exclusively focuses on planned behavior, and does not take into account situations when behavior is unplanned; • the model is of universal nature and is applied to a broad range of human behaviors without taking into account the specifics of a particular type of behavior (in this case, social capital activation)	• the model emphasizes the distinction between wants/attitudes and beliefs for motivational constructs; • the model emphasizes the need to distinguish between individual drivers of the behavior and the reaction to social influence from the environment; • the model emphasizes the need to take into account possible interrelations between the determinants of the behavior
Shapero's Model of Entrepreneurial Event (Shapero, 1982)	• the model focuses on predicting intentions rather than actual behavior; • the model does not take into account the specifics of social capital activation as behavior (e.g., the existence of social networks as a key prerequisite for behavior to occur)	• the model emphasizes the need to take into account exogenous factors including positional characteristics of individuals; • the model emphasizes the need to include a precipitating event that triggers the actual intended behavior.

To summarize, the analysis of existing theories showed that when developing a comprehensive model of social capital activation, we need:

- to distinguish between the influence of individual and group characteristics in explaining social capital activation at the individual level;
- to include factors determining the desire to activate social capital in return to certain benefits, the skills necessary to activate social capital, and the access to the certain structural network configurations;
- to view motivation as a combination of wants and beliefs;
- to analyze the factors determining social capital activation through the prism of the individual's perceptions with regard to individual and group factors;
- to split motivation to activate social capital into two parts: individual's own motivation and individual's perceptions with regard to group's motivation;
- to take into consideration possible interrelations between the determinants of social capital activation;
- to take into consideration other exogenous factors such as the relevant demographic characteristics of academics; *and*
- to include a precipitating event that triggers the actual behavior.

Consequently, our approach implies selective use of ideas from different schools of thought, as we find these diverse perspectives highly compatible. Components of various theoretical models (concepts and constructs, relationships, assumptions and explanations) often complement each other, as each adds something that the others ignore or miss (Turner, 1988). As a result of reciprocal confrontation and, if appropriate, combination of those components, a more robust explanation of the process behind social capital activation can be achieved.

In the next section, we employ the abovementioned conclusions to design a new conceptual model. We begin with a brief overview of the new conceptual model and then proceed to examining the structural and causal logic of the model.

2.2 CONCEPTUAL MODEL IN BRIEF

Figure 2-4 presents the proposed conceptual model of social capital activation. This model was built not only based on the abovementioned review of existing theories, but also based on the results of empirical analyses related to the four research questions of the current study. The contribution of the latter will be presented in more detail in Chapter 8.

According to the model, social capital activation represents the result of a two-stage process that starts with the readiness of an individual to activate social capital. This readiness leads to the actual activation in the presence of a trigger.

The readiness to activate social capital represents a joint effect of four factors: individual motivation, perceived social influence, perceived ability and passive social capital. As a general rule, the greater the readiness of an individual to activate it, the higher the chance of a trigger to occur, the higher should be the level of social capital activation.

Most elements of the proposed model have already been (partially) used by other authors. In some cases, those blocks were labeled differently. Given that existing literature contains various labels for the same notions and that this model does not build on one specific theoretical framework, but combines various existing frameworks, we have chosen labels that seem most straightforward. When applicable, we will aim at inserting references to authors who use similar notions that are labeled differently.

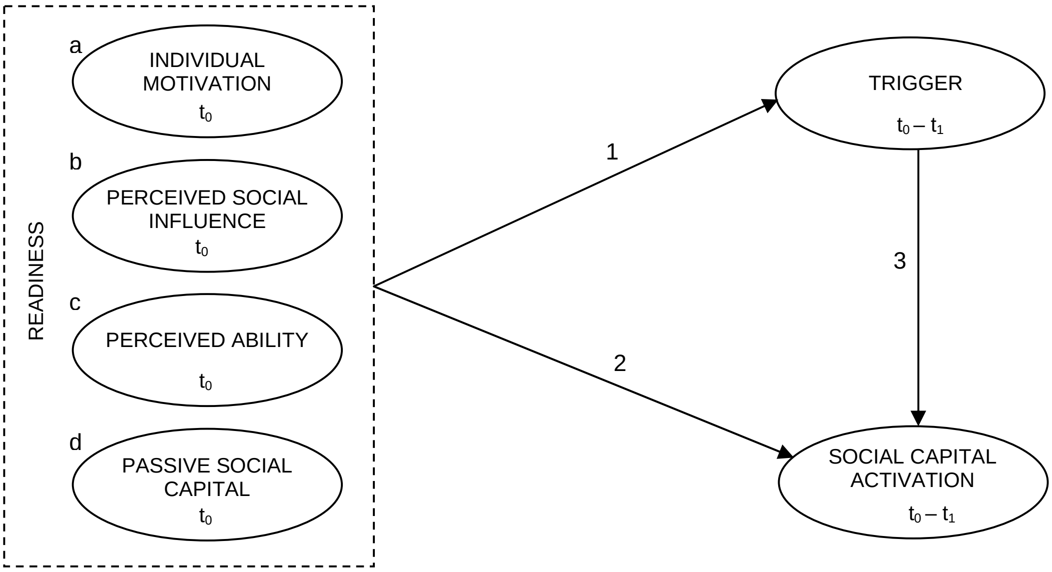

Figure 2-4: Proposed conceptual model of social capital activation

The proposed model employs the principle of aggregation meaning that it aims at explaining general behavioral patterns related to social capital activation rather than predicting single behaviors. Any single behavior is a combination of both general behavioral patterns relevant to the nature of this behavior and a reaction to a wide range of other (usually random) factors that are unique to the particular situation being observed (Ajzen, 1991). Those random and thus unique factors are likely to weight heavily on the demonstrated behavior. Therefore, studying single behaviors might jeopardize the external validity of the research. However, by aggregating single behaviors observed in different situations, those other random factors tend to neutralize each other. As a result, the aggregate represents a more valid measure of the underlying behavioral nature than any single behavior. Consequently, the model aims to allow estimating a general level of social capital activation for a particular individual within a longer period of time $t_0 - t_1$ (for example, one year) rather than for a single moment of time.

2.3 STRUCTURAL AND CAUSAL LOGIC OF THE MODEL

In this sub-section, we examine the structural and causal logic underlying the proposed model. Figure 2-5 illustrates the two main blocks of the structural logic: (a) basic mechanism behind planned and unplanned behavior; and (b) main components of readiness. When merged together, those form the model presented above.

Basic mechanism behind planned and unplanned behavior

Our starting point is that social capital activation, or the point at which (information) resources actually start flowing through the social network of relationships, is an immediate effect of *behavior*. Consequently, if we are looking for the best predictors of an immediate effect of behavior, it would be reasonable to address the antecedents of that behavior.

As mentioned above, social capital activation can result from both planned and unplanned behavior. To act in either planned or unplanned way, a person has to demonstrate a certain *readiness* to perform a given behavior (Ajzen, 1991; Shapero, 1982). Therefore, an academic is expected to be potentially ready to engage in interaction with industry; otherwise social capital activation is much less likely to occur. In addition, social capital activation can be considered a result of unplanned behavior only to extent that it might be caused by factors that are beyond individual’s control while an individual is still potentially ready for this behavior.

However, even exceptionally strong readiness does not necessarily have to lead to actual behavior (Triandis, 1967, Katz, 1989 quoted in Krueger et al., 1993). Therefore, an extra set of factors needs to be considered that may ‘precipitate’ or trigger individual’s behavior (Krueger et al., 1993; Shapero, 1982). Consequently, readiness alone does not guarantee behavior, and a *trigger* is needed. The trigger here refers to an event, action or occasion that serves as a reason for behavior to occur. The following types of triggers can be identified. First, an academic may spot ideas that are potentially interesting for industry him- or herself and then approach industry proactively to communicate those ideas. Second, an academic may get connected with industry by the head of research group/peer colleagues/academic research partners. Third, industry representatives may approach an academic directly. Finally, academics can also be connected to industry by third parties (e.g., university-industry match-making services provided by governmental agencies).

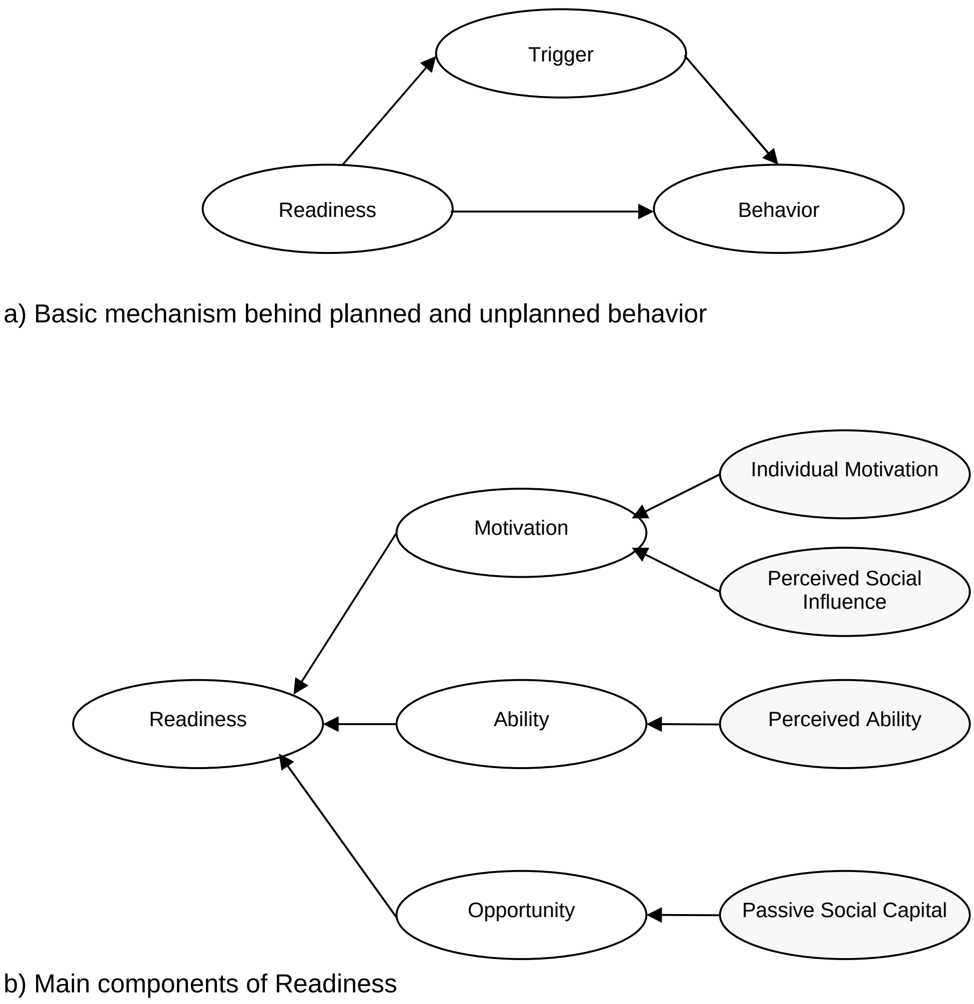

Figure 2-5: Structural logic of the model

Main components of readiness

Individual's readiness to engage in behavior represents a joint effect of a number of factors. The three main factors that currently form a theoretical basis for the explanation of social capital activation refer to *motivation*, *ability* and *opportunity*. In the context of social capital activation, by motivation one should understand a set of reasons that determine one to engage in interaction. Ability here refers to the competencies and skills needed for social interaction. Opportunity, in turn, can be defined as the presence of certain structural configurations of a network of relationships allowing one to participate in a network (Adler & Kwon, 2002). The emphasis should be put on existing networks since the current study focuses on exploitation rather than creation of networks. Therefore, the notion of opportunity directly corresponds to passive social capital. In entrepreneurship literature, however, opportunity has a completely different meaning. Given that the current research studies the behavior of entrepreneurial academics, the opportunity construct will be labeled here as *passive social capital* to avoid any confusion. Passive social capital refers to social networks that might be exploited (or activated) should the necessity arise.

Additionally, the current model views motivation as a higher-order construct resulting from two first-order constructs: *individual motivation* and *perceived social influence*. In his book 'A Theory of Human Action' (1970, p. 135), Goldman emphasized that the picture of a human agent as of "someone whose action flows from his desires, beliefs, and primitive abilities (basic act-types)" represents an exceptionally limited perspective. The scope of an individual's action is also affected by the environment, "which provides generational conditions for the performance of further acts". This statement is in line with other personality and organizational researchers who widely agree that behavior is a function of both individual and situational factors. As Schneider (1987) argued, situations may influence people, while people may influence situations and maintain distinctive personal styles across situations (O'Reilly III et al., 1994). It is crucial to understand the critical importance of situational effects, the existence of stable individual differences, and their interaction as causes of behavior (O'Reilly III et al., 1994; Wright et al., 1987). Given that motivation is argued to be a driver of behavior (Siemsen et al., 2008), we incorporate environmental factors into the model at the level of motivation. Consequently, we look not only at the individual motives of academics, but also at environmental factors influencing his or her decision to engage in behavior.

As argued by Lewin (1951), the individual's behavior is not a function of the way the world actually is, but the way the individual believes it to be (quoted in Goldman, 1970). Consequently, when considering the individual as the final decision-maker, it might be reasonable to analyze the abovementioned constructs through the prism of the individual's perceptions. Therefore, when referring to social influence and skills, we emphasize their perceived nature by using labels "*perceived social influence*" and "*perceived ability*".

Finally, all four readiness-forming constructs need to be present for social capital to be activated. For example, an academic might have access to certain networks (passive social capital), but might be not motivated enough to engage in interaction (individual motivation); or even when being highly motivated, an academic might think that he or she does not possess skills necessary to be able to participate in this interaction (perceived ability). Finally, an academic might be highly motivated and might think he or she has necessary skills; however, if there is no access to networks, interaction will not be likely to occur. Consequently, individual motivation, perceived social influence, perceived ability and passive social capital are bonded by extreme complementarity, by this meaning that one variable has no effect unless the other variable is present (Adler et al., 2002; Cummings et al., 1973; Siemsen et al., 2008).

The proposed theoretical model presents readiness as a set of four distinctive constructs. An alternative approach would be to create a second-order construct for readiness that would represent the result of a conceptual relation among the four identified first-order constructs. Another alternative would be to present motivation as a second-order construct resulting from individual motivation and perceived social influence, thereby making readiness a third-order construct (Cenfetelli & Bassellier, 2009). However, as suggested by Hulland (1999), when a particular construct is more properly conceptualized as multidimensional, the causal model should include separate constructs representing each of these dimensions. Intuitively, it seems likely that each of the four constructs could have a different impact on the other constructs (e.g., trigger or social capital activation). Therefore, the first approach is likely to yield superior empirical results when compared with the latter two approaches. Hence when formulating hypotheses, we will follow the first approach.

To sum up, the structural logic of the model is as follows. Social capital activation is viewed as an immediate effect of planned or unplanned behavior, which is in turn the function of readiness mediated by a trigger. Readiness represents a multidimensional concept comprising four distinctive constructs: individual motivation, perceived social influence, perceived ability and passive social capital.

2.4 VARIANCE RESEARCH MODEL

The current research examines questions that deal with the antecedents of social capital activation (or ‘what causes what’ questions). The exogenous latent variables (i.e., Individual Motivation, Perceived Social Influence, Perceived Ability and Passive Social Capital) represent the prerequisites of change of the individual’s level of Social Capital Activation. As suggested by Van de Ven (2007), this type of questions calls for a variance research design of the causal factors (independent variables) that statistically explain variations in some outcome criteria (dependent variables). However, the logic underlying an answer to a variance model is a process story about *how* a sequence of events unfolds to cause an independent (input) variable to apply its influence on a dependent (outcome) variable. Therefore, one way to significantly improve the robustness of answers to 'what' questions (variance model) is to explicitly examine the process that is assumed to explain why an independent variable causes a dependent variable (Van de Ven, 2007). Table 2-1 presents the results of the assessment exercise aiming to determine which approach (variance vs. process) best reflects the essence of the current research.

Table 2-2: Assessment of Research Model (based on the criteria by Poole (2000) and Van de Ven (2007)

Criterion	Manifestation in our model	Approach
1. Fixed entities with varying attributes vs. Entities that participate in events and change over time	The basic units of analysis are academics that are expected to maintain a unitary identity through time (i.e., the levels of Individual Motivation, Perceived Social Influence, Perceived Ability and Passive Social Capital are expected to be stable during a year). Academics possess a fixed set of variable attributes that are a subject of change in time (the level of Social Capital Activation). Levels of these variables represent the essential measurement task, and the goal of the research is to examine the relationships among these and other variables.	Variance
2. Explanations based on efficient causality vs. Explanations based on final, formal and efficient causality	Each cause in the model is assumed to function as an efficient cause, i.e., as a force that acts on a unit of analysis (academic) to change it from what it was (higher values of Individual Motivation, Perceived Social Influence, Perceived Ability and Passive Social Capital are expected to result in markedly increased levels of social capital activation).	Variance
3. Generality that depends on uniformity across contexts vs. Generality that depends on versatility across cases	Causes are assumed to operate in the same way across all cases. The relationship between the readiness-related variables (Individual Motivation, Perceived Social Influence, Perceived Ability and Passive Social Capital) and Social Capital Activation are expected to be stable for all cases.	Variance
4. Time ordering among independent variables is immaterial vs. Time ordering of	The time order in which the independent variables come into action makes no difference for the level of the outcome, as long as the analysis covers the time frame in which they can all operate or trigger. This is consistent with the	Variance

Criterion	Manifestation in our model	Approach
independent events is critical	general linear model, which employs linear combinations of independent variables to predict dependent variables (i.e., equivalent results no matter which independent variable operates first). As the readiness-related variables are assumed to be stable over time, and Trigger will be measured during a particular period of time, there is no critical need to require that a trigger has to occur after Individual Motivation, Perceived Social Influence, Perceived Ability and Passive Social Capital.	
5. Emphasis on immediate causation vs. Explanations that are layered and incorporate both immediate and distal causation	The readiness-related factors that matter to the level of Social Capital Activation at t_2 are assumed to be predictable from the situation at t_1. The possibility that unique effects of the readiness-related factors could interact with the level of Social Capital Activation at later points in time in ways unpredictable from previous situations is not considered by this research. It thus not expected that a particular antecedent operates only for a limited period of time.	Variance
6. Attributes have a single meaning over time vs. Entities, attributes, events may change in meaning over time	The model is assumed to operate continuously and uniformly over time. Each variable is treated as having the same status or meaning throughout the process. For example, when measuring the level of Social Capital Activation at t_0, it is expected to mean the same as what it meant at t_1.	Variance

The results of this exercise clearly suggest that the current research deals with a variance model.

2.5 SUMMARY

The key points from this chapter are as follows.

- Since academics' interaction with industry represents an example of social capital activation, in order to identify the antecedents of academics' behavior, we need to know the antecedents of social capital activation.

- To our knowledge, no comprehensive model exists that explains the antecedents of social capital activation. However, several existing theories have already touched upon some of the issues that might be relevant to the subject in question.

- Although existing models provide some valuable building blocks and highlight possible relationships among constructs, those models can only partially explain under what circumstances social capital gets activated. Consequently, there is a clear need to develop a new conceptual model that would capitalize on existing knowledge and at the same time reduce the limitations of existing theories.

- According to the proposed conceptual model, social capital activation represents the result of a two-stage process that starts with the readiness of an individual to activate social capital. This readiness leads to the actual activation only in the presence of a trigger. The readiness to activate social capital represents a joint effect of four factors: individual motivation, perceived social influence, perceived ability and passive social capital. As a general rule, the greater the readiness of an individual to activate it, the higher the chance of a trigger to occur, the higher should be the level of social capital activation.

- The model aims to allow estimating a general level of social capital activation for a particular individual within a longer period of time (for example, one year) rather than for a single moment of time. Social capital activation is viewed as an immediate effect of both planned and unplanned behaviors.

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3 Research methods

"The man of science has learned to believe in justification, not by faith, but by verification."
Thomas Henry Huxley (1825-1895), English biologist

In the previous chapter, we presented the proposed conceptual model. In this chapter, we design operational models to empirically examine the key aspects of the theory. We begin with the operationalization of the elements of the conceptual model into a set of measurable items. We postulate relations between the proposed observed measures and the underlying latent variables. We then move on to the key procedures related to data collection, including the specification of the target population and drawing a sample. We also elaborate on the key methods employed for data analysis and provide arguments that justify the selection of those methods. Finally, we outline the key limitations of our approach.

3.1 MEASUREMENT MODEL

The current research studies theoretical constructs that cannot be observed directly. These abstract phenomena (i.e., Individual Motivation, Perceived Social Influence, Perceived Ability, Passive Social Capital, Trigger and Social Capital Activation) represent so called latent variables, or factors. For the purpose of the empirical analysis, it is necessary to operationalize them into a set of measurable items or observed measures. So far we have been theoretically justifying structural relationships of the model, i.e., we specified the relations between the latent variables (*structural model*). The objective of this type of analysis was to hypothesize the impact of one latent construct on another in the modeling of causal direction (Byrne, 2001). In this chapter, we will focus our attention on measurement relationships. We aim to a priori postulate relations between the proposed observed measures and the underlying latent variables (*measurement model*), as both structural and measurement relationships should be regarded as hypotheses to be conceptually justified and tested (Bagozzi, 1984; Jarvis, MacKenzie, & Podsakoff, 2003).

As mentioned above, social capital activation represents a category of behavior, not a single action. Therefore, when operationalizing constructs, there is a need to develop measures that characterize the whole category of behavior, and not an individual action. Furthermore, operationalization of constructs needs to be situated in the context of university-industry interactions, and only the measures relevant to this particular setting will be taken on board. The employed scales were developed based on an extensive literature review and the guidelines on constructing questionnaires based on the Theory of Planned Behavior (Francis et al., 2004). In the reminder of this section, we design operational models for each of the elements of the conceptual model.

3.1.1 Individual motivation

As suggested by Turner (1988), individual perceptions, actions and interactions are, to a certain extent, mobilized, driven, energized and organized by internal psychological forces, i.e., motivational processes. However, the inability to define what motivation actually is and how it operates, has made many scientists discard the topic. Nevertheless, most models of human behavior and social interaction contain an implicit model of motivation (Adler et al., 2002; Ajzen, 1991; Argote et al., 2003; Blumberg et al., 1982; Boudreau et al., 2003; Goldman, 1970; Lawshe, 1945; MacInnis et al., 1991; Shapero, 1982; Siemsen et al., 2008; Wu et al., 2004; Wyatt et al., 1934). Some of them though still use the notion of motivation in a less recognizable way by replacing it with new terms and concepts. Since motivation is one of the basic and most fundamental properties of social interaction, we cannot avoid addressing it in this study.

Definition

Existing literature contains various definitions of motivation. For example, Goldman (1970) defined motivation as a person's willingness to expand effort and persist at an activity. Siemsen (2008) defines it more broadly as the individual's willingness to act. In the context of this study, we define individual motivation as the academic's willingness to engage in interaction with industry (comparable to Shapero's perceived desirability (Shapero, 1982)). For sociologists, motivation is only relevant to the degree that it influences the process of interaction (Turner, 1988). Therefore, it is not our intention to develop a theory of motivation per se or provide here an extensive overview of existing definitions of motivation. We rather aim to identify specific motives that drive academics to engage in interaction with industry, i.e., what energizes and organizes academics' behavior in the context of university-industry interactions.

Theoretical grounds

Academics do not represent a homogeneous population. Nor do they have homogeneous motives to interact with industry. Based on the literature, the following eight groups of academics' motives can be derived: (1) a motive of solving practical problems; (2) a motive of gaining recognition within the scientific community; (3) a motive of supporting teaching duties; (4) a motive of getting access to industry facilities; (5) a motive of getting access to industry knowledge; (6) a motive of keeping abreast of industry problems; (7) a motive of getting promotion on a career ladder, and (8) a motive of obtaining additional funding for research group, graduate students or laboratory equipment. Based on the literature analysis, a detailed description of each motive will be provided in Chapter 4. In that chapter, we examine the role of the identified motives in forming a general feeling of willingness to activate social capital with industry. We now proceed to the operationalization of each motive.

Operationalization

Individual motives are argued to have two distinctive components: individual beliefs and individual wants (Goldman, 1970). Individual beliefs refer to academic's own beliefs with regard to the consequences of social capital activation with industry (comparable to Ajzen's notion of behavioral beliefs, see Ajzen, 2006). Individual wants refer to academic's desire to have or not to have those consequences (for extensive discussions on wants and beliefs as basic building blocks of individual's motivation see, for example, Goldman, 1970; Smedslund, 1997). For example, a motive of contribution with something practical in the context of university-industry interactions consists of two distinctive parts: a belief that interaction with industry generally leads to contribution with something practical, and a desire to generally contribute with something practical. This distinction is important since an individual's motive can be low because of different reasons. First, an academic may desire to contribute with something practical, but he or she may not believe that interaction with industry is likely to lead to this outcome. Second, an academic may believe that interaction with industry is likely to lead to something practical. However, he or she may not desire to make any practice-related contributions.

Measuring both dimensions makes it possible to identify the reason for low levels of motivation. More importantly, it allows us to 'purify' individual wants by weighting them according to their level of relevance to interaction with industry. This approach is likely to increase the predictive power of the structural model. If we omitted individual beliefs and focused only on individual wants, the following would be likely to occur. If there were a strong positive relationship between the academics' desire to get promoted on a career ladder and the overall level of social capital activation with industry, we would only be able to conclude that academics engaging in interaction with industry are in general career-oriented (correlation). It would however be highly difficult for us to identify the cause-effect relationship, as we wouldn't know whether academics view interaction with industry as a means of getting a promotion or not.

Table 3-1 presents the proposed operationalization of individual beliefs and individual wants corresponding to each of the motives identified above. For the purpose of model specification, we will refer to the motives as observable variables. The measurement issues related to this approach will be discussed in the subsequent sub-section.

Table 3-1: Proposed operationalization of Individual Motivation

Variable	Composite variable	Individual beliefs	Individual wants
IM1	(1) Motive of solving practical problems	Belief that interaction with industry leads to solving practical problems	Desire to solve practical problems
IM2	(2) Motive of gaining recognition within the scientific community	Belief that interaction with industry leads to recognition within the scientific community	Desire to get more recognition within the scientific community
IM3	(3) Motive of supporting teaching duties (e.g., preparing student assignments based on cases from industry, going on field trips to the premises of industrial partners, getting access to practical problems that are suitable for student work)	Belief that interaction with industry provides support to teaching duties	Desire to support teaching duties
IM4	(4) Motive of getting access to industry facilities	Belief that interaction with industry provides access to industry facilities	Desire to get access to industry facilities
IM5	(5) Motive of getting access to industry knowledge	Belief that interaction with industry provides access to industry knowledge	Desire to get access to industry knowledge
IM6	(6) Motive of keeping abreast of industry problems	Belief that interaction with industry allows to keep abreast of industry problems	Desire to keep abreast of industry problems
IM7	(7) Motive of getting promotion on a career ladder	Belief that interaction with industry leads to promotion on a career ladder	Desire to get promoted on a career ladder
IM8	(8) Motive of obtaining additional funding for research group, graduate students or laboratory	Belief that interaction with industry leads to additional funding	Desire to obtain additional funding

Variable	Composite variable	Individual beliefs	Individual wants
	equipment		

The individual beliefs and individual wants related to each of the motives were then translated into a set of questions (see Annex A, variables IM1a-IM8a for questions on beliefs, and variables IM1b-IM8b for the corresponding questions on wants).

Specification of measurement model

In this sub-section, we aim to determine the appropriate measurement model by specifying whether Individual Motivation should be modeled as a formative or reflective construct. For this purpose, we employ the decision rules for determining whether a construct is formative or reflective suggested by Jarvis et al. (2003). We need to examine the relations between Individual Motivation (latent variable) and motives (observable measures). Table 3-2 presents the results of the model specification exercise.

Table 3-2: Specification of measurement model for Individual Motivation

Criterion	Manifestation in our model	Example	Model
1. Direction of causality from construct to measure implied by the conceptual definition	The indicators are viewed as defining characteristics of the construct. Changes in the indicators are expected to cause changes in the construct. Changes in the construct are not expected to cause changes in the indicators.	An increase in one or more motives is expected to lead to the overall increase of Individual Motivation; whereas an increase in Individual Motivation does not necessarily mean that a certain motive will also increase. For example, an academic who now wants to get access to industry skills and facilities more than before, is likely to be more motivated to engage in interaction with industry than before. However, if he or she will in general have motivation to engage in interaction with industry higher than before, it does not yet mean that he or she will also desire to get access to industry skills and facilities more than he or she did before.	Formative
2. Interchangeability of the indicators / items	The indicators do not share a common theme. Eliminating an indicator may alter the conceptual domain of the construct.	The proposed motives are not interchangeable and do not have similar content. For example, the motive of contribution with something practical and the	Formative

Criterion	Manifestation in our model	Example	Model
		motive of obtaining additional funding do not share a common theme. It was also our objective to capture the entire domain of academics' motives with regard to interaction with industry.	
3. Covariation among the indicators	A change in the value of one of the indicators is not necessarily expected to be associated with a change in all of the other indicators.	If one of the motives changes, it does not mean that all other motives will change. For example, if an academic will be less interested in keeping abreast of industry problems, it does not mean that he or she will be less interested in getting recognition within the scientific community.	Formative
4. Nomological net of the construct indicators	The indicators do not have the same antecedents and consequences.	The proposed motives have different nature. Some are of rational nature, some are more emotional (for example, obtaining additional funding vs. contribution with something practical). Furthermore, some refer to personal benefits; others refer to common benefits (for example, promotion on a career ladder vs. obtaining additional funding).	Formative

The model specification exercise clearly suggests that Individual Motivation presented as a set of motives should be labeled as a formative construct. However, in order to achieve model identification, there is a need to include a minimum of three reflective indicators for formative constructs (Cenfetelli et al., 2009). Therefore, in addition to formative measures, we have also developed a set of five reflective measures characterizing a general feeling of academics' motivation to engage in interaction with industry (see Table 3-3). Academics' general motivation to interact with industry can be expressed as "interest", "openness", "enthusiasm", "satisfaction" and "importance". For confirming the reflective nature of these measures, we again employed the decision rules by Jarvis et al. (2003). All four criteria such as the direction of causality, interchangeability, covariation and nomological net of indicators confirmed that the construct is reflective, i.e., it is manifested by its measures.

Table 3-3: Proposed operationalization of Individual Motivation (reflective measures)

Variable	Measure
IMR1	Interest in collaborating with industry
IMR2	Openness to interaction with industrial partners
IMR3	Enthusiasm about interaction with industry
IMR4	Satisfaction from interaction with industry
IMR5	Importance of interaction with industry

The reflective measures were then translated into a set of questions (see Annex A, variables IMR1-IMR5).

Figure 3-1 provides a visual presentation of the measurement model of Individual Motivation as a mixed construct.

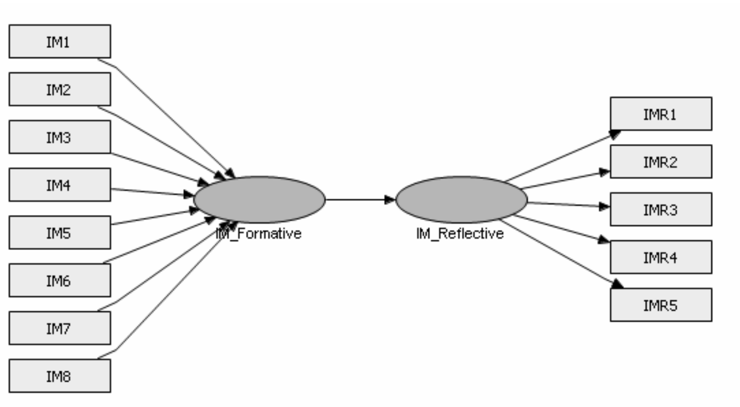

Figure 3-1: Measurement model of Individual Motivation as a mixed construct

For formative measures, the respondents will be asked to assess the strength of their beliefs using 7-point unipolar scales (1 to 7) and the strength of the corresponding wants using 7-point bipolar scales (-3 to +3). The format of these scales is based on work with the semantic differentials which found 7 points to be optimal (Francis et al., 2004). The composite score for each specific motive will then be calculated by multiplying the scores of the corresponding want and belief. Consequently, the possible range of scores for composite variables will be from -21 to +21. These scores will serve as an input for the empirical analysis. The five reflective items will be measured using 7-point bipolar scales. The same procedure will be applied to the formative measures of Perceived Social Influence and Perceived Ability.

3.1.2 Perceived social influence

Based upon the sociological literature on embeddedness (Granovetter, 1985; Kenney et al., 2004), we can distinguish between the efforts devoted to creating and maintaining a wide range of linkages with industry as the result of individual characteristics or as a function of the individual's environment (D'Este et al., 2007b). Therefore, in order to take into account influences coming from the academic's direct social environment, the construct of Perceived Social Influence was included in the model.

Definition

Perceived social influence refers to the academic's own estimate of the social pressure with regard to engaging in an interaction with industry (see, for example, sociological literature on embeddedness Granovetter, 1985; Kenney et al., 2004). This pressure comes from the academic's direct social environment and manifests itself as the opinions and behaviors of people around. Existing literature suggests that among the main elements of the environment that are likely to have the greatest influence on behavior of academics, the research group/laboratory/ department within which this researcher is active is likely to have the highest impact (Cukierman et al., 2007; D'Este et al., 2007b; Magnusson et al., 2008). Bercovitz and Feldman (2008) and Louis et al. (1989) also emphasized the importance of local group norms and culture for academic researchers engaged in university-industry interactions (Goktepe-Hultan, 2008). Therefore, we will consider factors related to perceived social influence at the level of research groups/laboratories/ departments that researchers are affiliated with (for similar approach, see Lazega et al., 2006).

Theoretical grounds

Existing literature suggests that among the main groups that are likely to have the greatest influence on behavior of academics, leaders and peer colleagues usually have the highest impact (Bercovitz et al., 2008; Goktepe-Hultan, 2008; Stuart et al., 2006).

Leaders are expected to influence behavior in organizations both by building culture and by acting as role models. The observable behavior of those in leadership roles shapes organizational culture by signalling what actions are expected, valued, and likely to be rewarded (House, 1977, Schein, 1985 quoted in Bercovitz et al., 2008). In academic departments, the department chair is the leader. The chair plays a direct and powerful role in, among others, reviewing and evaluating individual performance related to promotion and tenure (Bercovitz et al., 2008). If the chair is active in interactions with industry, then he or she sends a signal that interaction with industry is a valid activity. In this case, other members of the department might be more likely to engage in interaction with industry.

Furthermore, dating back to Durkheim, scientists have argued that the constraint on the beliefs of group's members is an increasing function of the degree of consensus of views within the group (Martin, 2002 quoted in Stuart et al., 2006). Academics are thus likely to adopt the behavior of local colleagues, i.e., these colleagues act as role models and, together with the decisions taken within the research group, influence the behavior of individual academics (Bercovitz et al., 2008; Goktepe-Hultan, 2008; Stuart et al., 2006). This proposition supports the evidence from the experimental studies showing the forceful influence of a group's consensus on an individual's (un)willingness to deviate from the majority view. This leads us to expect that academics who are trained at university departments in which the traditional norms represent the consensus view are less likely to participate in interactions with industry than their 'non-traditional' colleagues (Stuart et al., 2006).

Table 3-4 provides an overview of factors related to perceived social influence that are likely to have influence on academic's decision to engage in interaction with industry. The table contains influences related to three types of opinions and three types of behaviors (corresponding to the academic's boss, peer colleagues and academic research partners).

Table 3-4: Overview of factors related to perceived social influence that are likely to have influence on academic's decision to engage in interaction with industry

Social influences	Authors
(1) Boss's opinion	(Bercovitz et al., 2008; Goktepe-Hultan, 2008; Stuart et al., 2006)
(2) Opinion of peer colleagues	(Bercovitz et al., 2008; Cukierman et al., 2007; D'Este et al., 2007b; Goktepe-Hultan, 2008; Magnusson et al., 2008)
(3) Opinion of academic research partners	(Cukierman et al., 2007; D'Este et al., 2007b; Goktepe-Hultan, 2008; Magnusson et al., 2008)
(4) Boss's behavior	(Bercovitz et al., 2008; Goktepe-Hultan, 2008; Stuart et al., 2006)
(5) Behavior of peer colleagues	(Bercovitz et al., 2008; Cukierman et al., 2007; D'Este et al., 2007b; Goktepe-Hultan, 2008; Magnusson et al., 2008)
(6) Behavior of academic research partners	(Bercovitz et al., 2008; Cukierman et al., 2007; D'Este et al., 2007b; Goktepe-Hultan, 2008; Magnusson et al., 2008)

Operationalization

Similar to motives, social influences represent composite variables. Following the line of reasoning of the Ajzen's Theory of Planned Behavior (Ajzen, 1991), the two distinctive components of Perceived Social Influence are social beliefs and evaluation of social influence. Social beliefs refer to the academic's beliefs with regard to how other people in his or her direct environment would like him or her to behave (comparable to Ajzen's notion of normative beliefs, see Ajzen, 2006).

Evaluation of social influence implies academic's evaluation of the importance of what these people think and do for his or her own behavior (comparable to Ajzen's notion of subjective norm, see Ajzen, 2006). For example, influence of boss's opinion with regard to interaction with industry consists of two distinctive parts: a belief that the academic's boss thinks he or she should interact with industry and importance of boss's opinion to this particular academic. This distinction is important since the pressure to engage in interaction with industry that an academic feels from his boss can be low because of different reasons. First, an academic may find the boss's opinion highly important; however the academic may think that his or her boss has a negative opinion about interaction with industry. Second, the academic may know that his or her boss is highly positive about interactions with industry; however the academic may find the boss's opinion highly unimportant.

Measuring both dimensions makes it possible to identify the reason for low levels of perceived social influence. More importantly, it allows us to 'purify' social beliefs by weighting them according to their level of perceived importance to an academic. This approach is likely to increase the predictive power of the structural model. If we omitted social influence evaluation and focused only on social influences, the following would be likely to occur. If there were a strong positive relationship between the opinion of academic's research partners that he or she should interact with industry and the overall level of social capital activation with industry, we would only be able to conclude that academics engaging in interaction with industry in general have academic research partners who think the same way (correlation). It would however be highly difficult for us to identify the cause-effect relationship, as we wouldn't know whether academics engaging in interaction with industry were inspired by this opinion of their academic research partners or not.

Table 3-5 presents the proposed operationalization of social beliefs and social influence evaluation corresponding to each of the influences identified above. For the purpose of model specification, we will refer to the influences as observable variables. The measurement issues related to this approach will be discussed in the subsequent subsection.

Table 3-5: Proposed operationalization of Perceived Social Influence

Variable	Composite variable	Social beliefs	Social influence evaluation
PSI1	(1) Influence of boss's opinion with regard to interaction with industry	Belief that the academic's boss thinks he or she should interact with industry	Importance of boss's opinion
PSI2	(2) Influence of opinion of peer colleagues with regard	Belief that academic's peer colleagues think he	Importance of opinion of peer colleagues

Variable	Composite variable	Social beliefs	Social influence evaluation
	to interaction with industry	or she should interact with industry	
PSI3	(3) Influence of opinion of academic research partners with regard to interaction with industry	Belief that academic's research partners think he or she should interact with industry	Importance of opinion of academic research partners
PSI4	(4) Influence of boss's behavior with regard to interaction with industry	Belief that boss interacts with industry	Importance of boss's behavior
PSI5	(5) Influence of behavior of peer colleagues with regard to interaction with industry	Belief that peer colleagues interact with industry	Importance of behavior of peer colleagues
PSI6	(6) Influence of behavior of academic research partners with regard to interaction with industry	Belief that research partners interact with industry	Importance of behavior of academic research partners

The social beliefs and evaluations related to each of the social influences were then translated into a set of questions (see Annex A, variables PSI1a-PSI6a for questions on beliefs, and variables PSI1b-PSI6b for the corresponding questions on evaluations).

Specification of measurement model

In this sub-section, we aim to determine the appropriate measurement model by specifying whether Perceived Social Influence should be modeled as a formative or reflective construct. For this purpose, we again employ the decision rules for determining whether a construct is formative or reflective suggested by Jarvis et al. (2003). We need to examine the relations between Perceived Social Influence (latent variable) and individual influences (observable measures). Table 3-6 presents the results of the model specification exercise.

Table 3-6: Specification of measurement model for Perceived Social Influence

Criterion	Manifestation in our model	Example	Model
1. Direction of causality from construct to measure implied by the conceptual	The indicators are viewed as defining characteristics of the construct. Changes in the indicators are expected to cause changes in the construct. Changes in the construct are not expected to cause	An increase in one or more influences is expected to lead to the overall increase of Perceived Social Influence; whereas an increase in Perceived Social Influence does not necessarily mean that a certain influence will also increase. For example, an	Formative

Criterion	Manifestation in our model	Example	Model
definition	changes in the indicators.	academic who now feels more pressure from his academic peer colleagues to engage in interaction with industry, will in general feel more pressure to engage in interaction with industry than before. However, if his or her feeling of social pressure to interact with industry will increase in general, it does not yet mean that he or she will also feel more pressure from the academic peer colleagues than he or she did before.	
2. Inter-changeability of the indicators / items	The indicators do not share a common theme. Eliminating an indicator may alter the conceptual domain of the construct.	The proposed influences are not interchangeable and do not have similar content. Suggested influences cover three distinctive types of opinions and three distinctive types of behaviors of people around an academic. It was also our objective to capture the entire domain of influences on an academic from his or her direct social environment.	Formative
3. Covariation among the indicators	A change in the value of one of the indicators is not necessarily expected to be associated with a change in all of the other indicators.	If one of the influences changes, it does not mean that all other influences will change. For example, if the pressure to interact with industry from the academic research partners decreases, it does not mean that the academic's boss will change his opinion or behavior.	Formative
4. Nomological net of the construct indicators	The indicators do not have the same antecedents and consequences.	The proposed influences have different nature. Some are opinions, some of them are behaviors. Those influences refer to three distinctive types of publics: the academic's boss, peer colleagues and academic research partners.	Formative

The model specification exercise clearly suggests that Perceived Social Influence presented as a set of various influences should be labeled as a formative construct. However, in order to achieve model identification, we also need to include a minimum of three reflective indicators for formative constructs (Cenfetelli et al., 2009). Therefore, in addition to formative measures, we have developed a set of five reflective measures characterizing a general feeling of social pressure to engage in interaction with industry (see Table 3-7). For confirming the reflective nature of these measures, we again employed the decision rules by Jarvis et al. (2003). All four criteria such as the direction of causality, interchangeability, covariation and nomological net of indicators confirmed that the construct is reflective, i.e., it is manifested by its measures.

Table 3-7: Proposed operationalization of Perceived Social Influence (reflective measures)

Variable	Measure
PSIR1	A feeling of expectation from the environment to interact with industry
PSIR2	A feeling of being under social pressure to collaborate with industry
PSIR3	A feeling that there is a need to interact with industry
PSIR4	A feeling that people whose opinion is important to the academic think that he or she should work together with industry
PSIR5	A feeling that interaction with industry is part of academic's duty

The reflective measures were then translated into a set of questions (see Annex A, variables PSIR1-PSIR5).

Figure 3-2 provides a visual presentation of the measurement model of Perceived Social Influence as a mixed construct.

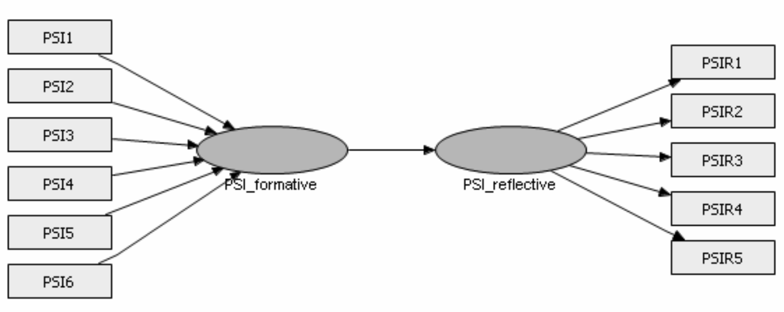

Figure 3-2: Measurement model of Perceived Social Influence as a mixed construct

3.1.3 Perceived ability

It would be not appropriate to assume that entrepreneurial academics facing unique opportunities will automatically have the pertinent knowledge, skills, and abilities to accomplish their objectives (Gartner, Shaver, Gatewood, & Katz, 1994). It is therefore crucial to distinguish between academics willing to engage in university-industry interactions and academics actually capable of doing it (Magnusson et al., 2009). Existing research suggests that people's behavior is strongly influenced by their confidence with regard to their ability to perform that behavior (Bandura, Adams & Beyer, 1977, Bandura, Adams, Hardy & Howells, 1980 quoted in Ajzen, 1991). Therefore, Perceived Ability was included in the model.

Definition

Ability represents the individual's skills and knowledge base related to the action (Rothschild, 2000; Siemsen et al., 2008). In the context of this study, ability refers to the internal skill set available to academics to engage in interaction with industry. As mentioned above, we specifically emphasize the perceived part of abilities of academics. Perceived ability demonstrates the extent to which an academic feels able to engage in interaction with industry. It is, however, not our intention to develop a complete list of skills and knowledge that an academic needs to possess to be able to interact with industry. We rather aim to identify specific skills that are particularly relevant to university-industry interactions.

Theoretical grounds

Several existing theories use a similar construct. Perceived Ability corresponds to Ajzen's (1991) perceived behavioral control and Shapero's (1982) perceived feasibility, i.e., the degree to which one feels personally capable of engaging in entrepreneurial behavior (Krueger et al., 2000). In his Social Systems Theory, Parsons (1964) would refer to those skills as definition and mediation in terms of culturally structured and shared symbols (Parsons 1964 pp. 5-6 quoted in Groen, de Weerd-Nederhof, Kerssens-van Drongelen, Badoux, & Olthuis, 2002). This notion also corresponds to Adler and Kwon's ability, i.e., the competences and resources at the nodes of the network (Adler et al., 2002).

Existing literature suggests a number of skills that academics need to possess in order to succeed in interactions with industry. First, academics need to demonstrate 'integration skills' which refer not only to the capacity to operate with a wide range of bodies of knowledge (i.e., basic science and applied research), but also “the capacity to balance and align conflicting interests arising from the distinct system of incentives between academia (governed by “open science” norms) and industry (governed by “proprietary technology” norms)” (D’Este et al., 2007b; see also Magnusson et al., 2008). In addition, another difference refers to the attitude of academics and industry representatives toward timing issues and production of deliverables. In academia, people tend to think in a scale of 4-5 years and strive to publish the results of their research, i.e., make them publicly available; whereas industry people tend to think in a scale of a couple of months, and are more result-oriented. In order to cooperate successfully, academics, therefore, need to accept the high pace of industrial world and have to be ready to deliver results in a quick manner. Table 3-8 provides an overview of skills and knowledge that are suggested to be relevant to academics engaging in interactions with industry.

Table 3-8: Overview of skills relevant to university-industry interactions

Skills and knowledge	Authors
(1) Ability to balance conflicting interests of incentive systems between academia and industry	(D’Este et al., 2007b)
(2) Ability to operate with a wide range of bodies of knowledge (e.g., basic science vs. applied research; multiple disciplines)	(D’Este et al., 2007b)
(3) Good understanding of practical applicability of scientific concepts	(Interviews)
(4) Working according to industry standards (e.g., quick delivery of results)	(Interviews)

Operationalization

Similar to motives and social influences, perceived skills represent composite variables. Perceived Ability is assumed to have two distinctive components: ability beliefs and ability evaluation. Ability beliefs refer to the academic’s beliefs about the power of situational and internal factors that can facilitate or inhibit interactions with industry (comparable to Ajzen’s notion of control beliefs, see Ajzen, 2006). Ability evaluation implies academic’s evaluation of how confident he or she feels about being able to engage or not to engage in interactions with industry (comparable to Bandura’s self-efficacy (Bandura, 1982, 1997); Ajzen’s perceived behavioral control (Ajzen, 2006); controllability of behavior (Francis et al., 2004)). For example, an ability to balance conflicting interests of incentive systems comprises two distinctive parts: a belief that that interaction with industry requires balancing conflicting interests of incentive systems, and the current level of ability to balance conflicting interests of incentive systems. This distinction is important since an individual’s ability to interact with industry can be low because of different reasons. First, an academic may genuinely believe that interaction with industry requires balancing conflicting interests of incentive systems, be he or she may think that he or she does not possess an adequate level of such skill. Second, the academic may think to possess an adequate level of such skill, but he or she may believe that this skill is not relevant to university-industry interactions.

Measuring both dimensions makes it possible to identify the reason for low levels of Perceived Ability. More importantly, it allows us to 'purify' abilities by weighting them according to their level of relevance to interaction with industry. This approach is likely to increase the predictive power of the structural model. If we omitted ability beliefs and focused only on ability evaluations, the following would be likely to occur. If there were a strong positive relationship between the academics' perceived ability to operate with a wide range of bodies of knowledge and the overall level of social capital activation with industry, we would only be able to conclude that academics engaging in interaction with industry are in general able to operate with a wide range of bodies of knowledge (correlation). It would however be highly difficult for us to identify the cause-effect relationship, as we wouldn't know whether this skill actually enables them to interact with industry or not.

Table 3-9 presents the proposed operationalization of ability beliefs and ability evaluations corresponding to each of the skills identified above. For the purpose of model specification, we will refer to the skills as observable variables. The measurement issues related to this approach will be discussed in the sub-sequent subsection.

Table 3-9: Proposed operationalization of Perceived Ability

Variable	Composite variable	Ability beliefs	Ability evaluation
PA1	(1) Perceived ability to balance conflicting interests of incentive systems between academia and industry	Belief that interaction with industry requires balancing conflicting interests of incentive systems between academia and industry	Level of ability to balance conflicting interests of incentive systems between academia and industry
PA2	(2) Perceived ability to operate with a wide range of bodies of knowledge	Belief that interaction with industry requires operating with a wide range of bodies of knowledge	Level of ability to operate with a wide range of bodies of knowledge
PA3	(3) Perceived ability to understand practical applicability of scientific concepts	Belief that interaction with industry requires understanding practical applicability of scientific concepts	Level of ability to understand practical applicability of scientific concepts
PA4	(4) Perceived ability to work according to industry	Belief that interaction with industry requires	Level of ability to work according to industry

Variable	Composite variable	Ability beliefs	Ability evaluation
	standards	working according to industry standards	standards

The beliefs and evaluations related to each of the abilities were then translated into a set of questions (see Annex A, variables PA1a-PA4a for questions on beliefs, and variables PA1b-PA4b for the corresponding questions on evaluations).

Specification of measurement model

In this sub-section, we aim to determine the appropriate measurement model by specifying whether Perceived Ability should be modeled as a formative or reflective construct. Table 3-10 presents the results of the model specification exercise (see Jarvis et al., 2003).

Table 3-10: Specification of measurement model for Perceived Ability

Criterion	Manifestation in our model	Example	Model
1. Direction of causality from construct to measure implied by the conceptual definition	The indicators are viewed as defining characteristics of the construct. Changes in the indicators are expected to cause changes in the construct. Changes in the construct are not expected to cause changes in the indicators.	An increase in one or more skills is expected to lead to the overall increase of Perceived Ability; whereas an increase in Perceived Ability does not necessarily mean that a certain skill will also increase. For example, an academic who now has higher perceived ability to understand industry needs than before, is expected to have higher Perceived Ability in general. However, if he or she will in general have higher Perceived Ability to engage in interaction with industry than before, it does not yet mean that he or she will have higher perceived ability to understand industry needs.	Formative
2. Interchangeability of the indicators / items	The indicators do not share a common theme. Eliminating an indicator may alter the conceptual domain of the construct.	The proposed skills are not interchangeable and do not have similar content. For example, the ability to balance conflicting interests of incentive systems and the ability to work according to industry standards do not share a common theme. It was also our objective to capture the entire domain of academics' specific	Formative

Criterion	Manifestation in our model	Example	Model
		skills related to interaction with industry.	
3. Covariation among the indicators	A change in the value of one of the indicators is not necessarily expected to be associated with a change in all of the other indicators.	If one of the skills changes, it does not mean that all other skills will change. For example, if an academic will be less capable of understanding industry needs, it does not mean that he or she will be less able to operate with a wide range of bodies of knowledge.	Formative
4. Nomological net of the construct indicators	The indicators do not have the same antecedents and consequences.	The proposed skills have different nature. Some are related to knowledge, others are related to experience and training.	Formative

The model specification exercise clearly suggests that Perceived Ability should be labeled as a formative construct. In addition to formative measures, we have developed a set of five reflective measures characterizing a general feeling of academic's ability to engage in interaction with industry (see Table 3-11). For confirming the reflective nature of these measures, we again employed the decision rules by Jarvis et al. (2003). All four criteria such as the direction of causality, interchangeability, covariation and nomological net of indicators confirmed that the construct is reflective, i.e., it is manifested by its measures.

Table 3-11: Proposed operationalization of Perceived Ability (reflective measures)

Variable	Measure
PAR1	General knowledge of how to interact with industry
PAR2	A feeling of being comfortable when collaborating with industry
PAR3	A feeling of confidence when working together with industry
PAR4	Feeling capable of interacting with industry
PAR5	Easiness of collaboration with industry

The reflective measures were then translated into a set of questions (see Annex A, variables PAR1-PAR5).

Figure 3-3 provides a visual presentation of the measurement model of Perceived Ability as a mixed construct.

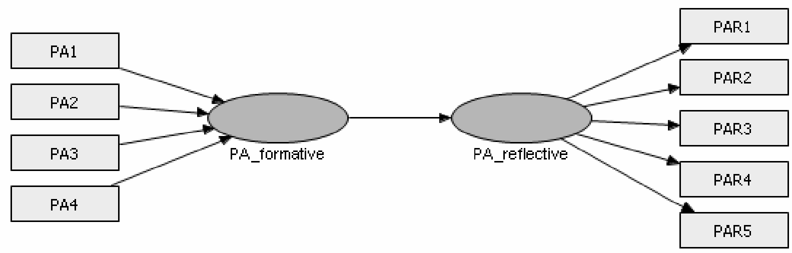

Figure 3-3: Measurement model of Perceived Ability as a mixed construct

3.1.4 Trigger

As mentioned above, even exceptionally strong readiness does not necessarily have to lead to actual behavior (Triandis, 1967, Katz, 1989 quoted in Krueger et al., 1993). Therefore, an extra set of factors needs to be considered that may 'precipitate' or trigger individual's behavior (see, for example, Shapero's precipitating event in Krueger et al., 1993; Shapero, 1982). Readiness alone does not guarantee behavior, and a trigger is needed.

Definition

The trigger here refers to an event, action or occasion that serves as a reason for behavior to occur. We will consider behavior as being planned in cases when a triggering event, action or occasion makes an individual initiate an interaction. For example, if an academic proactively approaches an industry representative because a large governmental program has issued a new call for tenders, and reciprocal exchange of (information) resources occurs between both nodes, then this behavior will be considered as planned, with a new call for tenders as a trigger to initiate an interaction. Accordingly, we will consider behavior as being unplanned when the initiative to start an interaction came from an interaction partner. The initiative of an interaction partner in this case serves as a trigger for an academic to engage in interaction.

Theoretical grounds

As mentioned in the theoretical chapter, we distinguish between the four main types of situations when the trigger occurs (see Table 3-12). First, an academic may spot ideas that are potentially interesting for industry him- or herself and then approach industry proactively to communicate those ideas. Second, an academic may get connected with industry by the head of the research group/peer colleagues/academic research partners. Third, industry representatives may approach an academic directly. Finally, academics can also be connected to industry by third parties (e.g., university-industry match-making services, governmental agencies, cluster organizations). The first situation corresponds to planned behavior, while the latter three refer to unplanned behavior.

Table 3-12: Overview of proposed triggers

Trigger	Type of behavior
(1) An academic approaches industry representatives him- or herself to communicate ideas that might be might be potentially interesting for industry.	Planned
(2) An academic gets connected with industry by the head of research group/peer colleagues/academic research partners.	Unplanned
(3) Industry representatives approach an academic directly.	Unplanned
(4) An academic gets connected to industry by third parties (e.g., university-industry match-making services by governmental agencies, cluster organizations, TTOs etc.)	Unplanned

Operationalization

Table 3-13 presents the proposed operationalization of a trigger. The questions on triggers for an interaction to occur need to cover the entire domain of possible triggers (Petter, Straub, & Rai, 2007). Due to high diversity of possible triggers, systematization of them would represent a utopian task. Therefore, rather than systemizing the reasons, we systemize the initiators of interactions. Empirical research suggests that interactions between university and industry can be initiated by (1) an academic him- or herself; (2) an academic's boss (the head of research group/laboratory/department/university) and/or his or her academic peer colleagues; and (3) industrial acquaintances (Lazega et al., 2006). In addition, academics can also be connected to industry by third parties (e.g., university-industry match-making services provided by governmental agencies). The current approach is based on the assumption that every time when an interaction is initiated by somebody, that somebody has a reason to initiate it. Therefore, the idea of having a reason for an interaction to occur stays central, while the feasibility of its measurement increases.

Table 3-13: Proposed operationalization of Trigger

Variable	Measure
TR1	An academic approaches industry him- or herself with ideas that might be potentially interesting for them.
TR2	Academic's interactions with industry are initiated by his or her boss (i.e., the head of research group/laboratory/department/university) and/or his or her

Variable	Measure
	academic peer colleagues.
TR3	Industry representatives approach an academic directly.
TR4	An academic gets connected to industry by third parties (e.g., university-industry match-making services by governmental agencies, cluster organizations, TTOs etc.).

Each of the situations was then translated into specific questions (see Annex A, variables TR1-TR4).

Specification of measurement model

In this sub-section, we aim to determine the appropriate measurement model by specifying whether Trigger should be modeled as a formative or reflective construct. Table 3-14 presents the results of the model specification exercise and suggests that Trigger should be labeled as a formative construct.

Table 3-14: Specification of measurement model for Trigger

Criterion	Manifestation in our model	Example	Model
1. Direction of causality from construct to measure implied by the conceptual definition	The indicators are viewed as defining characteristics of the construct. Changes in the indicators are expected to cause changes in the construct. Changes in the construct are not expected to cause changes in the indicators.	An increase in one or more observable variables is expected to lead to the overall increase of Trigger; whereas an increase in Trigger does not necessarily mean that a certain observable variable will also increase. For example, an academic who now is approached by industry directly more often than before, is expected to have Trigger larger than before. However, if he or she will in general have Trigger that is larger than before, it does not yet mean that he or she will also be approached by industry more often than before, as this increase in Trigger may also be related to increase in the number of times when an academic was connected with industry by his academic colleagues or when he approached industry him- or herself.	Formative
2. Interchangeability of the indicators / items	The indicators do not share a common theme. Eliminating an indicator may alter the conceptual domain of the construct.	The proposed observable variables are not interchangeable and do not have similar content. They refer to three different initiators of interaction between an academic	Formative

Criterion	Manifestation in our model	Example	Model
		and industry.	
3. Covariation among the indicators	A change in the value of one of the indicators is not necessarily expected to be associated with a change in all of the other indicators.	If one of the observable variables changes, it does not mean that all other observable variables will change. For example, if an academic will get connected with industry by his academic colleagues more often than before, it does not yet mean that industry will approach this academic directly more often than before (though correlation is expected).	Formative
4. Nomological net of the construct indicators	The indicators do not have the same antecedents and consequences.	The proposed observable variables have different nature. They refer to three different initiators of interaction between an academic and industry, and those initiatives are not likely to have the same antecedents and consequences. For example, the reason why an academic approaches industry proactively is not expected to be the same as the reason when industry decides to approach that academic.	Formative

In addition to formative measures, we have developed a set of four reflective measures characterizing the general presence of opportunities to engage in interaction with industry (see Table 3-15). For confirming the reflective nature of these measures, we again employed the decision rules by Jarvis et al. (2003). All four criteria such as the direction of causality, interchangeability, covariation and nomological net of indicators confirmed that the construct is reflective, i.e., it is manifested by its measures.

Table 3-15: Proposed operationalization of Trigger (reflective measures)

Variable	Item
TRR1	The presence of opportunities to collaborate with industry during the last year
TRR2	The presence of many chances to communicate with industry in the course of the last year
TRR3	The presence of many reasons to seek or receive information from industrial partners last year
TRR4	The presence of occasions where an academic met industry representatives last year

The reflective measures were then translated into a set of questions (see Annex A, variables TRR1-TRR4).

Figure 3-4 provides a visual presentation of the measurement model of Trigger as a mixed construct.

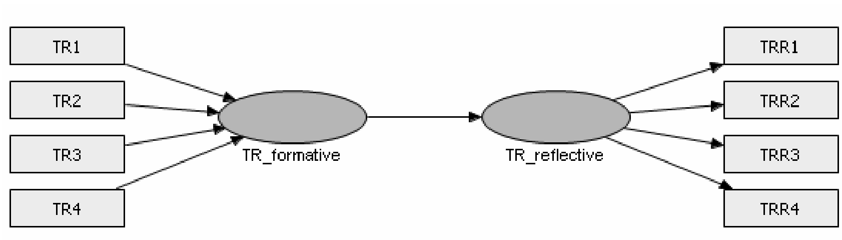

Figure 3-4: Measurement model of Trigger as a mixed construct

With regard to the measurement issues, the respondents will be asked to assess the frequency of triggers using 7-point unipolar scales (1 to 7).

3.1.5 Passive and activated social capitals

In the past thirty years of social capital research, many attempts have been made to find valid and reliable measures of social capital (Blumstein et al., 1988; Borgatti et al., 1998; Burt, 1983, 1992; Marsden et al., 1984; Petróczi et al., 2006). However, little sustained attention has been paid to the development of measures that would allow capturing the dynamic nature of social capital, i.e., measures that would allow us to trace its switching between passive and active modes. Hence also no systematic analysis of the antecedents of social capital activation has been possible. The measures capturing the dynamic nature of social capital would allow organizational researchers and management practitioners to trace its development in time, i.e., to analyze how it is accumulated, maintained and changed. The understanding of the antecedents of social capital activation, in turn, would allow predicting how social capital will be exploited in the future, and consequently also the corresponding effects of its exploitation in the future.

Definition

As explained before, at moments when reciprocal exchange of resources does not occur between two or more actors, social capital should be considered passive. In other words, passive social capital refers to networks that might be exploited (or activated) should the necessity arise. At moments when reciprocal exchange of resources does occur between the actors, social capital should be considered activated. Finally, the notion of social capital activation implies that an individual’s social capital at a certain moment of time represents a sum of his or her passive and activated social capitals.

Theoretical grounds

An individual's social capital with a particular interaction partner at a certain moment of time can thus be considered either passive or active depending on whether an interaction takes place. Furthermore, both passive and activated social capitals represent dynamic concepts, i.e., they change over time. Consequently, to be able to capture the dynamic nature of social capital, the measures of social capital need take into account both the distinction between passive and active modes and the constant change of those two modes over time.

Up to this moment, we were referring to an individual's social capital with a particular interaction partner at a certain moment of time. However, tracing individual interactions at each moment of time represents a highly challenging task, and therefore aggregated measures are needed, i.e., measures that capture total results. Firstly, social networks of individuals usually involve multiple interaction partners, and thus individual's total social capital at a certain moment of time represents a sum of his or her passive and activated social capitals related to all interaction partners in his or her network. Furthermore, instead of focusing on a certain moment of time, it is reasonable to estimate a general level of social capital activation for a particular individual within a longer period of time (for example, one year), which would neutralize the effects of a wide variety of random factors related to individual interactions. The question that needs to be answered would then be 'How actively did an individual exploit his or her network last year?'.

Let us assume that the distance between two points of time t_0 and t_1 is one year (see Figure 3-5). In this case, two primary groups of measures that would allow us answering the abovementioned question refer to passive social capital at t_0 and activated social capital between t_0 and t_1. Both groups represent aggregated measures. The measures of passive social capital at t_0 refer to the cumulative results of previous interactions, i.e., the results of interactions by the beginning of the year in question. The measures of activated social capital, in turn, refer to the interactions during that year. In the remainder of this section, we discuss specific measures from both groups.

To derive the possible measures for both modes, we first address the existing literature. Two primary variables that have been argued to form individual's social capital refer to network size and tie strength (Gabbay & Leenders, 2001 quoted in Anderson, 2008) which represent social network characteristics. Another possible variable could refer to resources that are embedded in social networks and exchanged during social interaction. However, we do not aim at measuring those resources directly and we will not view them as a direct manifestation of social capital. Tracing and measuring (information) resources that are embedded in social networks and exchanged during social interaction, represents a highly challenging task. Therefore, social network researchers often do not measure the amount and diversity of information that flows through networks, but instead assume that structure determines information channels, and employ social network characteristics as proxies for information transfer (Seibert et al., 2001 quoted in Anderson, 2008).

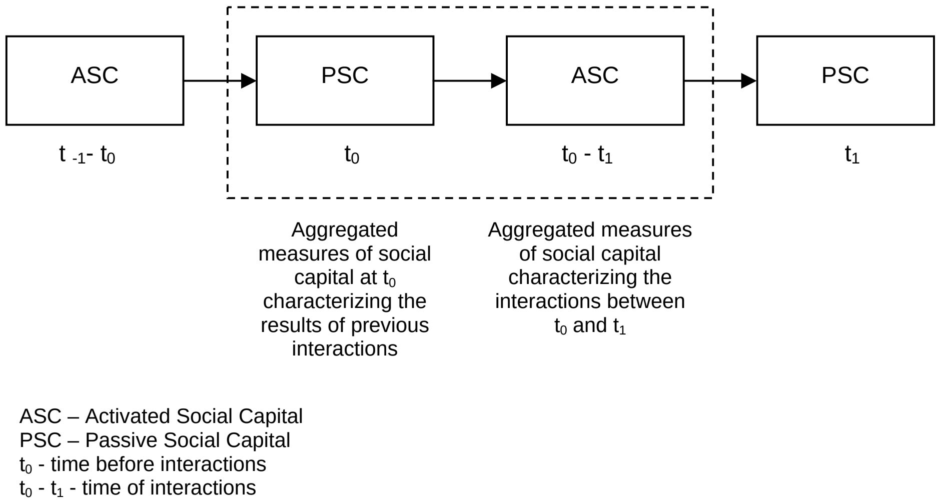

Figure 3-5: Distinction between the measures of passive and activated social capitals

Network size and tie strength can be used for measuring both passive and activated social capitals. However, different aspects of those variables are relevant to different modes of social capital. Table 3-16 provides an overview of suggested aggregated measures for both types of social capital.

Table 3-16: Proposed measures of passive and activated social capitals

Category	**Passive social capital t_0**		
	Measure	**References**	**Description**
Network size	Actual network size	(Burt, 1983), (Borgatti, 1997), (Hansen, Podolny, & Pfeffer, 2001)	The number of contacts that an individual is directly connected to at t_0.
	Effective network size	(Burt, 1992), (Borgatti, 1997), (Borgatti et al., 1998), (Hansen et al., 2001)	The number of contacts that an individual is directly connected to at t_0, reduced by the extent to which the individual's contacts know one another.

Tie strength	Closeness	(Anderson, 2008), (Blumstein et al., 1988), (Hansen et al., 2001), (Marsden et al., 1984), (Petróczi et al., 2006)	The degree familiarity of an individual to his or her contacts at t_0.
	Multiplexity of roles	Authors' own	The diversity of roles in which an individual knows his or her contacts in relation to him- or herself
	History of interaction	(Anderson, 2008), (Blumstein et al., 1988), (Granovetter, 1973), (Marsden et al., 1984), (Petróczi et al., 2006)	The duration of a relation between an individual and his or her contacts at t_0.
Category	**Activated social capital t_0 – t_1 (1 year)**		
	Measure	**References**	**Description**
Network size	Actual size of exploited network	Authors' own	The number of contacts with whom an individual had an actual interaction during last year.
	Effective size of exploited network	Authors' own	The number of contacts with whom an individual had an actual interaction during last year, reduced by the extent to which those contacts know one another.
Tie strength	Frequency	(Anderson, 2008), (Benassi, Greve, & Harkola, 1999), (Blumstein et al., 1988), (Granovetter, 1995), (Hansen et al., 2001), (Lin, Vaughn, & Ensel, 1980), (Marsden et al., 1984), (Petróczi et al., 2006)	The regularity at which an individual interacted with his or her contacts during last year.
	Multiplexity of interactions	(Blumstein et al., 1988), (Granovetter, 1973), (Marsden et al., 1984), (Petróczi et al., 2006)	The breadth of topics which were covered during interactions between an individual and his or her contacts last year.
	Total duration	(Blumstein et al., 1988), (Granovetter, 1973), (Marsden et al., 1984), (Petróczi et al., 2006)	The total amount of time that an individual spent on interactions with his or her contacts last year.

Operationalization

Network size is typically measured in one of the two ways: actual or effective network size (Borgatti et al., 1998). *Actual network size* represents the number of contacts an individual has (sometimes also called ‘degree’ or ‘degree centrality’). *Effective network size* reduces the actual network size by the extent to which the individual’s contacts know one another. Effective network size incorporates a fundamental assumption of structural hole theory implying that people who are connected to one another offer less information benefits to each other (Burt, 1992). That is, the amount and diversity of information available from an actor’s social network is expected to be less to the extent that the actor’s contacts know one another, because those connected people are likely to possess more information in common, and thus less unique information in general. An actor’s effective network size is thus larger when the people he or she is connected to do not know one another (Anderson, 2008).

Measuring actual and effective network sizes at t_0 would provide us with information on the individual’s existing network by the beginning of the period in question. Actual and effective network sizes at t_0 refer to the results of the previous interactions and thus represent appropriate measures for passive social capital.

In case of activated social capital, these measures exclusively refer to the contacts that have been exploited during the period in question. Thus, actual size of exploited network during t_0 - t_1 refers to the number of contacts with whom an individual had an actual interaction during last year. Similarly, effective size of exploited network during t_0 - t_1 reduces actual size of exploited network during t_0 - t_1 by the extent to which those contacts know one another.

For the needs of the current study, we measure actual network size (‘degree’ or ‘degree centrality’) because of a number of reasons. First, the number of industrial acquaintances measured in this study refers to people from different organizational entities. As a result, the amount and diversity of information they possess is already likely to be significantly higher than in situations when people work within the same organization. Furthermore, empirical evidence suggests that academics are likely to have from 4 to 10 industrial partners (Balconi et al., 2004); consequently, for most academics, the number of industrial partners in their networks is already relatively low. Finally, the current study aims to measure network size with regard to the whole category of behavior, and not one interaction. Therefore, it might be highly challenging for the respondents to provide exact information on their effective network size, and the reliability of obtained data would need to be put under question.

As mentioned above, next to network size, tie strength represents the second variable that has been argued to form individual’s social capital (Gabbay & Leenders, 2001 quoted in Anderson, 2008). In the past three decades, many attempts have been made to find reliable indicators of tie strength. At this moment, more than ten indicators exist that characterize different aspects of tie strength including, among others, frequency (Benassi et al., 1999; Blumstein et al., 1988; Marsden et al., 1984; Mitchell, 1987), intimacy (Blumstein et al., 1988; Marsden et al., 1984; Mitchell, 1987), breadth of topics (Blumstein et al., 1988; Granovetter, 1973; Marsden et al., 1984) and duration (Blumstein et al., 1988; Granovetter, 1973; Marsden et al., 1984) (for a comprehensive overview of existing tie-strength indicators see, for example Petróczi et al., 2006). To our knowledge, no attempt has been made, however, to classify those indicators depending on whether they refer to the possession or the actual exploitation of social capital. Given that not all existing tie strength indicators are relevant to all types of relations (some of them are of more informal and intimate nature), we have selected a restricted set of tie strength characteristics that we view as applicable to any relation. These include closeness, history of interaction, frequency, multiplexity and total duration. Table 3-17 shows which of these variables are relevant to which type of social capital.

Two commonly used tie-strength measures that refer to the results of previous interactions and thus characterize passive social capital are closeness and history of interactions. While closeness characterizes the extent to which an individual is familiar to his or her contacts, the history of interactions refers to the duration of relations between an individual and his contacts. Those measures thus provide an indication of how well and how long an individual knows his or her contacts by the beginning of the period in question (t_0) and refer to the possession of a social network. In addition, the multiplexity of roles can serve as another measure of passive social capital. The multiplexity of roles here refers to the diversity of roles in which an individual knows his or her contacts in relation to him- or herself.

Three tie-strength measures that refer to the process of interaction during the last year ($t_0 - t_1$) and thus characterize activated social capital are frequency, multiplexity of interactions and total duration. Frequency refers to the regularity at which an individual interacted with his or her contacts during last year. Multiplexity of interactions implies the breadth of topics which were covered during interactions between an individual and his contacts last year. Finally, total duration refers to the total amount of time that an individual spent on interactions last year. Those measures thus provide an indication of how frequent, diverse and long the interactions were in the course of the last year ($t_0 - t_1$) and refer to the actual exploitation of social capital.

Table 3-17: Proposed operationalization of Passive Social Capital and Social Capital Activation

Variable name	Measure
Passive Social Capital	
PSCR1	Actual network size: the number of industrial acquaintances in academic's social network by September 2009
PSCR2	Closeness of interactions: a feeling of affinity with industrial partners by September 2009 (cumulative measure)
PSCR3	Multiplexity of roles: the diversity of roles of industrial acquaintances in which an academic knows them in relation to him- or herself by September 2009 (cumulative measure)
PSCR4	History of interactions: the number of years an academic has been knowing his or her industrial partners by September 2009 (cumulative measure)
Social Capital Activation	
SCAR1	Actual size of exploited network between September 2009 and September 2010
SCAR2	Frequency of interactions: the frequency of seeking or receiving information from industrial partners between September 2009 and September 2010 (cumulative measure)
SCAR3	Multiplexity of interactions: the diversity of interaction types an academic was engaged in between September 2009 and September 2010 (cumulative measure)
SCAR4	Total duration of interactions with industrial partners between September 2009 and September 2010 (cumulative measure)

The abovementioned measures were then translated into a set of questions (see Annex A, variables PSCR1-PSCR4 for questions on passive social capital, and variables SCAR1-SCAR4 for the questions on social capital activation).

Specification of measurement model

In this sub-section, we aim to determine the appropriate measurement model by specifying whether Passive Social Capital and Social Capital Activation should be modeled as a formative or reflective constructs. Table 3-18 presents the results of the model specification exercise and suggests that both constructs should be labeled as reflective.

Table 3-18: Specification of measurement model for Passive Social Capital and Social Capital Activation

Criterion	Manifestation in our model	Example	Model
Passive Social Capital			
1. Direction of causality from construct to measure implied by the conceptual definition	The indicators are viewed as manifestations of the construct.	Actual network size, total closeness, total multiplexity of roles and total history of interactions are viewed as various ways of capturing the concept of passive social capital.	Reflective
2. Interchangeability of the indicators / items	Indicators are interchangeable. Dropping an indicator should not alter the conceptual domain of the construct.	The proposed observable variables are interchangeable. For example, in case we do not measure the total multiplexity of roles, we can still judge passive social capital by looking at the actual network size, total closeness and total history of interactions.	Reflective
3. Covariation among the indicators	Indicators are expected to covary with each other. A change in one of the indicators is likely to be associated with changes in the other indicators.	If one of the observable variables changes, it is likely that the other observable variables will change as well. For example, if the size of the network increases, it automatically means the increase in the total closeness, multiplexity of roles and history of interactions (as these are all cumulative variables depending on the network size).	Reflective
4. Nomological net of the construct indicators	The indicators have the same antecedents and consequences.	The proposed observable variables have the same antecedents related to the creation and maintenance of social contacts in the past. The proposed observable variables are also expected to have the same consequences related to the level of activation of their social capital in the future.	Reflective
Social Capital Activation			
1. Direction of causality from construct to measure implied by the conceptual definition	The indicators are viewed as manifestations of the construct.	The size of exploited network, as well as the total frequency, multiplexity and duration of interactions are viewed as various ways of capturing the concept of activated social capital.	Reflective
2. Interchangeability of the indicators / items	Indicators are interchangeable. Dropping an indicator should not alter the conceptual	The proposed observable variables are interchangeable. For example, in case we do not measure the total multiplexity of interactions, we can still judge activated social capital by looking at the size of exploited	Reflective

Criterion	Manifestation in our model	Example	Model
Passive Social Capital			
	domain of the construct.	network, as well as the total frequency and duration of interactions.	
3. Covariation among the indicators	Indicators are expected to covary with each other. A change in one of the indicators is likely to be associated with changes in the other indicators.	If one of the observable variables changes, it is likely that the other observable variables will change as well. For example, if the size of the exploited network increases, it automatically means the increase in the total frequency, multiplexity and duration of interactions (as these are all cumulative variables depending on the size of exploited network).	Reflective
4. Nomological net of the construct indicators	The indicators have the same antecedents and consequences.	The proposed observable variables have the same antecedents related to the creation and maintenance of social contacts in the past. The proposed observable variables are also expected to have the same consequences related to the level of activation of their social capital in the future.	Reflective

With regard to the measurement issues, the respondents will be offered open and multiple-choice questions, and cumulative measures will be calculated to be used as an input for the empirical analysis (for more information on these calculations see Annex A, column “Additional operations”).

3.1.6 Positional factors

Existing research suggests that several additional factors are likely to affect the academics’ level of engagement in interaction with industry. These factors represent so called positional factors as they refer to the individual’s current position in academia. Table 3-19 provides an overview of positional factors employed in this study: (1) hierarchical position; (2) scientific orientation; and (3) scientific domain. Below we elaborate on each of the abovementioned positional factors in more detail.

Table 3-19: Positional factors

Variable	Measure	Options
POS1	Hierarchical position	Full professor (Hoogleraar) Associate professor (Universitair Hoofddocent) Assistant professor (Universitair Docent) Postdoc (Onderzoeker) PhD candidate (Promovendus) Other (please specify)
POS2	Scientific orientation	Pure Basic More Basic than Applied Equally Basic and Applied More Applied than Basic Pure Applied
POS3	Scientific domain	Biotechnology Nanotechnology Other (please specify)

POS1: Hierarchical position

Existing research suggests that hierarchical position correlates directly with the academics' level of engagement in university-industry interactions (Bercovitz et al., 2008; D'Este et al., 2007b; Landry, Amara, & Ouimet, 2005; Lazega et al., 2006; Zucker et al., 1996). Hierarchical position is also suggested to determine the influence of the chair on the behavior of academics (Bercovitz et al., 2008), i.e., perceived social influence presented above, as well as academics' perceived ability to interact with industry (Lin & Bozeman, 2006).

Definition

Hierarchical position here refers to the academic rank amongst scholars in academia (e.g., professor, research fellow, PhD candidate). In the operationalization sub-section, we will elaborate on the hierarchical ranking structure in the Netherlands.

Theoretical grounds

Academic's engagement in interaction with industry is the result of his or her decision to do so (as this task is not compulsory). Academic's autonomy of decision making, in turn, is likely to be affected by his or her hierarchical position (Gaston, 1975; Van Dierdonck, Debackere, & Engelen, 1990). Accordingly, within a research group, professors are likely to have the highest autonomy regarding their decision to interact with industry, followed by associate professors and assistant professors. In addition, the human capital argument suggests that those individuals who are well established in their academic careers will be more likely to proactively leverage their reputations for commercial gains (Bercovitz & Feldman, 2008; Stephan & Levin, 1992). Young academics, in turn, are suggested to demonstrate a relative lack of participation in decision making (Gaston, 1975), as they are likely to possess less freedom of decision making than their senior colleagues.

Finally, the higher one is on the academic ladder, the better indication that he or she has shown the capacity to collaborate and attract resources (Lin & Bozeman, 2006). A hierarchical position may also be related to industry experience, especially for those academics actively recruited from industry. It is thus reasonable to assume that, in general, academics from higher hierarchical positions are more likely to be convinced about their ability to interact with industry than their less senior colleagues. The latter may, in turn, prevent less senior academics from actual engagement in university-industry interaction.

Consequently, this positional factor is likely to have a considerable influence for academics on the role of the key determinants of social capital activation with industry and should be included in the study.

Operationalization

The list of academic ranks below identifies the hierarchical ranking structure found amongst scholars in academia in the Netherlands. The Dutch academic ranking system is comparable to the U.S. system, although PhD candidates are usually employed by the university.

Faculty Positions in The Netherlands are as follows[4]:

- *Universiteitshoogleraar* (a distinguished full professor);
- *Hoogleraar 1* (a senior full professor, leading a large department or university institute);
- *Hoogleraar 2* (a junior full professor, leading a research group);
- *Universitair Hoofddocent* (an associate professor);
- *Universitair Docent* (an assistant Professor);
- *Onderzoeker / Postdoc* (a senior research fellow; postdoctoral fellow);
- *Junior Onderzoeker/Assistent in Opleiding/Promovendus* (a junior researcher; PhD candidate employed by the university);
- *Docent* (Lecturer, teaching staff usually not holding a PhD);
- *Student Assistant* (Research or Teaching Assistant, (under)graduate student employed by university for research or teaching activities).

[4] http://en.wikipedia.org/wiki/List_of_academic_ranks#Netherlands

As can be seen in Table 3-19, in this research, we have transformed the abovementioned 9 categories into 6 main groups of academic ranks, including one broader category “Other”. Such transformation was done in order to avoid the unnecessary sophistication of the analysis, as we are interested in the key differences between general hierarchical levels of academics.

The analysis of the differences between the behaviors of academics having different hierarchical positions is likely to provide valuable insights into how the necessary policy measures may differ depending on the hierarchical position.

POS2: Scientific orientation

In addition, scientific orientation (basic vs. applied) is reported to correlate directly with the level of engagement in university-industry interactions (Bercovitz et al., 2008; D’Este et al., 2007b; Landry, Amara, & Ouimet, 2005; Lazega et al., 2006; Zucker et al., 1996).

Definition

Scientific orientation here refers to a group of scientific research methods that pursue specific objectives. By pure basic research one should understand the research carried out to increase understanding of fundamental principles. The results of such research often do not have direct or immediate commercial benefits, and the research is typically conducted out of scientific curiosity. Nevertheless, in the long term, it may form the basis for applied research and commercial products. Applied research, in turn, involves practical application of science and deals with solving practical problems.

Theoretical grounds

The academics’ scientific orientation is likely to determine the autonomy of decision-making regarding interactions with industry. Academics mainly working on applied research are per definition predisposed to actively interact with industry, while academics with a more basic orientation have more ‘freedom’ to decide whether to engage in interactions with industry or not (Stokes, 1997). In addition, as introduced by Stokes, there is also a type of research that lies in between purely basic and purely applied research (so called Pasteur’s Quadrant), and that often links semi-autonomous domains of science and technology (Balconi & Laboranti, 2006). This group of academics too has a relative freedom to decide whether to interact with industry or not.

In addition, the influence of chairs and peer colleagues on academics' social capital activation with industry is likely to vary depending on the scientific orientation of the university department. Academics from university departments in which interaction with industry is not a norm are less likely to collaborate with industry than academics from more 'non-traditional' departments (Stuart & Ding, 2006). It is thus reasonable to assume that in departments with more basic scientific orientation, academics will feel less social pressure to interact with industry than in departments with more applied orientation.

Finally, academics working in the applied fields must be closely familiar with industry needs (Klevorick, Levin, Nelson, & Winter, 1995) in order to be able to create significantly new designs, concepts, methods and prototypes (Balconi & Laboranti, 2006). As a result, for academics with a more applied orientation, the perceived ability to interact with industry is likely to be less of an issue. For academics doing a more basic research, however, such knowledge and skills are not compulsory, and their absence is likely to hinder academic's interaction with industry.

Consequently, this positional factor is also likely to have a considerable influence for academics on the role of the key determinants of social capital activation with industry and should be included in the study.

Operationalization

For capturing the scientific orientation, we used a semantic differential scale between two extremes: pure basic and pure applied research. The analysis of the differences between the behaviors of academics with these scientific orientations is likely to provide valuable insights into how the necessary policy measures may differ depending on the scientific orientation.

POS3: Scientific domain

Finally, existing research suggests that academics' behavior may differ depending on their scientific domain (D'Este et al., 2007a; Kenney et al., 2004).

Definition

By scientific domain here one should understand a specific sphere of activity or a field. The current study focuses on two scientific domains: bio- and nanotechnology. Biotechnology is a field of applied biology that implies the use of living organisms and bioprocesses in engineering, technology, medicine and other fields involving bioproducts. Biotechnology also uses these products for manufacturing purposes. Biotechnology draws on the pure biological sciences (genetics, microbiology, animal cell culture, molecular biology, biochemistry, embryology, cell biology) and in many cases is also dependent on knowledge and methods from outside the sphere of biology (chemical engineering, bioprocess engineering, information technology, and biorobotics). On the other hand, modern biological sciences (including concepts such as molecular ecology) are closely entwined and dependent on the methods developed through biotechnology and what is commonly thought of as the life sciences industry[5].

Nanotechnology, in turn, is the study of manipulating matter on an atomic and molecular scale. Generally, nanotechnology deals with developing materials, devices, or other structures possessing at least one dimension sized from 1 to 100 nanometres. Nanotechnology is highly diverse, ranging from extensions of conventional device physics to completely new approaches based upon molecular self-assembly, from developing new materials with dimensions on the nanoscale to investigating whether it is possible to directly control matter on the atomic scale. Nanotechnology entails the application of fields of science as diverse as surface science, organic chemistry, molecular biology, semiconductor physics, microfabrication, etc[6].

Theoretical grounds

Scientific domain may influence the autonomy of decision-making regarding interactions with industry. When comparing bio- and nanotechnology, it has been estimated that nanotechnology is currently at the level of development similar to the emergence of biotechnology in 1980s, with biotechnology offering considerably more industrial applications (Miyazaki & Islam, 2007; Roco, 2005). Academics working in biotechnology are thus currently more predisposed to working with industry than their nanotechnology colleagues.

Additionally, the influence of chairs and peer colleagues on academics' social capital activation with industry may also vary depending on the scientific domain. As mentioned above, biotechnology demonstrates a higher degree of maturity of university-industry interactions when compared to nanotechnology (Miyazaki & Islam, 2007; Roco, 2005). Thus, for biotechnology academics, we can expect a stronger imprint of social capital activation with industry into group's norms than for their nanotechnology colleagues.

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[5] http://en.wikipedia.org/wiki/Biotechnology
[6] http://en.wikipedia.org/wiki/Nanotechnology

Finally, for academics working in biotechnology, perceived ability is likely to have a larger effect on social capital activation than for the academics from the nanotechnology field. This difference can be expected due to the sensitive intellectual property domain related to biotechnology, and the corresponding implications for university-industry projects (Cantor, 2000; Conley & Makowski, 2003; Drahos, 1999). At the same time, nanotechnology represents an emerging field, and the intellectual property domain there is less defined (Bowman, 2007). Consequently, not all academics from the biotechnology field may feel confident when interacting with industry because of IP issues they have to deal with.

As a result, scientific domain too is likely to have a considerable influence for academics on the role of the key determinants of social capital activation with industry and should be included in the study.

Operationalization

The scientific domains included in this study are currently at different stages of development, and, as a result, with different degrees of predisposition of academics to interacting with industry. The analysis of the differences between the behaviors of academics active within these two domains is likely to provide valuable insights into how the necessary policy measures may differ depending on the domain.

3.1.7 Control variables

Existing research also suggests that academic’s level of engagement in interaction with industry depends on his or her affiliated institution (D’Este et al., 2007b) and country of origin, i.e., depending whether academics are local or foreign-born (Lee, 2004). Additionally, academics’ engagement in interactions with industry is likely to be influenced by their gender (Lin & Bozeman, 2006). Therefore, when empirically analyzing the results, when possible, we also controlled for the following three factors: (1) affiliated institution, (2) gender, and (3) country of origin (local vs. foreign-born).

Table 3-20: Control variables

Variable	Measure	Options
CONV1	Affiliated institution	Delft University of Technology (TU Delft) Eindhoven University of Technology (TU/e) Erasmus University Rotterdam Leiden University Radboud University Nijmegen(RU) University of Amsterdam (UvA) University of Groningen (RUG) University of Twente (UT) Utrecht University (UU) VU University Amsterdam (VU) Wageningen University and Research Centre (WUR) Other (please specify)
CONV2	Gender	Female Male
CONV3	Country of origin	Netherlands Other (please specify)

3.2 DATA COLLECTION

Data collection took place over a two-month period, from October to December 2010. Academics were approached by means of an online survey focusing on their interactions with industrial partners between September 2009 and September 2010. Participation in the survey was voluntary. We assured respondents of their anonymity, as participants are more likely to provide unbiased responses when their anonymity is assured (Heneman, 1974). We applied a coding scheme that prevented us from identifying the response of any specific individual. In the reminder of this sub-section, we elaborate on the key characteristics of the sample and examine the main steps related to the development of an online survey.

3.2.1 Sample

As mentioned above, we aimed to broaden our attention beyond the groups of academics that are actively engaged in university-industry interactions (that fit well with the description of "entrepreneurial academics" by Meyer, 2003) to thoughtfully consider other key types of publics: socially inactive academics with high potential, uninvolved but aware, and unaware academics (for detailed descriptions of different types of publics see Hallahan, 2000). These groups of academics have been largely overlooked by both theorists and practitioners. Such approach provides an opportunity for the segmentation of academics based on the abovementioned positional factors and control variables. This approach allows for describing various types of publics and helps to develop guidance on the types of intervention that may be effective in steering their behavior (for a similar approach see Rothschild, 1999 quoted in Binney, Hall, & Shaw, 2003).

The final sample of the study consists of 184 academics from 12 Dutch universities and research centers. We targeted academics from bio- and nanotechnology fields. The survey was sent to the total population of academics from those fields based on the data from the Dutch Research Database (KNAW). In total, 1386 surveys were distributed, and 110 delivery failures were received due to outdated email addresses. After two reminders, 184 surveys were filled out corresponding to a response rate of 14.4%. Table 3-20 presents the key sample characteristics.

Table 3-21: Sample characteristics

Positional factor	**1. Hierarchical position**		
Sub-groups	High (Full professors and Associate professors)	Medium (Assistant professors, Postdocs, Other)	Low (PhD candidates)
n **%**	47 26	54 29	83 45
Positional factor	**2. Scientific orientation**		
Sub-groups	More Basic than Applied	Equally Basic and Applied	More Applied than Basic
n **%**	66 36	61 33	57 31
Positional factor	**3. Scientific domain**		
Sub-groups	Biotechnology	Nanotechnology	Other
n **%**	71 39	65 36	48 25
Control variable	**4. Gender**		
Sub-groups	Female	Male	
n **%**	52 29	132 71	
Control variable	**5. Country of origin**		
Sub-groups	Netherlands	Other	
n **%**	122 66	52 34	

3.2.2 Online survey

There are a number of reasons why we decided to employ an online survey as the key data collection method instead of other surveying methods. The key reasons are listed below:

- Statistical compilation of the results was possible in real time (i.e., it was possible to monitor survey results throughout the time the survey was online).
- Automatic reporting functions allowed for compiling all survey results in one file thereby saving time and efforts (including addition of late responses).
- Online survey eliminates interviewer bias or error since the survey is delivered in exactly the same manner to all respondents.
- Geographic location of respondents does not impact the quality of the data or the efficiency of the data collection process.
- The employed survey tool allowed for top-level internet security and encryption-protected data.
- The employed survey tool allowed for privacy protection, i.e., the respondents remained anonymous; privacy and confidentiality were protected.
- Helpdesk services were offered to the respondents in case they needed any technical assistance with the survey. Such assistance enabled several extra responses and consequently increased the total response rate.

The construction of the survey to measure the variables in the model proceeded in the following eight phases (based on the guidelines by Francis et al., 2004):

(1) Defining the population of interest and deciding how best to select a representative sample from this population;
(2) Defining the behavior under study;
(3) Deciding how best to measure constructs;
(4) Determining the most frequently perceived advantages and disadvantages of performing the behavior;
(5) Determining the most important people or groups of people who would approve or disapprove the behavior;
(6) Determining the perceived barriers or facilitating factors that could make it easier or more difficult to adopt the behavior;
(7) Including items to measure all of these constructs in the first draft of the questionnaire;
(8) Conducting a pilot test of the draft and rewording items if necessary.

Once the hypotheses were formulated, we launched a pilot online survey. 45 respondents were asked to complete the survey and to provide their feedback on the included items. The pilot sample consisted of nanotechnology academics from the University of Twente. In total, 12 responses were obtained, of which 7 were partially completed and 5 were fully completed surveys. As a result of the pilot test, the final draft of the survey was developed.

During the pilot survey, the respondents were given an opportunity to comment on the structure of the survey, its format and the degree of user-friendliness. One of the key observations of the pilot respondents referred to the fact that in order to reach some questions in the survey, they needed to scroll down, and that was not always obvious. As a result, a considerable part of the pilot respondents either skipped certain “hidden” questions or indicated it as a point of improvement for the final questionnaire. Another improvement refers to the question on the main scientific orientation. In the pilot version of the survey, the respondents were offered two options: basic and applied. However, many of them indicated the need to expand the scale and introduce different extents of basic and applied orientation. This observation was later transformed into a semantic differential scale with five items including two extremes: pure basic and pure applied (see above). In addition, some textual adjustments have been made in questions on academics’ motivation and ability to interact with industry. Based on the suggestions of the pilot respondents, we removed ambiguous formulations and introduced pop up tip texts (additional explanations for the questions where some degree of ambiguity was still present). For example, a statement “Interaction with industry allows to contribute with something practical” was replaced by “Interaction with industry leads to solutions to practical problems”. The pilot did not indicate the need to change the sequence and number of questions, as well as the structure of the survey.

The final survey consisted of six main sections corresponding to the five constructs from the model (Individual Motivation, Perceived Social Influence, Perceived Ability, Trigger and Passive and Activated Social Capitals; the latter two were combined in one section) and an extra section on positional factors and control variables. Such survey structure was chosen based on the suggestion of Bethlehem (2009) that the questions about the same topic should be kept close together in order to make answering questions easier to respondents and by this assuring higher quality of the collected data. General questions corresponding to the reflective measures of examined constructs were put in the beginning of each section and preceded more specific questions on formative items (McColl et al., 2001).

Data collection took place over a two-month period, from October to December 2010. In total, the survey contained 100 items of which 3 were positional factors and 3 were control variables. Participation in the survey was voluntary. We assured respondents of their anonymity, as participants are more likely to provide unbiased responses when their anonymity is assured (Heneman, 1974). We applied a coding scheme that prevented us from identifying the response of any specific individual.

As a technical solution for both the pilot and the final survey, we employed Interactive Dialogues[7] (ID) survey building tool. The survey was available via an Internet link sent by e-mail. The employed tool proved to be cost-effective, time-saving, providing strong visualization functionalities and straightforward logistics. Once a survey was completed, the data was stored on the host server and reports were generated directly from there.

Additionally, ID platform allowed for constant online and off-line monitoring of responses. That means that a report containing submitted responses can be generated at any point of time starting from the moment when the survey was launched. Online monitoring refers to tracking of response rate online. Off-line monitoring means generation of off-line reports (Word, Excel or HTML formats) containing either a short overview of respondents that opened and or completed the survey, or an extensive report containing all the information submitted by respondents. The last version of the report offers three different levels of complexity. If necessary, the system automatically produces graphs and descriptive statistics for each of the questions. The standard report can be tailored and the data can be exported to other software packages (e.g., SPSS). We monitored response rates once per week and produced tailored reports for SPSS and SmartPLS software programs.

ID system also provided intelligent interaction opportunities with respondents. Regular reminders were sent out, when necessary. The system allowed sending reminders in a targeted way (it is, for example, possible to send reminders only to people who did not open the survey, or to people who did open but haven't submitted the survey yet etc.). This technical solution allowed us to avoid sending reminding e-mails to respondents who already completed the survey and thus prevented unnecessary irritation of respondents.

3.3.3 Additional procedures

The following steps were taken in order to minimize the likelihood of Common Method Variance (CMV) bias before collecting the data (based on Reio, 2010):

1. Spreading out measurement (i.e., introducing a time lag between the measurement of the predictors and criterion variables);
2. Ensuring the anonymity and confidentiality of the participants;
3. Using scale items that are written clearly and precisely and, thus, less subject to bias;

[7] http://www.interactivedialogues.com

4. Informing participants that there is no preferred or correct answer, rather that we desire their honest appraisal of the item;
5. Ensuring that all responses require equal effort (e.g., avoiding complicated wording and syntax, as well as dual-meaning questions);
6. Providing clear instructions for completing the measure, with definitions to avoid confusion.

In addition, in order to check for the presence of CMV bias, we carried out Harman's single factor test (Nunnally & Bernstein, 1994; Podsakoff et al., 2003) in SPSS 16.0 (see Table 3-22).

Table 3-22: Results of Harman's single factor test

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.256	54.264	54.264	3.256	54.264	54.264
2	1.087	18.117	72.381			
3	.719	11.991	84.372			
4	.468	7.807	92.180			
5	.326	5.425	97.605			
6	.144	2.395	100.000			

Extraction Method: Principal Component Analysis.

We constrained the number of factors to be just one (rather than extracting via eigenvalues). Then we examined the unrotated solution. The results suggest that CMV is likely to be an issue, as one factor accounts for the majority of the variance in the model (54.3%). Consequently, the role of some of our variables is likely to be inflated or deflated, and the conclusions need to be treated with caution. However, as emphasized by Reio (2010), this state of affairs does not automatically make the research suspect because of CMV bias; after careful examination for possible CMV bias and appropriate interpretation of the findings in light of this examination, future research will be needed to provide convergent evidence supporting the validity of our findings.

Reio (2010; p. 409) also argues that when researchers conduct exploratory studies testing the possible relationships between a variety of variables in a newly proposed conceptual model, the only way to proceed is often by using self-reports (e.g., online surveys) because the opportunity for data collection is limited to one point in time. In case of this research too, asking the respondents to participate in a study employing self-reports on several occasions was not feasible because of severe time constraints.

As emphasized by Richardson et al. (2009; p. 796), "there are multiple perspectives regarding CMV and, to some extent, there is no definitive evidence to date suggesting that one perspective [on CMV] is universally appropriate". Consequently, the researchers should not be captivated by the threat of CMV bias. If CMV and its possible limitations are examined frankly and clearly, the research still can make valuable contributions to theory building (Reio, 2010).

In order to tackle the detected CMV bias, we applied a set of corrective measures with regard to the measurement of some of our indicators, namely measures related to passive social capital PSCR2 - PSCR4 and social capital activation SCAR2 – SCAR4. While these measures refer to the academics' whole social network with industry, the data on these measures were collected exclusively for five key industrial partners (it was not feasible to capture details of all industrial partners in the network of all respondents). To make sure these data better reflect the situation in the whole network, they were adjusted by means of multiplying them by $\frac{\sqrt{N}}{n}$, where N refers to the total number of industrial partners in the academic's social network (or PSCR1), and n refers to the actual size of exploited network during the year in question. Square root procedure was applied to N thereby diluting the effect of the whole network. Such correction was necessary in order to obtain more realistic estimations of effects of the whole network when the only data available exclusively refers to the key interaction partners. As a result, new estimations were obtained (see Table 3-23). After conducting Harman's single factor test again, the total variance explained by one factor was lower than before the corrective measures. However, the CMV bias was not removed completely. These results will be taken into consideration in the next chapters when interpreting the results and drawing conclusions.

Table 3-23: Results of Harman's single factor test after corrective measures

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.097	51.612	51.612	3.097	51.612	51.612
2	.921	15.358	66.970			
3	.700	11.670	78.639			
4	.670	11.175	89.814			
5	.458	7.635	97.449			
6	.153	2.551	100.000			

Extraction Method: Principal Component Analysis.

3.3 DATA ANALYSIS

As the final dataset contained missing values, we first conducted the Missing Value Analysis. The data proved to be MAR (Missing at Random), and the missing values were imputed by means of the EM (Expectation Maximization) method (Graham, 2009) using SPSS 16.0. Within each research question, the results with imputed data were compared to the results exclusively based on non-missing data, and no significant differences were detected in the strength of tested relations. The main reason to work with imputed data was the need to have a sufficient sample for group comparisons (when the total sample is split into sub-groups which are then compared with each other; see Table 3-20).

We then tested the reliability and validity of the employed measures and analyzed the effects of our anticipated predictors of behavior on the level of social capital activation of academics with industry between September 2009 and September 2010. Both types of analysis were conducted using the PLS path modeling in SmartPLS. The PLS path modeling methodology was chosen as it is suitable for prediction-oriented research and complex models, it implies no distributional assumptions and it is appropriate for a small sample size (Henseler, Ringle, & Sinkovics, 2009). Furthermore, PLS is robust with different scale types (Henseler et al., 2009). In the remainder of this sub-section, all these steps will be examined in more detail.

3.3.1 Missing data analysis

The missing data analysis pursues the following three objectives (SPSS, 2007):

(1) to describe the pattern of missing data (i.e., the location of missing values, the extent to what those values are missing, the presence of extreme values, the randomness of missing values etc.);

(2) to estimate means, standard deviations, covariances and correlations using appropriate missing value methods; *and*

(3) to impute missing values.

Imputation of missing values has proven to be superior to complete case analysis and the missing-indicator method, as, for example, illustrated by Van der Heijden et al. (2006) in the context of multivariable diagnostic research. In the context of the current study, the missing data analysis was carried out in SPSS 16.0. SPSS 16.0 allows for applying various methods such as listwise, pairwise, and regression estimations, and EM (Expectation Maximization) method. Before deciding which of these methods to apply, the nature of the missingness of data needed to be determined (Graham, 2009). The SPSS outputs used for the missing data analysis were not included in this dissertation due to their large size. These tables are however available upon request.

The separate-variance *t* tests exercise did not signal that our data is not MCAR (Missing Completely at Random). However, we needed to look at more output before deciding what type of data (MCAR, MAR or MNAR) we were dealing with, as the type of data defines the type of estimation that we can use for imputing missing values.

The crosstabulations of categorical variables (in our case, positional factors and control variables) versus indicator variables showed whether there are differences in missing values among categories of categorical variables. This exercise confirmed that our data are not MCAR (Missing Completely at Random). An extensive description of this analysis is provided in Annex B.

Missing value imputation

Since we are dealing with the data that is missing at random or MAR, the most unbiased missing value estimations in this situation can be produced using the EM method (SPSS, 2007).

The EM method is an iterative procedure that produces maximum likelihood estimates. It is a two-step process. For the E-step of EM at one iteration, cases are read in one by one. If a value is present, then the sums, sums of squares, and sums of crossproducts are incremented. If the value is missing, then the current best guess for that value is used instead. The best guess is based on a regression-based single imputation with all other variables in the model used as predictors. For the sums, the best guess value is used as it is. For the sums of squares and the sums of cross-products, if just one value is missing, then the quantity is incremented directly. However, if both values are missing, then the quantity is incremented, and a correction factor is added. This correction is conceptually equivalent to adding a random residual error term in MI (Graham, 2009).

In the M-step of the same iteration, the parameters (variances, covariances, and means) are calculated based on the current values of the sums, sums of squares, and sums of cross-products. Based on the covariance matrix at this iteration, new regression equations are calculated for each variable predicted by all others. These regression equations are then used to update the best guess for missing values during the E-step of the next iteration. This two-step process continues until the elements of the covariance matrix stop changing. When the changes from iteration to iteration are so small that they are judged to be trivial, EM is considered to have converged (Graham, 2009).

The EM Estimated Statistics contain, among others, Little’s MCAR test (Chi-Square = 3297.266, DF = 3140, Sig. = .025 (< .05)). The null hypothesis for Little’s MCAR test is that the data are missing completely at random (MCAR). Because the significance value is less than .05 in our case, we can conclude that our data are not missing completely at random. This confirms the conclusion that we drew from the descriptive statistics and tabulated patterns. After we concluded that our data is MAR, we proceeded with the imputation of missing values using the EM method. The final database served as a basis for the empirical analysis.

3.3.2 PLS path modeling

As illustrated above, the current research studies theoretical constructs that cannot be observed directly. Therefore, it is necessary to (1) statistically test the a priori postulated relations between the proposed observed measures and the underlying factors (*measurement model*); and (2) to specify the relations between the latent variables (*structural model*), i.e., to construct a full latent variable model. The objective of the second type of analysis is to hypothesize the impact of one latent construct on another in the modeling of causal direction (Byrne, 2001). Consequently, for a comprehensive empirical analysis, we aim at confirming the complete model comprising both a measurement model and a structural model: the measurement model depicting the links between the latent variables and their observed measures, and the structural model depicting the links between the latent variables themselves. For this purpose, we will need to employ SEM (Structural Equation Modeling) techniques.

There are two distinctive families of SEM techniques: covariance-based techniques (CBSEM), as represented by LISREL, and variance-based techniques, of which Partial Least Squares (PLS) path modeling is the most well-known representative (Henseler et al., 2009). In order to decide which of the abovementioned techniques to use, the following key issues need to be taken into account (Chin, 2010):

- Degree of emphasis on covariance explanation;
- Soft distributional assumptions;
- Exploratory nature;
- Modeling formative measurement items;
- Higher order molar and molecular models;
- High model complexity;
- Sample size requirement;
- Accuracy of parameter estimation;
- Eschewing the "true" model for prediction focus;
- Determinate scores/indices for predictive relevance;
- Ease of model specification and model interpretation.

In the remainder of this sub-section we will examine each of those issues in more detail.

Degree of emphasis on covariance explanation: CBSEM analysis is often viewed as confirmatory in nature and is often considered by many as requiring relatively strong theoretical and substantive background knowledge for adequate deployment. Model misspecification with missing structural parts or multidimensional items placed under one construct can jeopardize the entire model estimation process. In contrast, PLS estimates are limited to the immediate blocks of a particular construct is structurally connected with. Item weights and loadings for a particular construct are developed based on the inner weight relationships with related constructs (Chin, 2010). Given that research on social capital activation and its antecedents is still at its embryonic stage, it would be reasonable to employ PLS techniques, in order to avoid possible CBSEM estimation bias.

Soft distributional assumptions: Whereas a covariance-based maximum likelihood (ML) estimation is based on the assumptions of a specific joint multivariate distribution and independence of observations, the PLS approach does not make these hard assumptions. Rather, PLS uses very general soft distributional assumptions. No restrictions are made on the structure of the residual covariances, and under PLS modeling the residual variance terms are minimized (Chin, 2010).

Exploratory nature: PLS is primary appropriate for exploratory studies where theoretical knowledge is relatively scarce, and it would be inappropriate to believe that CBSEM is superior to PLS for establishing theoretical models. PLS is also argued to be suited for incremental studies that build on a prior model by developing both new measures and structural paths. Depending on how extensive the model is, there may be a desire to use PLS to constrain the new construct and measures to its immediate nomological neighborhood of constructs by this avoiding possible CBSEM estimation bias that can be affected by minor modeling or item selection errors (Chin, 2010).

Modeling formative measurement items: Some of the observable items employed in this study are formative ones (also known as cause measures), i.e., they cause the formation of or changes in unobservable variables (Bollen & Lennox, 1991; Haenlein & Kaplan, 2004). For example, the unobservable variable "Individual Motivation" is considered as a combination of formative indicators corresponding to each of the eight motives. Formative indicators of the same construct can have positive, negative or zero correlation with one another (Haenlein et al., 2004; Hulland, 1999). A higher level of motivation does not imply that a person has all those motives at the same time. One of those motives alone can be sufficient to drive an individual to engage in interaction with industry. For the measurement model identification purposes, the reflective items are also included in the study. Since PLS explicitly estimates the outer weights to form construct scores, modeling formative indicators is much less problematic than in CBSEM. A construct with formative indicators (whether endogenous or exogenously modeled) must be connected to at least one other construct to yield meaningful information. Otherwise, without some structural linkage, the weights would end up being identical. This differs from modeling reflective indicators where the weights are meant to form the single best score to maximally predict its own measures (Chin, 2010).

Higher order molar and molecular models: Higher order latent variables are often useful if a researcher wishes to model a level of abstraction higher than those first order constructs used in a basic CBSEM and PLS model (Chin, 2010). This issue, however, does not fall under the scope of the current study.

High model complexity: More complex models capturing many factors related to attitudes, opinions, and behaviors over time could be difficult to fully capture using CBSEM. In these cases, component-based methods such as PLS may be very useful, especially if one places greater emphasis on the completeness of the model, i.e., how well the complexities of the real world are represented in the model (Chin, 2010).

Sample size requirements: Sample size requirements when using PLS for complex models are much smaller than required for CBSEM (Chin & Newsted, 1999). The researcher needs to determine which dependent variable (either at the structural level or item measurement level) has the highest number of predictors. Since this represents the largest regression performed during the PLS iterative process, this would be the logical starting point for choosing an adequate sample to ensure an adequate level of accuracy and statistical power (Chin, 2010).

Accuracy of parameter estimation: Critics often argue that PLS estimates are not as efficient or potentially even biased relative to those obtained by CBSEM. This bias tends to manifest itself in somewhat higher estimates for loadings and lower structural path estimates. However if the model is not covariance-based, PLS will estimate model parameters consistently. PLS can be used for testing the appropriateness of a block of indicators in a predictive sense and for suggesting potential relations among blocks without necessarily making any assumptions regarding which latent variable model generated the data (Chin, 2010).

Eschewing the "true" model for prediction focus: The benefits of CBSEM largely depend on the accuracy of the model being tested. Model fits and estimates can be influenced by many sources of error, including simply having one or two poor measures that do not belong with the other measures for a particular construct. Subsets of items may correlate as they are mutually affected by other underlying trait or method factors. In addition, nonlinear relationships may exist between the construct and its measures. Consequently, if the tested model is an imperfect representation of the real world, the obtained estimated will hardly be robust (Chin, 2010).

Determinate scores/indices for predictive relevance: In PLS, the scores at the first order level can be scaled in different ways (e.g., normalized or 0 to 100 points). These scores are immediately interpretable from a predictive perspective, which is not the case in CBSEM (Chin, 2010).

Ease of model specification and model interpretation: For PLS, as a component-based approach with explicit estimation via indicator weights, a researcher only needs to specify a set of indicators representing each construct in question and the structural path among all constructs. Rather than determining whether various model fit indices are appropriate, PLS focuses on variance explained (i.e., the predictiveness of the model). For CBSEM analysis, additional considerations such as model identification, measurement scale adequacy for the discrepancy estimator, setting the metric for each construct, and other constraints need to be addressed.

To conclude, we will employ PLS techniques for the purpose of this study as we (1) want to avoid negative impact due to errors in modeling or item usage; (2) value soft distributional assumptions; (3) have formative measurement items; (4) want to shift the perspective of a "true" model towards a predictive focus; and (5) value the ease of model specification and interpretation.

The detailed empirical analysis related to each of the research questions will be presented in the subsequent chapters. In addition, we have examined alternative configurations of our conceptual model that do not correspond to any specific research questions. The objective of this additional exercise was to explore other possibilities of modeling the relations among the constructs in question, in search of the model with the best predictive power. For example, we tried to model the trigger as a moderator rather than mediator in the model. The results of this exercise improved our understanding of the relationships among the constructs in the model. These results are included in the following sub-section.

3.4 LIMITATIONS

The employed methodology also has a number of limitations. First, some issues with reliability and validity of two variables were detected because of the selected measurement approach. These issues refer to an indicator reliability of the actual network size and a higher outer loading of the actual size of exploited network on the passive social capital latent variable than on its own activated social capital latent variable. Both divergences have been caused by the fact that the data for academics' passive social capital have been gathered on five industrial partners with whom academics had the strongest connections instead of the whole network. Ideally, it would be necessary to gather data for all contacts from the individuals' social networks at the beginning of the year in question. In our case, however, it was not possible as some of the respondents had more than fifty industrial partners. When the size of a particular social network is smaller, the researchers should try to gather data on the whole network to avoid biased estimates. However, given that social networks are usually large in size, it will often be impossible, and alternative solutions such as focus on partners with the strongest connections (as employed in this study) can be useful.

Second, in this study, we did not gather empirical data on two of the proposed measures, effective network size and the effective size of exploited network, because of a number of reasons. First, the number of industrial acquaintances measured in this study refers to people from different organizational entities. As a result, the amount and diversity of information they possess is already likely to be significantly higher than in situations when people work within the same organization. Furthermore, empirical evidence suggests that academics are likely to have from 4 to 10 industrial partners (Balconi, Breschi, & Lissoni, 2004); consequently, for most academics, the number of industrial partners in their networks is already relatively low. Finally, the current study aimed to measure network size with regard to the whole category of behavior, and not one interaction. Therefore, it would be highly challenging for the respondents to provide exact information on their effective network size, and the reliability of obtained data would need to be put under question. However, in order to understand the nature of both passive and activated social capitals, there is a need to look for their most precise manifestations. Future studies focusing on other empirical settings should therefore consider the feasibility of including these two measures in their empirical analysis in order to examine to what extent they reflect passive and active modes respectively.

Third, ideally, it would be necessary to test the conceptual model at various points in time in order to be able to check the proposed causal relationships. In practice, however, such approach might be quite a challenge, and thus might be replaced by a more feasible alternative of a one-time comprehensive survey. The current research is of retrospective nature, i.e., the research is conducted when outcomes are already known before data collection begins (Van de Ven, 2007). The key advantage of a retrospective study refers to the ability to see a ‘big picture’, i.e., how things developed and what the outcomes of those developments are. This post hoc knowledge is helpful for constructing the narrative of the mechanism in question.

Finally, despite various benefits, PLS also has a number of limitations. First, PLS lacks a global optimization function and, consequently, it does not measure the global goodness of model fit, which limits the use of PLS for theory testing. However, given that the current study deals with the situation of high complexity but low theoretical information, the objective of the current research is to carry out causal-predictive analysis and theory building rather than theory testing. As stated by Henseler (2009), the PLS approach is adequate for causal modeling applications with the purpose of prediction and/or theory building. Therefore, PLS represents a reasonable choice for the needs of the current research.

In addition, when using PLS, we make an assumption that there is no error at the construct level as all constructs in PLS are modeled without error. Thus PLS estimation results in the construct being an exact weighted sum of its indicators. A lack of error term tends to increase the weights by this inflating their importance (Bollen et al., 1991; Cenfetelli et al., 2009). As a result, the contribution and validity of specific indicators may potentially be misinterpreted as being more significant than they actually are (Cenfetelli et al., 2009). These limitations, however, will be taken into account when analyzing the results in the next chapters.

3.5 SUMMARY

The key points from this chapter are as follows.

- The current research studies theoretical constructs of latent nature. For the purpose of the empirical analysis, we operationalized them into a set of measurable items and postulated relations between the proposed observed measures and the underlying latent variables.

- We aimed to develop operational measures that characterize the whole category of behavior, and not an individual action. Furthermore, the operationalization of constructs was situated in the context of university-industry interactions, and only the measures relevant to this particular setting were taken on board.

- Most of the employed latent variables proved to be of mixed nature, i.e., they can be modeled as both formative and reflective constructs. When modeling a construct as a formative measure was possible, we developed a set of reflective measures in order to achieve model identification.

- We modeled Individual Motivation as a set of eight specific motives of academics to engage in interaction with industry. The specific motives, in turn, were presented as composite variables comprising individual beliefs and the corresponding individual wants. The reflective measures of motivation refer to a set of five indicators corresponding to a general willingness of academics to interact with industry.

- Perceived Social Influence was modeled as a set of six social influences related to the opinions and behavior of academics' bosses, peer colleagues and other academic partners. The specific influences, in turn, were presented as composite variables comprising social beliefs and the corresponding social influence evaluations. The reflective measures of social influence refer to a set of five indicators corresponding to a general feeling of social pressure to interact with industry.

- Perceived Ability was modeled as a set of four formative indicators corresponding to specific skills that academics need to interact with industry. These skills, in turn, have been presented as composite variables comprising ability beliefs and the corresponding ability evaluations. The reflective measures of perceived ability refer to a set of four indicators corresponding to a general feeling of being able to interact with industry.

- Trigger was modeled as a set of four specific situations that may serve as reasons for social capital activation to occur, including both planned and unplanned behaviors. In addition, the reflective measures of the trigger were developed. Those correspond to a general feeling of the presence of various opportunities to interact with industry.

- Two distinctive sets of measures were developed for passive social capital and social capital activation. The measures of passive social capital refer to the cumulative results of previous interactions by the beginning of the year in question. The measures of activated social capital, in turn, refer to the interactions during that year. The measures capturing the results of previous interactions include actual and effective network sizes, closeness, multiplexity of roles and history of interactions. The measures of activated social capital refer to the actual and effective sizes of networks exploited during the last year, as well as frequency, multiplexity of interactions and total duration of interactions in that period.

- Existing research suggests that several additional factors are likely to affect the academics' level of engagement in interaction with industry. Therefore, when empirically analyzing the results, we controlled for the following six factors: (1) hierarchical position; (2) scientific orientation (basic vs. applied), (3) scientific domain; (4) affiliated institution, (5) gender, and (6) country of origin (local vs. foreign-born).

- When drawing the sample, we aimed to broaden our attention beyond the groups of academics that are actively engaged in university-industry interactions to thoughtfully consider less active publics. We targeted academics from bio- and nanotechnology fields from twelve Dutch universities and research centres. The final sample contains 184 respondents. The data was collected by means of an online survey.

- As the final dataset contained missing values, we first conducted the Missing Value Analysis. The data proved to be MAR (Missing at Random), and the missing values were imputed by means of the Expectation Maximization method using SPSS 16.0.

- For the empirical analysis, we decided to employ PLS techniques as we (1) want to avoid negative impact due to errors in modeling or item usage; (2) value soft distributional assumptions; (3) have formative measurement items; (4) want to shift the perspective of a "true" model towards a predictive focus; and (5) value the ease of model specification and interpretation.

- The key limitations of the methodology refer to the retrospective nature of the study instead of longitudinal analysis; inability of PLS to measure the global goodness of model fit, which limits the use of PLS for theory testing; as well as limited data on contacts from the academics' social networks which led to some drawbacks in the analysis.

In the sub-sequent chapters, each of the abovementioned research questions will be examined in more detail.

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4 Examining the roles of specific motives

"Never judge a man's action until you know his motives."

Wayne Dyer (1940), American writer

In the current chapter, we aim to examine which specific motives comprised of wants and beliefs are the most significant in determining academics' motivation to activate their social capital with industry (Research question 1). Policy makers wanting to promote knowledge transfer between university and industry need a good understanding of academics' motives to interact with industry. While existing literature offers various specific motives (e.g., the motive to solve practical problems, to get access to industry skills and facilities, and to obtain additional funding), hardly any attempts have been made to measure the relative weight of those motives on academics' general motivation. Advancing knowledge on the key sources of academics' motivation would allow policy makers to design better targeted knowledge transfer policies. In this chapter, by means of PLS path modeling, we regress specific motives on the academics' general feeling of motivation to interact with industry. We conclude that the only two motives that demonstrate a significant impact on the general feeling of motivation refer to the motive of solving practical problems and the motive of getting access to industry knowledge. In addition, we analyze the differences in the role of specific motives between academics from different hierarchical positions and scientific orientations, as well as between academics engaged in a few vs. many different types of interactions.

4.1 INTRODUCTION

The success of knowledge transfer depends on academics' willingness to engage in interaction with industry (Audretsch, Bönte, & Krabel, 2010; D'Este & Perkmann, 2010; Lowe, 2006; Perkmann & Walsh, 2009), as they are not obliged to do so, contrary to teaching. Consequently, policy makers and university administrators who want to promote knowledge transfer need a good understanding of motives that determine the academics' decision to engage in interaction with industry. The objective of the chapter is to examine to what extent the presence of specific motives expressed as interaction of wants and beliefs can explain the general level of academics' motivation to engage in interaction with industry. The chapter therefore aims to find out whether we really know what motivates academics to engage in interaction with industry.

The remainder of the chapter is organized as follows. Based on existing literature, we model academics' motivation to interact with industry as both reflective and formative constructs and formulate hypotheses. The reflective measures of motivation refer to its actual manifestation, i.e., a general feeling of motivation. The formative measures, in turn, refer to the specific motives derived from the literature and represent the building blocks of motivation. For formative measures, we design composite variables representing an interaction of academics' wants and beliefs. Using the results of a survey of Dutch universities and research centers, in SmartPLS, we regress the formative motivation index on its reflective measure. We examine to what extent the specific motives are able to explain the academics' actual willingness to engage in interaction with industry. We also examine the relative weight of each of those specific motives. Finally, we examine the differences in the role of those motives between academics from different hierarchical positions and scientific orientations, as well as between academics engaged in a few vs. many different types of interactions.

4.2 THEORETICAL BACKGROUND AND HYPOTHESES

There is lack of agreement in existing literature on motives that drive academics to engage in interaction with industry. The opinions of various authors can be divided in two general groups. The first group stresses that academics collaborate with industry primarily to pursue their commercialization interests, thereby emphasizing academics' utility-maximizing behavior (Clark, 1998; Etzkowitz, 2003; Shane, 2004). The second group of authors, in turn, suggests that even when collaborating with industry, academics still follow science-specific norms and values, and, rather than wanting to be entrepreneurs, academics mainly collaborate with industry to support their research and teaching activities (D'Este et al., 2010). One of the objectives of this chapter is to find out which of the two perspectives is more accurate and whether there are differences between academics from different hierarchical positions and scientific orientations, as well as between academics engaged in a few vs. many different types of interactions. In this section, we present a list of specific academics' motives suggested by the literature in order to subsequently test whether those motives can explain a significant part of the general academics' motivation to interact with industry.

Based on the literature, the following eight groups of academics' motives can be derived: (1) a motive of solving practical problems; (2) a motive of gaining recognition within the scientific community; (3) a motive of supporting teaching duties; (4) a motive of getting access to industry facilities; (5) a motive of getting access to industry knowledge; (6) a motive of keeping abreast of industry problems; (7) a motive of getting promotion on a career ladder, and (8) a motive of obtaining additional funding for research group, graduate students or laboratory equipment. Table 1 provides an overview of the authors mentioning the importance of those motives. The list of the authors is not exhaustive, and serves for a purpose of illustration.

The identified motives refer to different natures of motivations. The basic distinction in the motivation literature refers to intrinsic and extrinsic motivations (Deci & Ryan, 1985; see, for example Ryan & Deci, 2000). Intrinsic motivation refers to doing something because it is inherently interesting or enjoyable, while extrinsic motivation refers to doing something because it leads to a specific outcome. Some of the identified motives are thus of intrinsic nature (e.g., a motive of solving practical problems, a motive of getting access to industry knowledge), while other motives are extrinsic (e.g., a motive of getting promotion on a career ladder, a motive of obtaining additional funding). Existing research suggests that even extrinsically motivated individuals can perform with an attitude of willingness that reflects their inner acceptance of the value of a task (Ryan et al., 2000). Understanding the role of different types of extrinsic motives is an important issue for policy makers and university administrators who cannot always rely on intrinsic motives of academics to foster interactions with industry. In this chapter, we aim to find out whether the nature of academics' motives has a significant influence on the way they experience interactions with industry.

Table 4-1: Overview of academics' motives to engage in interaction with industry

Motive	Type	Authors
(1) Solving practical problems	Intrinsic	(D'Este et al., 2010; Goktepe & Mahagaonkar, 2008; Gulbrandsen, 2005; Hull, 1988; Lee, 2000; Mansfield, 1995; Meyer-Krahmer & Schmoch, 1998a; Stephan, 1996; Stephan & Levin, 2005; Stern, 2004; Stokes, 1997)
(2) Gaining recognition within the scientific community	Extrinsic	(Audretsch et al., 2010; Baldini et al., 2007; Etzkowitz, 1998; Goktepe-Hultan, 2008; Goktepe et al., 2008; Hackett, 1990; Merton, 1957; Meyer-Krahmer et al., 1998a; Owen-Smith & Powell, 2001, 2003; Siegel, Waldman, Atwater, & Link, 2004; Thursby, Jensen, & Thursby, 2001)
(3) Supporting teaching duties (e.g., preparing student assignments based on cases from industry, going on field trips to the premises of industrial partners, getting access to practical problems that are suitable for student work)	Intrinsic	(Belkhodja & Landry, 2007; Carayol, 2003; Gulbrandsen, 2005; Lee, 1996, 2000; Orsenigo, 2001; Rohrbeck & Arnold, ; Santoro & Chakrabarti, 1999)
(4) Getting access to industry facilities	Intrinsic	(Baldini et al., 2007; D'Este & Patel, 2007b; Dooley & Kirk, 2007; Inzelt, 2004; Meyer-

Motive	Type	Authors
		Krahmer et al., 1998a; Murray, 2002; Perkmann et al., 2009; Teece, 1986)
(5) Getting access to industry knowledge	Intrinsic	(Baldini et al., 2007; D'Este et al., 2010; Lee, 2000; Meyer-Krahmer et al., 1998a; Perkmann et al., 2009)
(6) Keeping abreast of industry problems	Intrinsic	(D'Este et al., 2007b; D'Este et al., 2010; Santoro & Gopalakrishnan, 2000; Thach, Gvozdiov, & Hull, 2005)
(7) Getting promotion on a career ladder	Extrinsic	(Goktepe-Hultan, 2008; Lee, 1996)
(8) Obtaining additional funding for research group, graduate students or laboratory equipment	Extrinsic	(Audretsch et al., 2010; Baldini et al., 2007; D'Este et al., 2007b; D'Este et al., 2010; Etzkowitz, 1998; Goktepe-Hultan, 2008; Goktepe et al., 2008; Gulbrandsen, 2005; Jensen, Thursby, & Thursby, 2003; Lee, 2000; Meyer-Krahmer et al., 1998a; Mulkay & Turner, 1971; Siegel et al., 2004; Slaughter & Leslie, 1997; Thursby et al., 2001)

In the reminder of this section, we briefly review each of those motives and formulate hypotheses.

4.2.1 Motive of solving practical problems

Academics are intrinsically motivated to do research, and much of their motivation comes from the joy of solving research questions (Goktepe et al., 2008; Stephan, 1996). The problems that academics choose to work on are, however, often inspired by their experience from interacting with industry (D'Este et al., 2010; Mansfield, 1995). Besides applied research, also a significant portion of basic research is associated with the so called 'Pasteur's quadrant', i.e., it is driven by long-term considerations of practical applicability (D'Este et al., 2010; Stokes, 1997). Puzzle-solving involves a fascination for the research process itself (Stephan et al., 2005), while solving practical puzzles also creates a feeling of usefulness and adds utility value to the work of academics (Gulbrandsen, 2005). The need to solve practical puzzles creates an intrinsic affinity between academic and industry research (D'Este et al., 2010). Consequently, the academics' desire to work on practical research problems is likely to increase their motivation for choosing to interact with industry (Gulbrandsen, 2005; Stern, 2004; Goktepe, 2008; D'Este, 2010; Meyer-Krahmer, 1998).

Hypothesis 1: The motive of solving practical problems significantly increases academics' general motivation to interact with industry.

General motivation here refers to the academics' enthusiasm about doing something professionally interesting and enjoyable, their interest in and openness towards engaging in a certain type of activities.

4.2.2 Motive of gaining recognition within the scientific community

Academics, by their very nature, are motivated to achieve reputation, recognition and prestige among their peers (Merton, 1957) through, for example, citing in the literature, election to a national academy and the ultimate honor of getting the Nobel Prize (Etzkowitz, 1998; Goktepe et al., 2008). Existing research suggests that academics' engagement in interaction with industry makes them more visible in the scientific community (Audretsch et al., 2010; Baldini et al., 2007; Goktepe et al., 2008; Owen-Smith et al., 2001, 2003; Thursby et al., 2001). Furthermore, scientific success is increasingly measured in commercial terms (Audretsch et al., 2010; Hackett, 1990; Owen-Smith et al., 2003), e.g., the amount of attracted funding. The attention of industrial partners to certain academics is often associated with the excellence, novelty and usefulness of their research and with their ability to attract additional funding, i.e., the factors that are likely to increase the reputation of those academics among their peers. In addition, collaborative projects with industry can be used by academics as references for attracting public projects (Meyer-Krahmer et al., 1998a). Consequently, the academics' desire to gain recognition within the scientific community is likely to increase their motivation for choosing to interact with industry.

Hypothesis 2: The motive of gaining recognition within the scientific community significantly increases academics' general motivation to interact with industry.

4.2.3 Motive of supporting teaching duties

Academics' engagement in interaction with industry is often integrated with their teaching duties (Gulbrandsen, 2005; Lee, 2000). For example, they develop student assignments based on patents, they organize field trips to spin-offs, they include actual commercialization cases in their curriculum, and finally, they regularly contact their industrial acquaintances to see if there are any practical problems suitable for student projects (Gulbrandsen, 2005). However, while teaching is a compulsory task for academics, collaboration with industry is not. Consequently, academics interacting with industry in order to support their teaching duties must realize significant benefits from such activities, the benefits that excite them. Existing research confirms that academics' engagement in interaction with industry may represent a powerful way of strengthening their teaching function (Lee, 2000). Not only may the teaching function be strengthened by gaining knowledge useful for teaching, but also by creating student jobs and internships.

Hypothesis 3: The motive of supporting teaching duties significantly increases academics' general motivation to interact with industry.

4.2.4 Motive of getting access to industry facilities

In the context of university-industry interactions, industrial partners may agree to contribute 'in kind' by providing access to their laboratories, materials, compound libraries and databases, prototypes and measurement instruments (Baldini et al., 2007; D'Este et al., 2010; Dooley et al., 2007; Meyer-Krahmer et al., 1998a; Murray, 2002). Academics may thus be given access to industry facilities that would otherwise have been inaccessible (Perkmann et al., 2009). Such extensive site visits represent an opportunity for academics to gather new ideas for their research and learn about new industry applications (Murray, 2002). Consequently, the academics' desire to get access to industry facilities is likely to increase their motivation for choosing to interact with industry.

Hypothesis 4: The motive of getting access to industry facilities significantly increases academics' general motivation to interact with industry.

4.2.5 Motive of getting access to industry knowledge

By closely interacting with industry, academics get an opportunity to gain insights into industrial knowledge bases that are otherwise inaccessible. Getting access to industrial research expertise, gathering information on industry research and obtaining feedback from industry represent unique learning opportunities (D'Este et al., 2010). Existing research suggests that for many academics, such access to learning opportunities is likely to play a key role when deciding whether to collaborate with industry or not (Baldini et al., 2007; Meyer-Krahmer et al., 1998a; Murray, 2002; Perkmann et al., 2009). Furthermore, secrecy problems typically do not constitute significant hurdles to such knowledge transfer, particularly if academics maintain high-trust relationships with their industrial partners (Perkmann et al., 2009). Consequently, the academics' desire to get access to industry knowledge is likely to increase their motivation for choosing to interact with industry.

Hypothesis 5: The motive of getting access to industry knowledge significantly increases academics' general motivation to interact with industry.

4.2.6 Motive of keeping abreast of industry problems

Another key driving force for academics to engage in interaction with industry refers to their desire to gain knowledge about industrial problems and needs (D'Este et al., 2007; D’Este et al., 2010; Thach et al., 2005). When a high level of trust is achieved, industrial partners are more willing to share their unique knowledge requirements with their academic partners (Santoro et al., 2000). This, in turn, enables academics to provide the kinds of knowledge that industry needs, by means of consultancy engagements, research agreements and other activities. As a result, staying current on industry needs increases the academics’ ability to attract new projects and therefore funding. Consequently, the academics’ desire to keep abreast of industry problems is likely to increase their motivation for choosing to interact with industry.

Hypothesis 6: The motive of keeping abreast of industry problems significantly increases academics’ general motivation to interact with industry.

4.2.7 Motive of getting promotion on a career ladder

Academics are also driven by extrinsic rewards of getting promotion and tenure (Gustin, 1973; Hagstrom, 1965; Tierney & Bensimon, 1996), and existing research suggests that interaction with industry may accelerate this process (Goktepe-Hultan, 2008). Although most promotion and tenure decisions continue to be almost exclusively based on publications and public research grants (Siegel et al., 2004), scientific success is increasingly measured in commercial terms (Audretsch et al., 2010; Hackett, 1990; Owen-Smith et al., 2003), e.g., the amount of attracted funds. Furthermore, as mentioned above, interaction with industry is also likely to increase the reputation of academics among their peers (Audretsch et al., 2010; Baldini et al., 2007; Goktepe-Hultan, 2008; Meyer-Krahmer et al., 1998a; see, for example, Owen-Smith et al., 2003; Thursby et al., 2001), which, in turn, indirectly increases their chances of getting promotion and tenure. Consequently, the academics’ desire to get promotion on a career ladder is likely to increase their motivation for choosing to interact with industry.

Hypothesis 7: The motive of getting promotion on a career ladder significantly increases academics’ general motivation to interact with industry.

4.2.8 Motive of obtaining additional funding for research group, graduate students or laboratory equipment

Existing research also suggests that academics may be attracted to interactions with industry by a desire to obtain additional funding for their research group, graduate students and laboratory equipment (Audretsch et al., 2010; D'Este et al., 2007b; Gulbrandsen, 2005; Lee, 2000; Meyer-Krahmer et al., 1998b; Mulkay et al., 1971; Siegel et al., 2004). Several studies found that the most interesting research is often complete before industry begins showing interest in commercial applications, and academics agree to work with industrial partners only if high financial incentives compensate academics for less interesting work (Aghion, Dewatripont, & Stein, 2008; Audretsch et al., 2010; Jensen & Thursby, 2001). Furthermore, as mentioned above, having a credibility to attract enough money is likely to increase the reputation of academics among their peers. Consequently, the academics' desire to obtain additional funding is likely to increase their motivation for choosing to interact with industry.

Hypothesis 8: The motive of obtaining additional funding significantly increases academics' general motivation to interact with industry.

4.2.9 General motivation

According to the literature, the abovementioned motives represent the key drivers of academics to engage in interaction with industry. The objective of this chapter, however, is to test to what extent these drivers reflect the general motivation of academics' to interact with industry. The following hypothesis can thus be formulated:

Hypothesis 9: When taken all together, the identified eight motives explain a sufficient variance in academics' general motivation to engage in interaction with industry.

By sufficient variance here one should understand a path of 0.8 or above, which according to Chin (2010) secures an adequate set of formative measures.

4.3 METHODS

In this section, we only elaborate on the measurement aspects. For other aspects of the methodology (i.e., sample and data collection procedures), the reader is invited to consult Chapter 3. Two sets of items were developed to measure academics' motivation to engage in interaction with industry. One set of five indicators consisted of reflective measures that tap into the general feeling of motivation to activate social capital with industry. The other set attempted to capture a comprehensive set of formative indicators that help create that motivation.

4.3.1 Reflective measures of academics' motivation to interact with industry

We define general motivation as the academics' willingness to engage in a certain type of activities that can be expressed as "interest", "openness", "enthusiasm", "satisfaction" and "importance", and first model it as a reflective construct. In Chapter 3, we explained how we confirmed the reflective nature of these measures. For a list of corresponding reflective measures the reader is invited to consult Annex A (IMR1-IMR5).

4.3.2 Formative measures of academics' motivation to interact with industry

As mentioned above, specific motives are argued to have two distinctive components: individual beliefs and individual wants or attitudes (Goldman, 1970; Shatz, 1987; Smedslund, 1997; Watson, 1975). Individual wants refer to academics' desire to have or not to have a certain consequence of behavior. Individual beliefs, in turn, refer to academics' beliefs with regard to the feasibility of those consequences. Measuring both dimensions of a motive makes it possible to identify the reason for low levels of motivation. More importantly, it allows us to 'purify' individual wants by weighting them according to their level of relevance to interaction with industry. This approach is thus likely to increase the predictive power of formative indicators.

The eight specific motives identified in the literature were therefore split in two groups: (a) academics' beliefs (see Annex A, IM1a-IM8a) and (b) academics' wants (see Annex A, IM1b-IM8b). The final formative measures of academics' motivation were calculated by multiplying a belief-related score with the corresponding want-related score. Table 4-2 presents a set of eight composite variables corresponding to each of the specific motives (for a similar approach, see, for example, Francis et al., 2004). In Chapter 3, we explained how we confirmed the formative nature of these measures. The scores for composite variables lie in a range between -21 to +21.

Table 4-2: Composite variables (belief x want)

Composite Variable	Motive	Scale
IM1 (IM1a x IM1b)	Motive of solving practical problems	-21 - +21 ("Very low" to "Very high")
IM2 (IM2a x IM2b)	Motive of gaining recognition within the scientific community	-21 - +21 ("Very low" to "Very high")
IM3 (IM3a x IM3b)	Motive of supporting teaching duties	-21 - +21 ("Very low" to "Very high")
IM4 (IM4a x IM4b)	Motive of getting access to industry facilities	-21 - +21 ("Very low" to "Very high")
IM5 (IM5a x IM5b)	Motive of getting access to industry knowledge	-21 - +21 ("Very low" to "Very high")
IM6 (IM6a x IM6b)	Motive of keeping abreast of industry problems	-21 - +21 ("Very low" to "Very high")
IM7 (IM7a x IM7b)	Motive of getting promotion on a career ladder	-21 - +21 ("Very low" to "Very high")
IM8 (IM8a x IM8b)	Motive of obtaining additional funding for research group, graduate students or laboratory equipment	-21 - +21 ("Very low" to "Very high")

4.3.3 Additional variables

Existing research suggests that several additional factors are likely to affect academics' general motivation to engage in interaction with industry. For example, factors like hierarchical position and scientific orientation (basic or applied) are reported to correlate directly with the inclination of researchers to engage in university-industry interactions (Bercovitz & Feldman, 2008; D'Este et al., 2007b; Landry, Amara, & Ouimet, 2005; Lazega, Mounier, Jourda, & Stofer, 2006; Zucker & Darby, 1996). In addition, academics' motives may differ depending on the type and the number of interactions they are engaged in (D'Este et al., 2010). Therefore, when empirically analyzing the results, we controlled for the following three factors: (1) hierarchical position; (2) scientific orientation (basic vs. applied), and (3) multiplexity of interactions.

4.4 ANALYSIS

We first assessed the reflective measurement model to check whether the general feeling of motivation was measured properly or not. We then proceeded with assessing the formative measurement model and tested the aforementioned hypotheses. Finally, we analyzed the differences in the role of specific motives between academics from different hierarchical positions and scientific orientations, as well as between academics engaged in a few vs. many different types of interactions.

4.4.1 Assessing reflective measurement model

Following the PLS path modeling algorithm outlined by Henseler et al. (2009), we first examined the internal consistency reliability, indicator reliability and validity of the reflective measurement model of academics' motivation to interact with industry. The objective of this part of analysis was to find out whether the measures we employed for the general feeling of motivation adequately reflect what we intended to measure.

Internal consistency reliability
To check the internal consistency reliability, we employed both the traditional Cronbach's α reliability coefficient (Cronbach, 1951) and the composite reliability ρ_c (Werts, Linn, & Jöreskog, 1974). Both coefficients (Cronbach's α (IMR) = 0.863; ρ_c (IMR) = 0.901) pass the required threshold of 0.7 (Nunnally & Bernstein, 1978). Consequently, the internal consistency reliability of the employed reflective set of indicators for academics' motivation to engage in interaction with industry can be regarded as acceptable.

Indicator reliability
The squared loadings of the employed reflective measures show that the general feeling of motivation explains more than 50% of variance in most of these measures (see Table 4-3). Consequently, most of the proposed reflective measures can be considered reliable (based on the threshold of 50% suggested by Henseler et al., 2009).

Table 4-3: Squared loadings of reflective items

Variable	Questionnaire item	Squared loading
IMR1	In general, I am *not* interested in collaborating with industry. (reverse coding)	0.478
IMR2	Overall, I am open to interaction with industrial partners.	0.630
IMR3	I feel enthusiastic about interaction with industry.	0.822
IMR4	Interaction with industry brings me satisfaction.	0.771
IMR5	All things considered, collaboration with industry is *not* important to me. (reverse coding)	0.542

Interestingly, the highest share of explained variance (82%) corresponds to being enthusiastic about interaction with industry, i.e., the general feeling of motivation to interact with industry explains 82% of variance in academic's enthusiasm about interaction with industry. Consequently, this measure can be considered the most precise manifestation of academics' motivation to engage in interaction with industry in the current set of measures. The higher is the academic's enthusiasm to interact with industry, the more we can speak of his or her motivation to engage in such interaction.

Although the squared loading of IMR1 ("Interest in collaboration with industry") is slightly below the required threshold, we will not omit this indicator. This discrepancy can partially be explained by the specificities of the measurement procedure for this indicator, and, in particular, the use of reverse coding for this item. We argue that, in general, being interested in collaborating with industry represents one of the key manifestations of academic's motivation to engage in interaction with industry, and more substantial arguments are needed to remove it from the proposed list of measures. Furthermore, a recommended threshold for eliminating reflective indicators from measurement models refers to an outer standardized loading lower than 0.4 (Churchill Jr, 1979), while the outer loading of IMR1 on IMR is 0.692, which is thus sufficient for this indicator to be kept in our set of measures.

Validity

For the assessment of validity of the reflective measurement model, we examined the convergent validity. Convergent validity indicates that a set of indicators represents one and the same underlying construct, which can be demonstrated through their unidimensionality (Henseler et al., 2009). We employed the average variance extracted (AVE) as a criterion of convergent validity (Fornell & Larcker, 1981). AVE (IMR) = 0.649 means that the IMR latent variable is able to explain about 65% of the variance of its indicators on average and can thus be considered sufficient (based on threshold of 0.5 suggested by Fornell et al., 1981).

In addition, bootstrap resampling was performed to examine the significance of the loadings for the reflective block (Henseler et al., 2009).

Table 4-4: Results of bootstrap resampling for reflective measures

Variable	Questionnaire item	t-value Bootstrapping
IMR1	In general, I am *not* interested in collaborating with industry. (reverse coding)	**7.217**
IMR2	Overall, I am open to interaction with industrial partners.	**19.847**
IMR3	I feel enthusiastic about interaction with industry.	**66.466**
IMR4	Interaction with industry brings me satisfaction.	**49.223**
IMR5	All things considered, collaboration with industry is *not* important to me. (reverse coding)	**10.106**

Critical value $t_{499,\,0,975} = 1.972$

All five reflective measures prove to be significant (see Table 4-4), i.e., they all represent valid measures of the general academics' motivation to interact with industry. The factors that represent the most significant manifestation of academics' motivation to interact with industry refer to feeling enthusiastic about interaction with industry and having a feeling of satisfaction.

Consequently, the employed reflective measurement model can be considered both valid and reliable, and we were thus able to sufficiently capture the general feeling of academics' motivation to interact with industry. In the next sub-section, we examine to what extent this general feeling can be explained by the presence of specific motives.

4.4.2 Assessing formative measurement model

Assessing formative measurement models comes down to assessing their validity. In contrast to reflective models, indicator reliability is irrelevant in this case (Diamantopoulos, 2006; Henseler et al., 2009). In this section, we analyze the validity of the formative model of academics' motivation to interact with industry, at both the construct and the indicator levels. Figure 4-1 presents an estimated PLS path model that will be used in the course of this analysis.

External validity
In the theoretical section, we hypothesized that when taken all together, the identified eight motives explain a sufficient variance in academics' general motivation to engage in interaction with industry (*Hypothesis 9*). To test this hypothesis, we regressed the formative index on a reflective measure of motivation and obtained the following variance of the error: Var(ν) = 0.619 (γ^2 = 0.343; rel (ξ) = 0.901), and the corresponding external validity of 0.381. Consequently, the formative index carries only about 40% of the intended meaning, which is far below the recommended threshold of 80% (see Henseler et al., 2009). Chin (2010) suggested that a path of 0.800 or above secures an adequate set of formative measures. In our case, γ = 0.586, which is still below this threshold. Hence the formative index based on the specific motives from the literature covers an insufficient part of a reflective measure of motivation. The motives accountable for the rest 60% of the academics' motivation to interact with industry were thus not included in the measurement model.

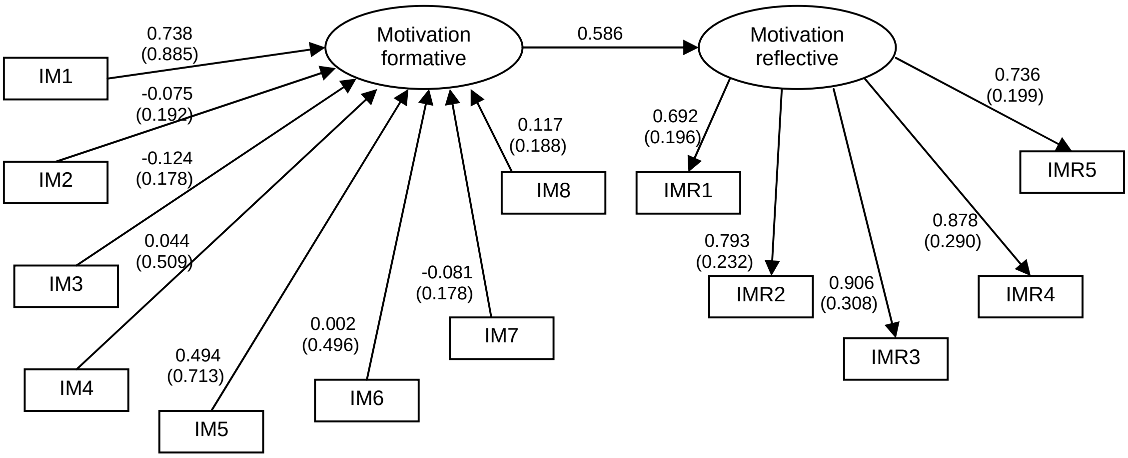

Figure 4-1: Estimated PLS path model

Significance of weights

In the theoretical section, we hypothesized that each of the identified eight motives significantly increases academics' general motivation to interact with industry (*Hypotheses 1 – 8*). To test these hypotheses, we assessed the significance of the estimated indicator weights by means of bootstrapping (see Chin, 1998b; Davison, Hinkley, & Young, 2003; Henseler et al., 2009; Tenenhaus, Vinzi, Chatelin, & Lauro, 2005). The results of bootstrap resampling are presented in Table 4-5.

Table 4-5: Results of bootstrap resampling for formative measures

Composite Variable	Motive	t-value Bootstrapping	Outcome Hypotheses
IM1 (IM1a x IM1b)	Motive of solving practical problems	**7.254**	**$H1_0$ can be rejected; hypothesis confirmed**
IM2 (IM2a x IM2b)	Motive of gaining recognition within the scientific community	0.884	not confirmed
IM3 (IM3a x IM3b)	Motive of supporting teaching duties	1.309	not confirmed
IM4 (IM4a x IM4b)	Motive of getting access to industry facilities	0.505	not confirmed
IM5 (IM5a x IM5b)	Motive of getting access to industry knowledge	**3.657**	**$H5_0$ can be rejected; hypothesis confirmed**
IM6 (IM6a x IM6b)	Motive of keeping abreast of industry problems	0.019	not confirmed
IM7 (IM7a x IM7b)	Motive of getting promotion on a career ladder	0.843	not confirmed
IM8 (IM8a x IM8b)	Motive of obtaining additional funding for research group, graduate students or laboratory equipment	1.398	not confirmed

Critical value $t_{499,\,0,975} = 1.972$

The only two factors that demonstrate a significant impact on the formative index refer to the motive of solving practical problems and the motive of getting access to industry knowledge. The rest of the identified motives prove to be insignificant in forming the general feeling of academics' motivation to interact with industry. Consequently, only two out of eight hypotheses were confirmed (H1 and H5).

Multicollinearity

At the indicator level, we also checked whether there is high multicollinearity among specific motives, which could mean that the information carried by some motives is redundant (Cassel, Hackl, & Westlund, 1999; Diamantopoulos & Winklhofer, 2001; Grewal, Cote, & Baumgartner, 2004; Henseler et al., 2009). The degree of multicollinearity among formative indicators was assessed by looking at the variance inflation factor (VIF) of each of those indicators (Henseler et al., 2009). VIFs were calculated in SPSS 16.0.

Table 4-6: Variance inflation factors of formative measures

Composite Variable	Motive	VIF
IM1 (IM1a x IM1b)	Motive of solving practical problems	1.314
IM2 (IM2a x IM2b)	Motive of gaining recognition within the scientific community	1.513
IM3 (IM3a x IM3b)	Motive of supporting teaching duties	1.462
IM4 (IM4a x IM4b)	Motive of getting access to industry facilities	2.096
IM5 (IM5a x IM5b)	Motive of getting access to industry knowledge	2.304
IM6 (IM6a x IM6b)	Motive of keeping abreast of industry problems	1.460
IM7 (IM7a x IM7b)	Motive of getting promotion on a career ladder	1.490
IM8 (IM8a x IM8b)	Motive of obtaining additional funding for research group, graduate students or laboratory equipment	1.067

The obtained VIFs are acceptable as they do not substantially exceed 1 and are far from the critical threshold of 10 (see Henseler et al., 2009). Consequently, the employed formative indicators do not exhibit high multicollinearity and are not redundant, i.e., they all carry different meaning.

4.4.3 Differences between academics from different hierarchical positions

In this sub-section, we examine the differences in the role of specific motives between academics from different hierarchical positions. The total sample of academics was split in two parts: (1) PhD candidates (n_1 = 83) and (2) academics having a position higher than PhD candidate, i.e., full professors, associate professors, assistant professors, postdocs and other (n_2 = 101). A rule of thumb for robust PLS path modeling estimations suggests that the minimum sample size should be equal to ten times the number of indicators of the scale with the largest number of formative indicators (Barclay, Higgins, & Thompson, 1995; Henseler et al., 2009), i.e., 80 in our case. The total number of academics in each of the sub-samples thus satisfies this criterion.

We estimated PLS path models for both sub-samples. For PhD candidates, Var(ν) = 0.461 (γ^2 = 0.493; rel (ξ) = 0.914), and the corresponding external validity is 0.539. Consequently, for PhD candidates, more than a half of variance in their motivation can be explained by the eight specific motives. For academics having a position higher than PhD candidates, Var(ν) = 0.660 (γ^2 = 0.303; rel (ξ) = 0.891), and the corresponding external validity is 0.340. Consequently, the formative index carries only about 34% of the intended meaning. These results suggest that the identified eight motives explain the general feeling of academics' motivation to interact with industry better for PhD candidates than for academics having a position higher than PhD candidates. Nevertheless, for both sub-samples, the portion of explained variance does not pass the required threshold of 80% (see Henseler et al., 2009).

We then proceeded with assessing the significance of the estimated indicator weights by means of bootstrapping (see Table 4-7). For PhD candidates, the only two motives that are significant in forming the general feeling of motivation to interact with industry refer to the motive of solving practical problems and the motive of getting access to industry knowledge. Interestingly, for academics higher than PhD candidates one more motive proves to be significant: the motive of obtaining additional funding for research group, graduate students or laboratory equipment. This difference can be explained by the fact that the need to obtain additional funding becomes important at later stages of academic career, and is thus less relevant for PhD candidates.

4.4.4 Differences between academics from different scientific orientations

In this sub-section, we examine the differences in the role of specific motives between academics from different scientific orientations. Using the median split approach, the total sample of academics was split in two parts: (1) academics whose scientific orientation is more basic than applied (n_1 = 92) and (2) academics whose scientific orientation is more applied than basic (n_2 = 92). The total number of academics in each of the sub-samples satisfies the criterion of the minimum required sample size, i.e., 80.

We estimated PLS path models for both sub-samples. For academics whose scientific orientation is more basic than applied, Var(ν) = 0.593 (γ^2 = 0.372; rel (ξ) = 0.914), and the corresponding external validity is 0.407. Consequently, the eight specific motives explain about 41% of the general motivation to interact with industry. For academics whose scientific orientation is more applied than basic, Var(ν) = 0.554 (γ^2 = 0.395; rel (ξ) = 0.886), and the corresponding external validity is 0.446. Consequently, the formative index carries about 45% of the intended meaning. These results suggest that the identified eight motives explain the general feeling of academics' motivation to interact with industry slightly better for academics whose scientific orientation is more applied than for those with more basic orientation. Interestingly, the difference is not substantial.

We then proceeded with assessing the significance of the estimated indicator weights by means of bootstrapping (see Table 4-7). For academics with a more basic orientation, four motives prove to be significant: the motive of solving practical problems, the motive of gaining recognition within the scientific community, the motive of getting access to industry knowledge, and the motive of keeping abreast of industry problems. Interestingly, the later proves to be not significant for academics with a more applied orientation. This difference can be explained by the fact that academics working on applied research per definition are aware of certain industry problems, and thus may not see it as a strong motivator for them to interact with industry. The results also suggest that the motive to solve practical problems is a stronger driver for academics with a more applied orientation that the ones working on basic research.

4.4.5 Differences between academics engaged in a few vs. many different types of interactions

The respondents were asked to identify all types of interactions that they were involved in with specific industrial partners in the period from September 2009 to September 2010. The suggested types of interactions included informal communication, consultancy work, contract research agreements, setting-up spin-off companies, creation of physical facilities with industry funding, postgraduate training in company, training company employees, joint research agreements and other (open option) (based on D'Este et al., 2007b). The respondents selecting less than two different types of interactions were than placed into one sub-sample (n_1 = 99), and the rest of the respondents we assigned to the second sub-sample (n_2 = 85).

We estimated PLS path models for both sub-samples. For academics engaged in a few types of interactions, Var(ν) = 0.442 (γ^2 = 0.501; rel (ξ) = 0.898), and the corresponding external validity is 0.558. Consequently, the eight specific motives explain about 56% of the general motivation to interact with industry. For academics engaged in many different types of interactions, Var(ν) = 0.720 (γ^2 = 0.252; rel (ξ) = 0.903), and the corresponding external validity is 0.280. Consequently, the formative index carries only about 28% of the intended meaning. These results suggest that the identified eight motives explain the general feeling of academics' motivation to interact with industry much better for academics engaged in a few different types of interactions than for the ones engaged in many different types. These results suggest that academics' motivation to interact with industry depends on the type of interaction, which is in line with the conclusions of D'Este and Perkmann (2010). i.e., each specific type of interaction with industry implies a specific set of motives that drive academics to engage in this type of interaction.

We then proceeded with assessing the significance of the estimated indicator weights by means of bootstrapping (see Table 4-7). The same four types of factors proved to be significant for both sub-samples: the motive of solving practical problems, the motive of supporting teaching duties, the motive of getting access to industry facilities, and the motive of getting access to industry knowledge. No considerable differences can be observed between the two groups with regard to weights of the specific motive.

Table 4-7: Results of bootstrap resampling for formative measures for specific sub-samples

Composite Variable	Motive	t-values Bootstrapping					
		PhD candidates	**Academics having a position higher than PhD candidate**	**Academics whose scientific orientation is more basic than applied[1]**	**Academics whose scientific orientation is more applied than basic**	**Academics engaged in a few types of interactions**	**Academics engaged in many different types of interactions**
MF1 (MF1a x MF1b)	Motive of solving practical problems	**9.514**	**4.595**	**4.436**	**10.040**	**9.441**	**4.746**
MF2 (MF2a x MF2b)	Motive of gaining recognition within the scientific community	0.798	1.274	**2.648**	**4.212**	0.779	1.498
MF3 (MF3a x MF3b)	Motive of supporting teaching duties	1.442	1.209	1.576	0.015	**3.419**	**2.301**
MF4 (MF4a x MF4b)	Motive of getting access to industry facilities	0.391	1.231	1.086	0.775	**2.114**	**2.669**
MF5 (MF5a x MF5b)	Motive of getting access to industry knowledge	**4.537**	**4.727**	**3.629**	**4.198**	**3.845**	**5.609**
MF6 (MF6a x MF6b)	Motive of keeping abreast of industry problems	0.339	1.086	**2.077**	1.963	0.450	1.181
MF7 (MF7a x MF7b)	Motive of getting promotion on a career ladder	0.549	1.187	1.963	1.304	0.086	1.892
MF8 (MF8a x MF8b)	Motive of obtaining additional funding for research group, graduate students or laboratory equipment	0.591	**2.589**	0.505	1.247	0.892	1.054

Critical value $t_{499,\ 0,975} = 1.972$ ($\alpha = 0.05$)

[1] full professors, associate professors, assistant professors, postdocs and other

4.5 CONCLUSIONS

Academics have not only different levels, but also different types of motivation to interact with industry. In this chapter, we examined to what extent specific motives from the literature are accountable for the academics' general feeling of motivation to interact with industry. We identified eight specific motives. Using the results of a large-scale survey of Dutch universities and research centers, we regressed those specific motives on the academics' general feeling of motivation to interact with industry.

The results of our analysis suggest that the specific eight motives carry about 40% of the general feeling of academics' motivation to interact with industry. Consequently, the major part of the academics' motivation to engage in interaction with industry cannot be explained by those motives. Among those specific motives, only two demonstrate a significant impact: the motive of solving practical problems and the motive of getting access to industry knowledge. Interestingly, both motives are of intrinsic nature. These results confirm the conclusions of D'Este and Perkmann (2010) who found that most academics engage in interaction with industry to advance their own research through learning rather than to become entrepreneurs. None of the extrinsic motives (e.g., a motive of getting promotion on a career ladder, a motive of obtaining additional funding) proved to be significant in forming the general feeling of enthusiasm about and openness towards interaction with industry. The results confirmed that the identified eight motives are not redundant and all carry different meaning. Consequently, their low individual significance is not related to potential overlap in their meaning.

The fact that six out of eight specific motives did not prove to be significant requires additional explanation. For instance, a motive of gaining recognition within the scientific community may be an important motive for academics in general (Merton, 1957), but it does not prove to be a key driver for academics to interact with industry. Gulbrandsen (2005) found that active engagement of academics in university-industry interactions made them 'stand out' in a slightly negative manner from their colleagues, and they "felt suspected of shrinking their academic duties". These academics thus felt excluded from academic membership for 'selling themselves' to industry. However, such situations are more likely to occur in research groups where university-industry interactions are more the exception than the rule. The importance of reputational rewards suggested by Audretsch et al. (2010) thus was not confirmed by the results of this study.

A motive of supporting teaching duties also did not prove to be significant in creating a general feeling of motivation to interact with industry. Academics interacting with industry in order to support their teaching duties must realize significant benefits from such activities (Lee, 2000); however, in practice, they may more often see it as a distraction from their primary task of teaching (Lee, 1996). The academics also do not seem to be primarily driven by the desire to get access to industry facilities. It is often the other way around: it is industry who tries to get access to expensive equipment in universities and public laboratories (Geisler & Rubenstein, 1989; Parker, 1992; Santoro et al., 1999). The low weight of the motive of getting promotion on a career ladder can be explained by the fact that universities rarely reward academics engaged in interaction with industry, since most promotion and tenure decisions continue to be almost exclusively based on publications and public research grants (Siegel et al., 2004). A motive of keeping abreast of industry problems proves to be significant only for academics whose scientific orientation is more basic than applied. It can be explained by the fact that academics working on applied research per definition are aware of certain industry problems, and thus may not see it as a strong motivator for them to interact with industry.

Finally, our results suggest that, in general, academics engaged in interaction with industry are not driven by the desire to obtain additional funding, which does not confirm the hypothesis that "that scientists are motivated by the same kinds of extrinsic rewards as 'everybody else', namely position and money" (Hangstrom, 1965, p. 52; quoted in Gustin, 1973, p. 1120). Academics, by the nature of their profession, are expected to put aside their material concerns and demonstrate a certain purity of motives (Etzkowitz, 1998; Goktepe et al., 2008). Our findings are in line with the statement that academics are driven by "naïve individualism" (Hagstrom, 1965) and "the need to engage in the charismatic activity" (Gustin, 1973), rather than by position and money. Interestingly, for academics higher than PhD candidates the motive of obtaining additional funding does prove to be significant. It can be explained by the fact that the need to obtain additional funding for a research group, graduate students or laboratory equipment becomes important at later stages of academic career, and is less relevant for PhD candidates.

The results also show that the identified eight motives explain the general feeling of academics' motivation to interact with industry much better for academics engaged in a few different types of interactions than for the ones engaged in many different types. These results suggest that academics' motivation to interact with industry depends on the type of interaction, and when different types of interactions and various motives are put together, the impacts of specific motives may neutralize each other. These findings are in line with the conclusions of D'Este and Perkmann (2010).

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5 Comparing the roles of motivation, embeddedness and prior experience

"Take away the cause, and the effect ceases."
Miguel De Cervantes (1547-1616), Spanish novelist

The current chapter examines the influence of motivation, embeddedness and prior experience on the academics' social capital activation with industry (Research question 2). We analyze the importance of each of these three factors to the actual academics' behavior. We conclude that, in general, academics' social capital activation with industry is clearly dominated by prior experience, while motivation and embeddedness play a secondary role. We also show the differences in the role of those factors between academics from different hierarchical positions, scientific orientations and scientific domains, as well as genders and origins.

5.1 INTRODUCTION

Existing literature offers various explanations of what essentially drives academics to interact with industry. Three general groups of authors can be distinguished. The first group stresses that academics actively collaborating with industry are primarily driven by a set of specific motives (Audretsch et al., 2010; Goktepe & Mahagaonkar, 2008; Hull, 1988; Lee, 2000; Mansfield, 1995; Meyer-Krahmer & Schmoch, 1998; Stephan, 1996; Stephan & Levin, 2005; Stern, 2004; Stokes, 1997). Such motives create a general feeling of enthusiasm about doing something professionally interesting and enjoyable, interest in and openness towards engaging in interaction with industry. The second group of authors suggests that academics' behavior is shaped by the environment in which they are embedded (Bercovitz & Feldman, 2003; Cukierman, Fontana, Sarfatti, & Nuova, 2007; D'Este & Patel, 2007a; Kenney & Richard Goe, 2004; Magnusson, McKelvey, & Versiglioni, 2008). This perspective emphasizes the importance of local group norms and culture, by group meaning primarily the research department or laboratory within which academics are active (Becher & Kogan, 1992; Goktepe-Hultan, 2008; Kenney et al., 2004). Finally, the third group of authors argues that academics' engagement in interaction with industry depends on their prior experience with such interactions (Bruneel et al., 2010; Hagedoorn et al., 1994; Hertzfeld et al., 2006; Lin et al., 2006; Van Dierdonck et al., 1990). Academics' experience with industry is suggested to reduce the cultural differences which exist between both worlds (Van Dierdonck et al., 1990). Furthermore, the distinct perspectives of motivation, embeddedness and prior experience are not mutually exclusive and complement each other.

In this chapter, we model Motivation, Embeddedness and Prior Experience as latent variables expressed by a set of reflective measures. We then regress these three factors on the actual engagement of academics in interactions with industry by means of PLS path modeling. We examine the relative weight of these factors on the actual academics' behavior and compare the weights of these factors with each other. Finally, we examine the role of positional factors and control variables. The current chapter thus aims to examine which of those factors can be considered the best predictor of academics' engagement in interactions with industry and under what conditions. The latter refer to possible moderating factors that are likely to influence the examined relationships.

5.2 THEORETICAL BACKGROUND AND HYPOTHESES

In this section, we first examine the complex nature of academics' engagement in interactions with industry. We then formulate a set of hypotheses with regard to how the level of academics' engagement in interactions with industry can be influenced by specific factors such as motivation, embeddedness and prior experience.

5.2.1 Engagement in interactions with industry

By academics' interactions with industry we mean reciprocal exchanges of information resources between academics and their industrial partners. The current study exclusively focuses on information resources since those refer to the most popular means of exchange between interaction partners via networks of relationships, and often precede the exchange of other types of resources, e.g., economic or reputational resources (Bourdieu, 1985; Portes & Sensenbrenner, 1993). Such interactions may take any form of communication (e.g., face-to-face, phone, e-mail, skype, videoconferencing, regular mail etc.). The exchange of information resources can occur either for the first time or it can be sequential, i.e., when an academic and his or her industrial partner have already been engaged in interaction with each other some time before. Furthermore, this exchange is of reciprocal nature, i.e., both an academic and his or her industrial partner have an effect upon one another, and this idea of a two-way effect is essential in the concept of interaction (Pinar, Reynolds, Slattery, & Taubman, 2000). This effect can be of both short-term and long-term nature. The short-term effects refer to the immediate benefits of such interaction for both actors. The long-term effects, in turn, refer to the notion of generalized reciprocity (Adler & Kwon, 2002; Portes, 1998; Putnam, 1993; Uzzi, 1997) that implies the principle "I'll do this for you now, knowing that somewhere down the road you'll do something for me" (Putnam, 1993).

Academics' engagement in interactions with industry is a complex multi-dimensional phenomenon. From the existing literature, we derive that the level of academics' engagement in interactions with industry can manifest itself as the following four characteristics: the size of exploited network, as well as the multiplexity, frequency and total duration of interactions during a certain period of time, for instance, one year.

The size of the exploited network refers to the number of industrial partners with whom an academic had an actual interaction during the time period in question. This notion is distinct from the total size of academics' network with industry, i.e., the total number of industrial partners with whom an academic is connected (Balconi, Breschi & Lissoni, 2004; Burt, 1983; Borgatti, 1997; Hansen, Podolny & Pfeffer, 2001). The distinction is important, as possessing networks does not yet mean their actual exploitation during a certain period of time (Adler et al., 2002; Anderson, 2008; Burnett, 2006; Foley & Edwards, 1999; Hebert, Lee, Sun, & Berti, 2003). The size of the exploited network is therefore a more accurate manifestation of the academics' actual engagement in interactions with industry during a certain period of time.

The multiplexity of interactions refers to the diversity of interaction channels with industry that were used by an academic during the time period in question (Blumstein & Kollock, 1988; Granovetter, 1973; Marsden & Campbell, 1984; Petróczi, Nepusz, & Bazsó, 2006). Interactions with industry can take various forms including consultancy work, contract research agreements, setting-up spin-off companies, creation of physical facilities with industry funding, as well as postgraduate training in a company, training company employees, joint research agreements and informal communication (Bonaccorsi & Piccaluga, 1994; D'Este et al., 2007a; Faulkner, Senker, & Velho, 1995; Perkmann et al., 2007; Schartinger, Schibany, & Gassler, 2001). The more interaction forms an academic used during a certain period of time, the more we can speak of academic's engagement in interaction with industry during that period.

The frequency of interactions refers to the regularity at which an academic interacted with his or her industrial partners during the time period in question (Anderson, 2008; Benassi, Greve, & Harkola, 1999; Blumstein et al., 1988; Granovetter, 1995; Lin, Vaughn, & Ensel, 1980; Marsden et al., 1984). The more frequent the interactions with industry were during a certain period of time, the more we can speak of academic's engagement in interaction with industry during that period.

Finally, the total duration of interactions refers to the total amount of time that an academic spent on interactions with his or her industrial contacts last year (Blumstein et al., 1988; Granovetter, 1973; Marsden et al., 1984; Petróczi et al., 2006). The longer the total duration of interactions during a certain period of time, the more we can speak of academic's engagement in interaction with industry during that period.

After examining the essence of academics' engagement in interactions with industry we now move on to the factors that are expected to influence the level of such engagement.

5.5.2 Motivation to interact with industry

According to the literature, one of the proposed predictors of the academics' engagement in interactions with industry refers to the academics' own motivation to do so (Adler et al., 2002; Anderson, 2008; Burt, 2000). Academics are argued to be driven by a set of specific motives that create a general feeling of enthusiasm about, interest in and openness towards interaction with industry (Audretsch et al., 2010; Goktepe et al., 2008; Hull, 1988; Lee, 2000; Mansfield, 1995; Meyer-Krahmer et al., 1998; Stephan, 1996; Stephan et al., 2005; Stern, 2004; Stokes, 1997).

Based on the literature, eight groups of academics' motives can be derived. For a detailed overview of those motives, the reader is invited to consult Chapter 4. Although different academics are suggested to be driven by different motives (Audretsch et al., 2010; D'Este et al., 2010), the presence of certain motives itself is argued to create a general feeling of willingness to engage in interaction with industry. Motivated academics are expected to demonstrate entrepreneurial behavior in a broader sense and pro-actively seek for opportunities to interact with industry in order to pursue their teaching, research or commercialization interests (Gulbrandsen, 2005; Meyer, 2003). This leads to our first hypothesis:

Hypothesis 1: Academic's motivation to interact with industry is positively associated with the level of his or her actual engagement in interaction with industry.

5.2.3 Embeddedness

Based upon the sociological literature on embeddedness (Granovetter, 1985; Kenney et al., 2004), scholars argue that academics' engagement in interaction with industry is as a function of their direct social environment (Bercovitz et al., 2003; Cukierman et al., 2007; D'Este et al., 2007b; Kenney et al., 2004; Magnusson et al., 2008). Existing literature suggests that among the main elements of the environment that are likely to have the greatest influence on the behavior of academics, the research department (research group or laboratory) within which this researcher is active is likely to have the highest impact (Cukierman et al., 2007; D'Este et al., 2007b; Magnusson et al., 2008). Within the research department, the literature distinguishes between the influence of leaders and peer colleagues (Bercovitz & Feldman, 2008; Goktepe-Hultan, 2008; Stuart et al., 2006).

The leaders of research departments (or chairs) are expected to influence academics' behavior by both building culture and by acting as role models. The observable behavior of those in leadership roles is argued to shape the department's culture by signalling what actions are expected, valued, and likely to be rewarded (House, 1977, Schein, 1985 quoted in Bercovitz et al., 2008; Lazega, Mounier, Jourda, & Stofer, 2006). In academic departments, the chair plays a direct and powerful role in, for example, reviewing and evaluating individual performance related to promotion and tenure (Bercovitz et al., 2008). If the chair is active in interactions with industry, then he or she sends a signal that interaction with industry is a valid activity. In this case, other members of the department might be more likely to engage in interaction with industry.

Furthermore, scholars have been arguing that academics are likely to adopt the behavior of local colleagues, i.e., these colleagues also act as role models and, together with the decisions taken within the research department, influence the behavior of individual academics (Bercovitz et al., 2008; Goktepe-Hultan, 2008; Louis, Blumenthal, Gluck, & Soto, 1989; Stuart et al., 2006). This proposition supports the evidence from the experimental studies showing a strong influence of a group's consensus on an individual's (un)willingness to deviate from the majority view (Stuart et al., 2006). Consequently, academics embedded in research departments in which the traditional norms represent the consensus view are suggested to be less likely to engage in interactions with industry than their colleagues from 'non-traditional' departments. As a result, the second hypothesis can be formulated as follows:

Hypothesis 2: Academic's embeddedness in a research department where interaction with industry is part of the culture is positively associated with the level of his or her actual engagement in interaction with industry.

5.2.4 Prior experience

Academics’ engagement in interaction with industry is also argued to be based on their prior experiences (Audretsch et al., 2010; Hite, 2005). Existing literature suggests that the past behavior of academics regarding their participation in university-industry interactions generates a strong imprint in their future behavioral pattern (Bercovitz et al., 2003; D’Este et al., 2007a; SewellJr, 1996).

Academics’ prior experience translates into a number of social network characteristics that are likely to influence their future behavior: the total size of their network with industry, as well as closeness and history of interactions with particular industrial partners, and the multiplexity of roles. The total size of an academic’s network with industry refers to the total number of industrial contacts that an academic has accumulated by the beginning of the time period in question (Balconi et al., 2004; Borgatti, 1997; Burt, 1983; Hansen et al., 2001). Closeness, in turn, refers to a certain degree of affinity that academics feel with their industrial partners as a result of previous interactions (Anderson, 2008; Blumstein et al., 1988; Hansen et al., 2001; Marsden et al., 1984; Petróczi et al., 2006). Affinity here refers to a high level of trust, sharing and interpersonal commonalities. The results of previous interactions can also be expressed as the history of interactions which refers to the total duration of the relation an academic and his or her industrial partners (Anderson, 2008; Blumstein et al., 1988; Granovetter, 1973; Marsden et al., 1984; Petróczi et al., 2006). Finally, the multiplexity of roles as another manifestation of the previous interaction results refers to the diversity of roles in which an academic knows his or her industrial partners in relation to him- or herself. Such roles may, for example, refer to friend, research partner, expert, business partner, coach or coachee etc.

Academics who once engaged in interactions with industry for the first time are suggested to have done so because of the following reasons. They either expected particular returns from such activities and acted *proactively* to obtain those benefits, or they were forced ‘to enter the playing field’ by, for example, their chairs, colleagues or industrial partners and thus acted *reactively* (Abbott, 1983; Helpman & Krugman, 1985; Mahoney, 2000; Pierson, 2000; Romer, 1986). If the behavioral pattern of interaction with industry delivers increasing benefits with its continued adoption, then over time, it becomes less and less likely for academics to transform this pattern. Consequently, academics’ prior experience of interaction with industry can be compared to ‘inertia’, i.e.., once a process of interaction with industry is set into motion and begins generating certain outcomes, this process tends to stay in motion and is unlikely to change even when alternative behavioral patterns are likely to lead to higher effectiveness (Abbott, 1983; Mahoney, 2000). This leads us to the third hypothesis.

Hypothesis 3: Academic's prior experience of interaction with industry is positively associated with the level of his or her actual engagement in interaction with industry.

In the remainder of this chapter, we aim at analyzing the relative weights of each of those factors on the academics' actual engagement in interaction with industry. We aim to find out which of those factors can be considered the best predictor of academics' engagement in future interactions and under what conditions. The latter refer to possible moderating factors that are likely to influence the examined relationships.

5.2.5 Moderating factors

Existing research also suggests that several moderating factors are likely to affect the academics' level of engagement in interaction with industry. For example, factors like hierarchical position and scientific orientation (basic or applied) are reported to correlate directly with the inclination of researchers to engage in university-industry interactions (Bercovitz et al., 2008; D'Este et al., 2007b; Landry, Amara, & Ouimet, 2005; Lazega et al., 2006; Zucker et al., 1996). Hierarchical position is also suggested to determine the influence of the chair on the behavior of academics (Bercovitz et al., 2008). In addition, academics' behavior may differ depending on their scientific domain (D'Este et al., 2007a; Kenney et al., 2004) and their country of origin, i.e., depending whether academics are local or foreign-born (Lee, 2004). Finally, academics' engagement in interactions with industry is likely to be influenced by their gender (Lin & Bozeman, 2006). Therefore, when empirically analyzing the results, we aim to examine the moderating effects of the following five factors: (1) hierarchical position; (2) scientific orientation (basic vs. applied), (3) scientific domain; (4) gender, and (5) country of origin (local vs. foreign-born).

5.3 METHODS

In this section, we report the results of the outer model assessment, i.e., the assessment of the reliability and validity of the employed measures. For other aspects of the methodology (i.e., sample and data collection procedures), the reader is invited to consult Chapter 3.

5.3.1 Measurement

Four sets of reflective measures employed in this analysis are as follows. The measures employed for motivation correspond to IMR1-IMR5 of Annex A. The embeddedness measures refer to PSIR1 – PSIR5 of Annex A. The employed measures of prior experience and interactions correspond to PSCR1 – PSCR4 and SCAR1 – SCAR4 of Annex A respectively. For a detailed overview of how these measures were developed and how their reflective nature was confirmed the reader is advised to consult Chapter 3.

5.3.2 Outer Model Assessment

In this sub-section, we examine the internal consistency reliability, indicator reliability and validity of the employed measures. For all our latent variables, both Cronbach's α (Cronbach, 1951) and the composite reliability ρ_c (Werts, Linn, & Jöreskog, 1974) pass the required threshold of 0.7 (Nunnally & Bernstein, 1978) (see Table 5-2). Consequently, the internal consistency reliability of the employed measures can be regarded as acceptable.

Table 5-1: Cronbach's Alpha, Composite Reliability and AVE

	Cronbach's Alpha	**Composite Reliability**	**AVE**
Motivation	0.863	0.900	0.643
Embeddedness	0.804	0.863	0.558
Prior experience	0.874	0.914	0.734
Interactions	0.894	0.925	0.756

The squared loadings confirmed the reliability of our indicators as most of our latent variables explain more than 50% (Henseler, Ringle, & Sinkovics, 2009) of each of their indicators' variance. Two exceptions refer to PSIR2 ($\lambda^2 = 0.430$) and PSCR1 ($\lambda^2 = 0.338$).

PD1 corresponds to the total network size of academics in relation to industry by September 2009. Low reliability of this measure can be explained by the fact that the rest of the measures of Prior Experience in our empirical example refer not to the whole network, but to a limited part of the academics' network with industry. Thus, for PSCR2 - PSCR4, the respondents were asked to provide detailed information on up to five industrial partners, whereas PSCR1 covers all industrial partners in their network. As a result, the Prior Experience latent variable currently is predominantly related to the five industrial partners the academics reported on. This approach has inevitably created a certain bias in the estimates. However, as those five industrial partners are partners with whom the academics have the strongest connections, the cumulative measures such as closeness, multiplexity of roles and history of interactions are expected to cover a representative part of academics' past experiences.

Another exception refers to PSIR2 corresponding to the statement "I am under social pressure to collaborate with industry". The reason for a low reliability of this indicator can be explained by a sensitive formulation of the statement corresponding to it. The respondents are likely to perceive "social pressure" in a more negative way than measures related, for instance, to expectations and duty, and the scores obtained for this measure are thus likely to be biased.

Although the reliability of PSCR1 and PSIR2 is low, we will not omit these indicators. Total network size is a key measure in research on university-industry interactions, and more substantial arguments are needed to remove it from the proposed list of measures. Furthermore, the outer standardized loadings of both measures are higher than 0.4 (λ_{PD1}= 0.581 and λ_{EMB2}= 0.656), a recommended threshold for eliminating reflective indicators from measurement models (Churchill Jr, 1979).

The convergent validity of all our latent variables is sufficient (see Table 3; in all cases, it is higher than 0.5; (Fornell & Larcker, 1981)). All latent variables also satisfy the Fornell-Larcker criterion, meaning that they share more variance with their assigned indicators than with each other (Henseler et al., 2009).

Table 5-2: SQRT AVE and correlations matrix

	Motivation	Embeddedness	Prior experience	Interactions
Motivation	**0.802**			
Embeddedness	0.299**	**0.747**		
Prior experience	0.300**	0.405**	**0.857**	
Interactions	0.245**	0.277**	0.845**	**0.869**

**. Correlation is significant at the 0.01 level (1-tailed).

The loading of each indicator on its assigned latent variable is greater than all of its cross-loadings (Chin, 1998b) for all our indicators. The only exception refers to INT1 or the size of exploited network (λ_{INT1_INT} = 0.872; λ_{INT1_PD} = 922). It can be explained by the fact that most of our measures of Prior Experience are directly related to the size of exploited network (i.e., these are the measures of the academics' past experiences by September 2009 exclusively for industrial partners with whom academics interacted between September 2009 and September 2010). In order to avoid the situation that the loading of SCAR1 on Prior Experience is higher than on Interactions, we should have asked our respondents to provide information on all industrial partners from their social network for all Prior

Experience measures. As mentioned above, in our case, some of the respondents had more than fifty industrial partners, and therefore, gathering data on all of those partners was not possible.

The outer model assessment suggests that the proposed measurement models in general proved to be reliable and valid. We now proceed to the analysis of the results.

5.4 ANALYSIS

In the previous section, we reported on the results of the outer model assessment. In this section, we proceed with examining the results regarding the endogenous latent variable, and then assess the inner model and test the aforementioned hypotheses. Finally, we analyze the differences in the role of the three factors between academics from different hierarchical positions, scientific orientations and scientific domains, as well as different genders and origin (local vs. foreign-born). We follow the guidelines on how to report the results of PLS analysis by Chin (2010) and Henseler (2009).

5.4.1 Data description

We first examine the results with regard to the endogenous latent variable, i.e., the level of engagement of the respondents in interactions with industry. The results show that between September 2009 and September 2010, more than a quarter of respondents (26%) were not engaged in interactions with industry (see Table 5-3). 19% of the respondents, in turn, were actively interacting with industry and collaborated with five or more industrial partners. The most popular option among the respondents was “one industrial partner” (28%), while the average of the sample is 1.95 industrial partners.

Interestingly, the size of exploited network is considerably smaller than the size of the total network of contacts that the academics have with industry. The data thus confirm the assumption that possessing networks does not yet mean their actual exploitation during a certain period of time (Adler et al., 2002; Anderson, 2008; Burnett, 2006; Foley et al., 1999; Hebert et al., 2003). The data presented in Table 5-3 are also in line with the results of Balconi et al. (2004) who found that academics have on average 4 to 10 industrial acquaintances.

With regard to the frequency of interactions, most often the respondents interacted with specific industrial partners about three times during the year in question (32%). For the majority of cases, interactions with industrial partners took place six times a year or less (70%). The results also suggest that only in 8% of cases, interactions with specific industrial partners took place on a daily or weekly basis.

The most popular interaction channel with industry for the majority of respondents (56%) refers to informal communication. Existing research regards informal communication as particularly important for transferring new information between academia and industry (Crane, 1971; Dahl & Pedersen, 2004; Poland, 1991). The information exchanged by means of informal communication refers not only to research, products and technologies, but also to rumors about specific individuals and future job openings. This information channel is also suggested to be used as a way to establish reputation in the local environment, i.e., the reputation that would make an individual valuable collaboration partner in the future in more formal types of interaction (Dahl et al., 2004). The second most popular interaction channel refers to joint research agreements (26%) followed by contract research agreements (17%) and consultancy work (16%). Other types of interaction channels not included in the list but mentioned by the respondents, among others, refer to the supervision of PhD projects, as well as conferences and symposia, and writing joint grant proposals.

Finally, in 28% of cases, the respondents spent more than sixty hours on interactions with a particular industrial partner. No clear trend can, however, be observed for the rest of the cases, which lie in the range between less than ten hours (10%) and fifty-sixty hours (10%).

Table 5-3: Distribution of data

Size of exploited network in September 2009 – September 2010 (INT1)									
Nr of ind partners	0	1	2	3	4	5 or more		**St dev**	**Average**
Nr of resp	48	51	27	13	10	35		1.82	1.95
% resp	26%	28%	15%	7%	5%	19%			
Total network size by September 2009 (PD1)									
Nr of ind partners	0	1-10	11-20	21-30	31-40	41-50	More than 50	**St dev**	**Average**
Nr of resp	26	90	26	24	4	1	13	14.67	12.72
% resp	14%	49%	14%	13%	2%	0.5%	7%		
Frequency of interactions per industrial partner in September 2009 – September 2010 (INT2)									
Frequency	Twice a week or more	Once a week	Twice a month	Once a month	Six times a year	Three times a year	Once a year	**St dev**	**Average**
Nr of ind partners	10	9	19	34	43	74	43	1.60	5.09 (or six times a year)
% ind partners	4%	4%	8%	15%	19%	32%	19%		
Multiplexity of interactions in September 2009 – September 2010 (INT3)									
Type of interaction	Informal communica-tion	Consultancy work	Contract research agreements	Setting up spin-off companies	Creation of physical facilities with industry funding	Postgraduate training in a company	Training company employees	Joint research agreements	Other
Nr of ind partners	200	59	62	8	15	10	19	94	34
% ind partners	56%	16%	17%	2%	4%	3%	5%	26%	9%
Total duration of interactions per industrial partner in September 2009 – September 2010 (INT4)									
Total duration	Less than 10h	10-20h	20-30h	30-40h	40-50h	50-60h	More than 60h	**St dev**	**Average**
Nr of ind partners	27	23	48	33	29	26	73	3.38	39.83
% ind partners	10%	9%	19%	13%	11%	10%	28%		

The following conclusions can be drawn from the descriptive analysis of the level of academics' engagement in interactions with industry. The size of exploited network of academics between September 2009 and September 2010 was considerably smaller than the total number of industrial partners in their network. Interactions with specific industrial partners typically took place six times a year or less. The main interaction channel referred to informal communication followed by joint research agreements, contract research agreements and consultancy work. The total duration of interactions varied depending on industrial partners and types of interaction from less than ten hours to more than sixty hours for the whole time period in question. These results provide an insight into the actual behavior of academics, the antecedents of which are being examined in the current chapter. In the remainder of this section, we examine to what extent the three predictors are able to explain the abovementioned level of engagement of academics in interactions with industry.

5.4.2 Inner model assessment

We now proceed to the inner model assessment which allows for examining the relations between the latent variables and thereby testing our hypotheses. Figure 5-1 presents the complete estimated PLS path model with Interactions as an endogenous latent variable.

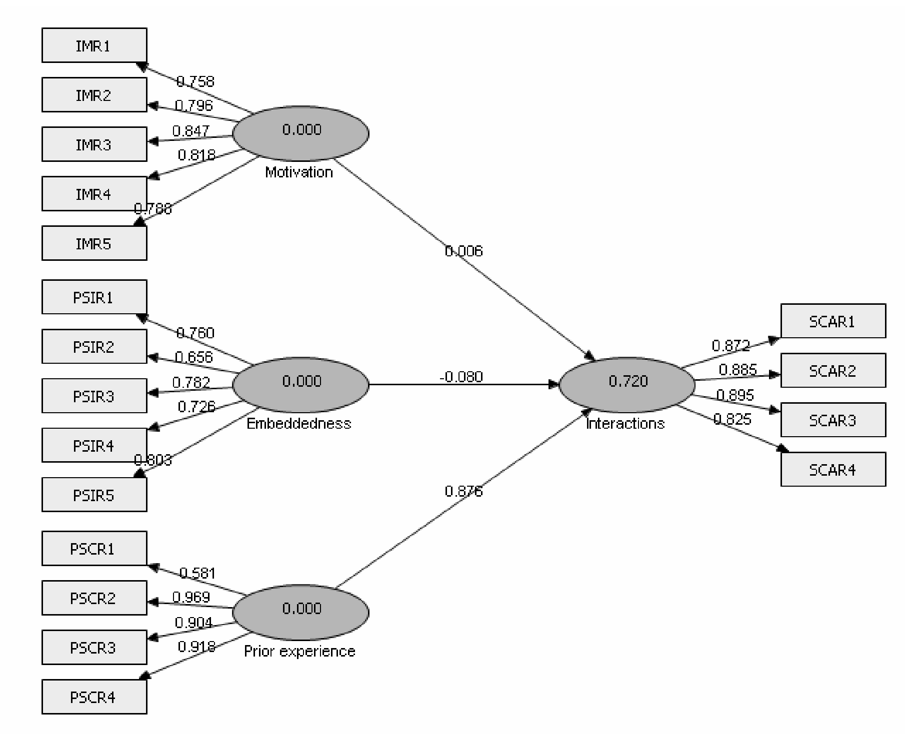

Figure 5-1: Estimated PLS path model

R^2 of endogenous latent variables
The coefficient of determination of the Interactions endogenous latent variable $R^2 = 0.720$ indicates a large effect (Chin, 1998b; Cohen, 1988). The three factors (i.e., Motivation, Embeddedness and Prior Experience) put together can thus explain 72% of the variance in the level of academics' engagement in interactions with industry between September 2009 and September 2010.

Path coefficients
Path coefficients show the influence of one exogenous variable if the effects of other variables are kept constant. Interestingly, if the factors and relationships in the whole model are taken into account, the path coefficients of the Embeddedness and Motivation latent variables become trivial (see Figure 5-1). For Embeddedness, we even observe a negative sign. The negative sign, however, should be interpreted with great caution, as we are likely to deal with a negative suppressor variable. In essence, such variables suppress irrelevant variance in other exogenous variables, by this indirectly allowing for a more concise estimate of the relationship between exogenous and endogenous variables (Lancaster, 1999).

To identify a possible suppressor variable, we estimated the model after removing each of the remaining latent variables, Motivation and Prior Experience, one at a time (Lancaster, 1999). The removal of Motivation did not change the situation, and the path coefficient from Embeddedness to Interactions still remained negative. Consequently, the Motivation latent variable is not likely to cause the suppression effect. However, after removing Prior Experience from the model, the negative coefficients disappeared. We concluded that Prior Experience represents a suppressor variable, and suppresses the irrelevant variance in Embeddedness and Motivation. In other words, Prior Experience explains significant variance in Embeddedness and Motivation not otherwise associated with the level of academics' engagement in interactions with industry. This reduces the common variance between Embeddedness, Motivation and Interactions. Thus, for example, while Embeddedness has a weak positive correlation with Interactions, once all other factors from the model are taken into account, higher Embeddedness scores predict lower Interactions.

Effect size
The analysis of the effect sizes in the complete model clearly shows that the structural relationships in the model are dominated by the presence of the Prior Experience latent variable.

f^2 (Motivation $\rightarrow$ Interactions) = -0.004 (trivial effect)

As f^2 is always higher than 0, the current result may seem illogical. It can be explained by the fact that in PLS, the computation of constructs is not independent of the paths in the structural model, and removing structural paths leads to changes in the values of constructs. Because the values of the constructs are not fixed, they will vary to some degree with the form of the structural model. The effect of Motivation on Interactions can be considered trivial.

f^2 (Embeddedness → Interactions) = 0.03 (weak effect)
f^2 (Prior Experience → Interactions) = 2.182 (very large effect)

Consequently, based on the results of the total sample, Prior Experience (or results of previous interactions by September 2009) proves to be the strongest predictor of academics' interaction with industry between September 2009 and September 2010. However, it does not yet mean that the rest of the factors are not important and should be omitted, as some of the factors may neutralize each other. Therefore, individual effects need to be examined.

Latent variable correlations
In this sub-section, we examine the individual effects of our latent variables. Table 5-3 presented the latent variable correlations and shows that all the proposed predictors of Interactions are positively associated with Interactions. Furthermore, the examined effects are either medium or large (following Cohen's guidelines for the social sciences: small effect size $r = 0.1 - 0.23$; medium $r = 0.24 - 0.36$; large $r = 0.37$ or larger (Cohen, 1988, 1992)). Consequently, with other factors being equal, the proposed predictors of Interactions are highly positively associated with the actual engagement of academics in interactions with industry, thereby confirming our hypotheses.

These findings combined with the results above suggest that, when taken individually, the proposed predictors of Interactions have a medium or large effect on the actual engagement of academics in interactions with industry. Prior Experience proves to be the strongest predictor, while Motivation and Embeddedness play a less important role, though still significant. The data also suggest that, in general, the role of Embeddedness on the level of academics' engagement in interactions with industry is slightly bigger than the one of Motivation. When all taken into account, the effects of these predictors neutralize each other, and most of the predictors (except Prior Experience) do not show a substantial effect on Interactions anymore.

Bootstrapping: Student's t-test for the significance of path model relationships
To identify the confidence intervals for all parameter estimates, we have applied the bootstrap procedure (Davison, Hinkley, & Young, 2003; Efron, Tibshirani, & Tibshirani, 1993; Henseler et al., 2009). We created 500 sub-samples each

containing 184 cases which is equal to the number of cases in the original sample. Table 5-4 presents the results of bootstrapping exercise and allows estimating whether the identified relations hold for the whole population.

Table 5-4: Bootstrapping results

Path coefficient	t-value Bootstrapping	Conclusion
Motivation -> Interactions	0.262	Non-significant
Embeddedness -> Interactions	1.938	Non-significant
Prior Experience -> Interactions	**28.645**	Significant

Critical value $t_{499,\,0{,}975} = 1.972$

The only factor that proves to have a statistically significant influence on Interactions in the total population is Prior Experience. Consequently, the first two hypotheses related to the significant influence of (1) motivation on interactions and (2) embeddedness on interactions can be rejected. The third hypothesis related to the influence of prior experience on interactions proves to be true. As was shown above, Prior Experience explains significant variance in the rest of our anticipated predictors that is not otherwise associated with Interactions. In the next sub-section, we will analyze the influence of Motivation, Embeddedness and Prior Experience while controlling for the hierarchical position, scientific domain and orientation, gender and the country of origin of academics.

5.4.3 Moderating variables

We conducted similar inner and outer model assessments for a number of sub-groups of the sample presented in Table 5-1. No considerable differences were observed between those groups with regard to inner model assessments. Consequently, we can conclude that the employed indicators in general proved to be reliable and valid in all sub-groups. In this section, we examine the correlations between our latent variables when looking at different sub-groups within the sample.

Hierarchical position

In this sub-section, we examine the differences in the role of three predictors between academics from different hierarchical positions. The total sample of academics was split in two parts: (1) PhD candidates ($n_1 = 83$) and (2) academics having a position higher than PhD candidate, i.e., full professors, associate professors, assistant professors, postdocs and other ($n_2 = 101$). The total number of academics in each of the sub-samples satisfies the requirement of the minimum sample size of 50 in our case (Barclay, Higgins, & Thompson, 1995; Henseler et al., 2009).

For both groups, the engagement in interactions with industry proves to be determined by their prior experience ($r_{PE<->INT\_PhD}$ = 0.886**; $r_{PD<->INT\_Higher}$ = 0.833**; correlation is significant at the 0.01 level (1-tailed)), which is in line with the general trend in the whole sample. Considerable differences, however, can be observed with regard to the role of Motivation and Embeddedness between the two groups. While for PhD candidates, Embeddedness has a higher influence on Interactions than Motivation ($r_{MOT<->INT\_PhD}$ = 0.141; $r_{EMB<->INT\_PhD}$ = 0.369**), for the academics from higher levels of hierarchy, it proves to be the other way around ($r_{MOT<->INT\_Higher}$ = 0.340**; $r_{EMB<->INT\_Higher}$ = 0.208*; correlation is significant at the 0.05 level (1-tailed)). Consequently, the role of embeddedness decreases with higher levels of hierarchy, while the role of own motivation increases as academics move up to higher levels of hierarchy.

Scientific orientation

In this sub-section, we examine the differences in the role of three predictors between academics from different scientific orientations. The total sample of academics was split in three parts: (1) academics whose scientific orientation is more basic than applied (n_1 = 66); (2) academics whose scientific orientation is equally basic and applied (n_2 = 61), and (3) academics whose scientific orientation is more applied than basic (n_3 = 57). The total number of academics in each of the sub-samples satisfies the criterion of the minimum required sample size, i.e., 50.

For all three groups, the engagement in interactions with industry proves to be primarily determined by their prior experience ($r_{PE<->INT\_Basic}$ = 0.879**; $r_{PE<->INT\_Equal}$ = 0.846**; $r_{PE<->INT\_Applied}$ = 0.821**), which is again in line with the general trend in the whole sample. The key difference between the three groups refers to the role of Motivation. For the academics whose scientific orientation is more applied than basic, own motivation proves to play a weaker role in determining their actual behavior ($r_{MOT<->INT\_Basic}$ = 0.274*; $r_{MOT<->INT\_Equal}$ = 0.335**; $r_{PE<->MOT\_Applied}$ = 0.118). This difference can be explained by the fact that academics mainly engaged in applied research are per definition predisposed to actively interact with industry, while academics from the first two groups have more ‘freedom’ to decide whether to engage in interactions with industry or not, and therefore motivation plays a greater role for them.

Scientific domain

Depending on the scientific domain, the total sample of academics was split in two parts: (1) academics working in biotechnology (n_1 = 71); and (2) academics working in nanotechnology (n_2 = 65). Although the survey exclusively targeted academics from these two scientific domains, 48 respondents (or 25% of the total sample) reported that they are active within a scientific domain other than bio- or nanotechnology. These respondents were not included in this part of analysis.

Existing research suggests that academics belonging to the same scientific domain have a common set of perceptions or practices that are likely to influence their level of engagement in interactions with industry (D'Este et al., 2007a; Kenney et al., 2004). Although bio- and nanotechnology represent two distinctive domains, the data do not show any considerable differences with regard to the role of specific predictors. For both scientific domains, the level of engagement in interactions with industry proves to be primarily determined by their Prior Experience, followed by Embeddedness and Motivation. The latter two factors prove to play a secondary role, though still significant.

Gender

Existing research also suggests that academics' behavior is likely to be influenced by gender differences (Brooks & Mackinnon, 2001; Corley & Gaughan, 2005; Link, Siegel, & Bozeman, 2007). The total sample was therefore split in two parts: (1) female (n_1 = 52), and (2) male (n_2 = 132) participants. The key difference between the two sub-samples refers to the role of Motivation in influencing the level of engagement in interactions with industry. Interestingly, for male participants, their own motivation plays a greater role in determining their behavior than for their female colleagues ($r_{MOT<->INT\_Female} = 0.171$; $r_{MOT<->INT\_Male} = 0.278^{**}$). Male academics are also less likely to be influenced by the norms and culture of their research department than their female colleagues ($r_{EMB<->INT\_Female} = 0.348^{**}$; $r_{EMB<->INT\_Male} = 0.252^{**}$). Consequently, the data suggests that female academics are more likely to 'go with the flow', while male academics are more likely to demonstrate entrepreneurial traits. Nevertheless, for both genders, prior experience plays a key role in determining whether they will actually engage in interactions with industry or not ($r_{PE<->INT\_Female} = 0.861^{**}$; $r_{PE<->INT\_Male} = 0.844^{**}$).

Country of origin

Finally, we split the academics in two groups depending on whether they are Dutch (n_1 = 122) or foreign-born (n_2 = 62). Foreign-born academics are expected to deal with some extra barriers at their work related to language and culture (Lee, 2004). Greater language proficiency and cultural assimilation are suggested to make them collaborate more easily and more actively participate in interactions with industry. However, our results do not indicate significant differences between Dutch and foreign-born academics with regard to the role of the three predictors on the actual level of engagement in interactions with industry. These results are in line with the findings of Lee (2004) who showed that language and culture of foreign-born academics do not influence the number of collaborations when compared with their 'local' colleagues.

5.5 CONCLUSIONS

Knowing what drives academics to engage in interactions with industry is crucial for designing effective knowledge transfer policies and measures. Existing research suggests that academics' engagement in interactions with industry is primarily determined by three factors such as Motivation, Embeddedness and Prior Experience. In this chapter, we examined to what extent those factors are able to predict academics' behavior, and identified relative weights of each of those factors. In addition, we examined the differences in the role of those factors between academics from different hierarchical positions, scientific orientations and scientific domains, as well as genders and origins.

Our findings suggest that, when examined individually, the three factors (i.e., motivation, embeddedness and prior experience) have a medium or large effect on the actual engagement of academics in interactions with industry. Prior experience clearly proves to be the strongest predictor, while motivation and embeddedness play a secondary role, though still significant. The data also suggest that, in general, the influence of embeddedness on the level of academics' engagement in interactions with industry is slightly bigger than the one of motivation. Consequently, in general, the norms and culture of the research department prove to be slightly more important than academics' own desire to pursue their teaching, research and possibly commercialization interests by actively engaging in university-industry interactions. However, when all taken into account, the effects of the three factors neutralize each other, and factors such as motivation and embeddedness do not show a substantial effect on the actual engagement of academics in interactions with industry anymore.

These findings confirm the results of recent research that suggested that only few academics pro-actively engage in interactions with industry and thereby demonstrate entrepreneurial behavior in a broader sense. For the majority of academics, however, future decisions to interact with industry are based on their past experiences (Audretsch et al., 2010; D'Este et al., 2010). Previous collaboration experiences of an academic are thus crucial in explaining the probability of his or her future engagement in a greater variety of interactions with more industrial partners, with a higher frequency and a larger amount of time spent on interactions (see also D'Este et al., 2007b).

In addition, we examined the role of the three predictors in specific sub-groups and obtained some more detailed results. The role of embeddedness decreases with higher levels of hierarchy, while the role of own motivation increases as academics move up to higher levels of hierarchy. These findings are not surprising as the more senior an academic becomes, the more he or she influences the surrounding environment (e.g., becomes a role model for others, creates norms and shapes culture etc.). These findings are also in line with the results of Bercovitz and Feldman (2008) who suggested that the influence of the chair on the behavior of academics is likely to vary depending on their hierarchical position. Although the role of embeddedness and motivation change with the career cycle, it is still prior experience that primarily determines the academics' level of engagement in interactions with industry. Unlike embeddedness and motivation, the importance of prior experience is less dependent of the career cycle.

For the academics whose scientific orientation is more applied than basic, own motivation proves to play a weaker role in determining their actual behavior than for their 'more basic' colleagues. This difference could be explained by the fact that academics mainly working on applied research are per definition predisposed to actively interact with industry, while academics with a more basic orientation have more 'freedom' to decide whether to engage in interactions with industry or not, and therefore motivation plays a greater role for them.

The results also suggest that for male academics, their own motivation plays a greater role in determining their behavior than for their female colleagues. Male academics are also less likely to be influenced by the norms and culture of their research department than their female colleagues. Consequently, the data suggests that female academics are more likely to 'go with the flow', while male academics are more likely to demonstrate entrepreneurial traits with regard to interaction with industry. Nevertheless, for both genders, prior experience plays a key role in determining whether they will actually engage in interactions with industry or not.

Our results did not indicate significant differences between academics from different scientific domains (biotechnology vs. nanotechnology). Neither did we find differences between Dutch and foreign-born academics with regard to the role of the three predictors on the actual level of engagement in interactions with industry. The latter is in line with the findings of Lee (2004) who showed that language and culture of foreign-born academics do not influence the number of collaborations when compared with their 'local' colleagues.

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6 Searching for moderating effects of positional and dispositional factors

"…we are naive if we think that we can "know it all". But even a small amount of understanding can make a difference."

Anselm Strauss and Juliet Corbin, American sociologists, 1998

In this chapter, we analyze the moderating effects of positional and dispositional factors on academics' social capital activation with industry (Research question 3). Dispositional factors refer to the academics' feelings and abilities such as individual motivation, perceived social influence and perceived ability. Positional factors, in turn, refer to the individual's current position in academia expressed as hierarchical position, scientific orientation and scientific domain. We examine two types of hypotheses. The first set of hypotheses refers to comparing the difference between the moderating effects of positional and dispositional factors with each other. We then move on to examining how the moderating effects of dispositional factors are influenced by positional factors. The results support part of the hypotheses, as well as indicate several reversed effects. Most of the detected effects are small, but worth further examination.

6.1 INTRODUCTION

In the current chapter, we aim to identify moderating factors that influence the transition of the passive mode of entrepreneur's social capital into the active mode. We take the bridging approach to social capital, i.e., we focus on entrepreneur's external ties and on how social capital is used for entrepreneur's own benefit (Adler & Kwon, 2002; Burt, 1992, 1997; De Carolis & Saparito, 2006). The bridging approach thus assists in the explanation of entrepreneur's success in exploitation of opportunities offered by the network (Adler & Kwon, 2002; Leana & Van Buren, 1999). When searching for moderating effects on social capital activation, we need to examine the influence of factors that are likely to increase the academics' inclination to engage in interaction with industry. In this chapter, we examine the influence of two distinctive groups of such factors: dispositional and positional.

In the remainder of this chapter, based on the literature, we first derive a set of positional and dispositional factors that are likely to influence the relationship between passive social capital and social capital activation, and formulate hypotheses. We then examine the proposed moderating effects by means of PLS path modeling and elaborate on the results.

6.2 PROPOSED MODERATORS OF SOCIAL CAPITAL ACTIVATION

We aim to examine the moderating effects on the relationship between passive social capital and social capital activation. As mentioned before, passive social capital refers to the results of the academic's previous interactions with industry expressed as existing networks of relationships, with resources embedded into them. Activated social capital, in turn, implies the actual exploitation of those networks. Existing research suggests that the way social capital was maintained in the past is likely to have a direct influence on social capital activation in the future (Adler & Kwon, 2002). Academics' future decisions to interact with industry are based on their past experiences (Audretsch, Bönte, & Krabel, 2010; Hite, 2005). The past behavior of academics regarding their participation in university-industry interactions generates a strong imprint and leads to an expectation to continue these activities in the future (Bercovitz & Feldman, 2003; D'Este & Patel, 2007a). The nature of academics' engagement in interaction with industry can therefore be thought of as 'inertia', i.e.., once a process of interaction with industry is set into motion and begins generating certain outcomes, this process tends to stay in motion and continue to generate those outcomes (Mahoney, 2000). This leads us to the first hypothesis.

H1: Academic's passive social capital with industry by a certain moment of time is a strong predictor of social capital activation in the future.

However, the strength of the relationship between passive social capital in the past and social capital activation in the future is likely to vary depending on the individual's inclination to engage in the behavior in question (Ajzen, 1991; Burt, 1992; De Carolis & Saparito, 2006). Consequently, when searching for moderating effects on academics' social capital activation with industry, we need to examine the influence of factors that are likely to increase the academics' inclination to interact with industry. Based on the literature, we were able to extract two distinctive groups of such factors: dispositional and positional. Dispositional factors refer to the individual's feelings and abilities regarding the behavior in question (Ajzen, 1987; Chen, Greene, & Crick, 1998; Heider, 1982) and thus literally correspond to the individual's inclination to engage in the behavior in question. Such factors include (1) individual motivation to interact with industry (Audretsch, Bönte, & Krabel, 2010; Goktepe & Mahagaonkar, 2008; Hull, 1988; Lee, 2000; Mansfield, 1995; Meyer-Krahmer & Schmoch, 1998;

Stephan, 1996; Stephan & Levin, 2005; Stern, 2004; Stokes, 1997); (2) the influence of direct social environment, i.e., research group of laboratory (Bercovitz & Feldman, 2003; Cukierman, Fontana, Sarfatti, & Nuova, 2007; D'Este & Patel, 2007a; Kenney & Richard Goe, 2004; Magnusson, McKelvey, & Versiglioni, 2008); and (3) perceived ability to interact with industrial partners (D'Este & Patel, 2007b; Magnusson, McKelvey, & Versiglioni, 2008). Positional factors, in turn, correspond to the individual's current position in academia that can be expressed as the hierarchical position, scientific orientation (basic vs. applied) and scientific domain (Bercovitz & Feldman, 2008; D'Este & Patel, 2007b; Landry, Amara, & Ouimet, 2005; Lazega, Mounier, Jourda, & Stofer, 2006; Zucker & Darby, 1996). These factors are expected to influence the relationship in question by determining the degree of predisposition of academics to engage in interactions with industry.

6.2.1 Moderating effects of positional vs. dispositional factors

Our first proposition is that when disentangling the influence of positional and dispositional factors on the relationship in question, it is reasonable to assume that the moderating effects of the two groups of factors are not equal. In this part of the research, we aim to explore which of the two groups proves to have a stronger moderation effect on the relationship in question, by comparing the moderating effects at different levels and in various combinations. Figure 6-1 presents a conceptual framework for this part of the research.

In the empirical section of this chapter, the following hypotheses will be tested. These hypotheses are of exploratory nature, and aim to enrich our knowledge about the factors influencing social capital activation. First, we will examine the difference between the moderating effects of the whole two groups (two-tailed hypothesis). Given that this is an exploratory part of the research as the existing research does not provide clear explanations, we work with a two-tailed hypothesis without specifying a directional relationship between groups of factors (i.e., without specifying that one particular group of factors is likely to have a higher influence on the relationship in question than another). Identifying a directional relationship will be the output of this analysis.

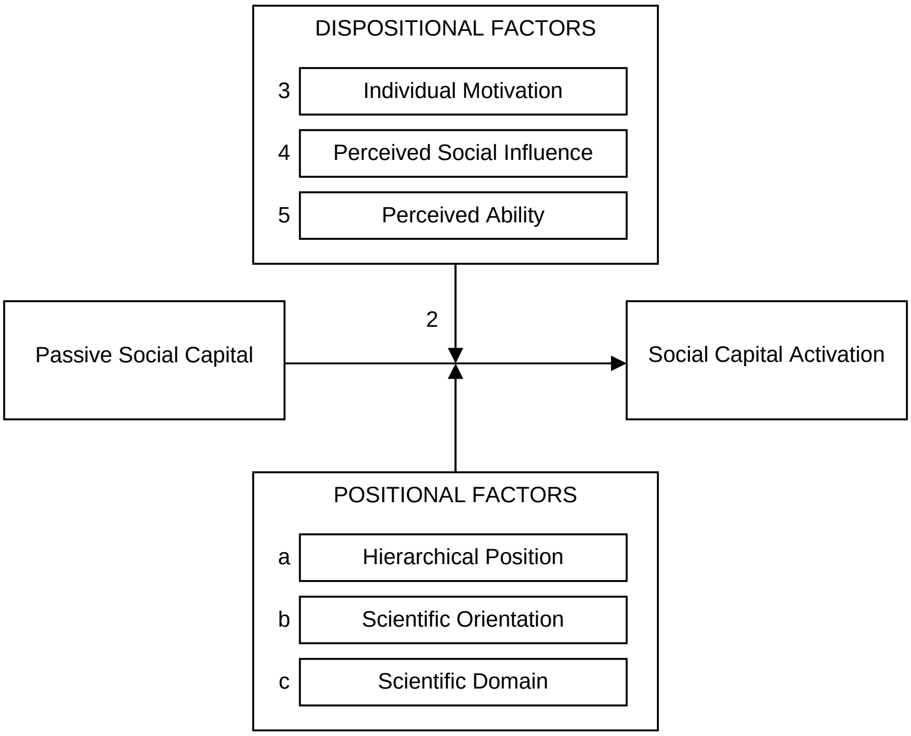

Figure 6-1: Conceptual framework for comparing the moderating effects of positional and dispositional factors

H2: The moderating effects of positional and dispositional factors on the relationship between Passive Social Capital and Social Capital Activation differ significantly.

We will then move on to examining the difference between the moderating effects of each type of dispositional factors with the one of the whole group of positional factors. We will compare separate moderating effects of Individual Motivation (H3), Perceived Social Influence (H4) and Perceived Ability (H5) with the moderating effects of positional factors on the relationship between Passive Social Capital and Social Capital Activation.

Finally, we will confront each dispositional factor with each positional factor, and examine the differences between their moderating effects (H3a – H3c comparing the moderating effects of Individual Motivation and each positional factor; H4a – H4c comparing the moderating effects of Perceived Social Influence and each positional factor; and H5a – H5c comparing the moderating effects of Perceived Ability and each positional factor).

By analyzing the difference between the moderating effects of positional and dispositional factors from different perspectives we aim to obtain a broader view of factors influencing social capital activation.

6.2.2 Moderating effects of dispositional factors influenced by positional factors

Our second proposition is that the academic's inclination to activate social capital with industry (i.e., dispositional factors) depends on his or her current position in academia, i.e., positional factors serve as a catalyst or retardant for dispositional factors to play a role in influencing the relationship in question. Below we derive a set of hypotheses supporting this proposition. Figure 6-2 presents a corresponding conceptual framework. H6 implies the presence of the moderating effect of dispositional factors on the relationship between passive social capital and social capital activation. Below we elaborate on the moderating effects of specific dispositional factors.

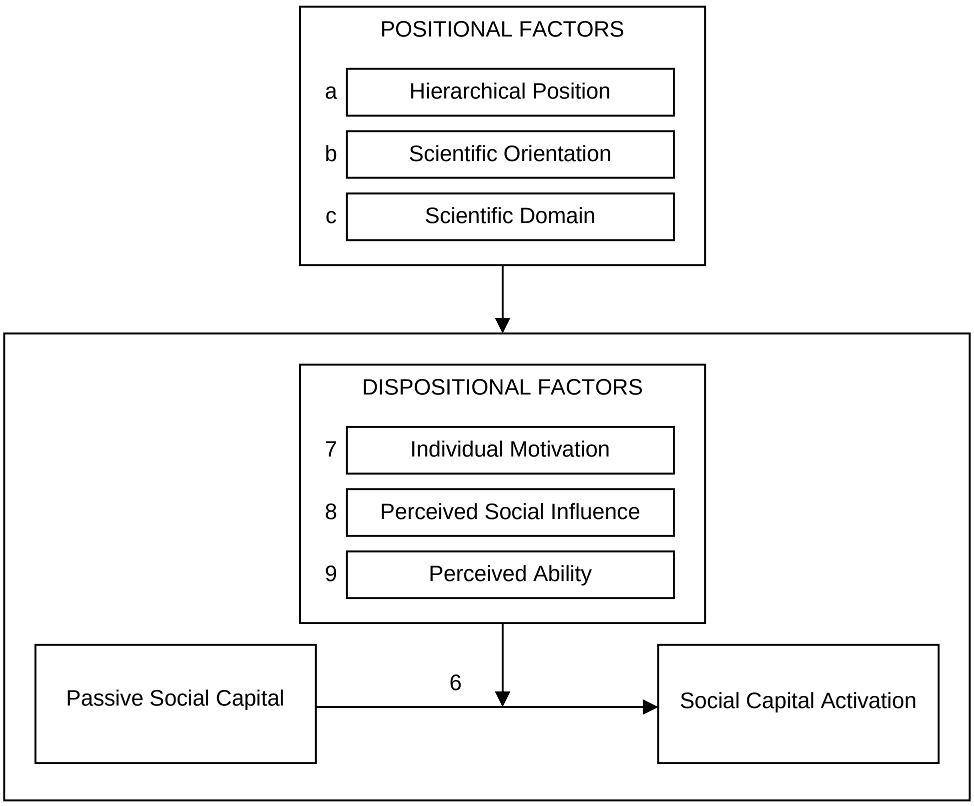

Figure 6-2: Conceptual framework for the role of positional factors as a catalyst/retardant for dispositional factors to play a role in influencing the relationship in question

Individual motivation

Academic's decision to activate his or her social capital with industry is likely to be influenced by his or her individual motivation (Agrawal & Henderson, 2002; Bercovitz & Feldman, 2003; Glaser & Bero, 2005; Lee, 1996; Louis, Blumenthal, Gluck, & Soto, 1989). We define individual motivation as the academics' enthusiasm about interaction with industry, finding it professionally interesting and enjoyable, their interest in and openness towards interaction with industry. Academics' individual motivation to interact with industry is formed by a set of specific motives. Such motives, among others, include the academics' desire to solve practical problems, as well as to get access to industry skills and facilities, to keep abreast of industry problems, and to obtain additional funding (D'Este & Perkmann, 2010; Goktepe & Mahagaonkar, 2008; Gulbrandsen, 2005; Meyer-Krahmer & Schmoch, 1998; Stephan & Levin, 2005; Stern, 2004; Stokes, 1997). We hypothesize that the presence of individual motivation increases the odds of the behavior in question.

H7: The higher the academic's individual motivation to interact with industry, the stronger the relationship between the academic's passive social capital with industry in the past and social capital activation in the future.

It is reasonable to assume that individual motivation can influence academic's decisions in case he or she possesses the sufficient autonomy of decision-making. The latter is closely linked to an academic's hierarchical position (Gaston, 1975; Van Dierdonck, Debackere, & Engelen, 1990). Within a research group, professors are likely to have the highest autonomy regarding their decision to interact with industry, followed by associate professors and assistant professors. In addition, the human capital argument suggests that those individuals who are well established in their academic careers will be more likely to proactively leverage their reputations for commercial gains (Bercovitz & Feldman, 2008; Stephan & Levin, 1992). Young academics, in turn, are suggested to demonstrate a relative lack of participation in decision making (Gaston, 1975), and consequently they are likely to follow their individual motivation to a lesser extent than their senior colleagues.

Furthermore, the autonomy of decision-making regarding interactions with industry is also likely to be related to the academics' scientific orientation, i.e., basic vs. applied research. Academics mainly working on applied research are per definition predisposed to actively interact with industry, while academics with a more basic orientation have more 'freedom' to decide whether to engage in interactions with industry or not (Stokes, 1997), and therefore individual motivation is likely to play a greater role in social capital activation for them. In addition, as introduced by Stokes, there is also a type of research that lies in between purely basic and purely applied research, and that often links semi-autonomous domains of science and technology (Balconi & Laboranti, 2006). Given a relative freedom to decide whether to interact with industry or not, also for this group of academics, the individual motivation is likely to play a more significant role than for academics with a more applied orientation.

Finally, the autonomy of decision-making regarding interactions with industry may also be influenced by the scientific domain. When comparing bio- and nanotechnology, it has been estimated that nanotechnology is currently at the level of development similar to the emergence of biotechnology in 1980s, with biotechnology offering considerably more industrial applications (Miyazaki & Islam, 2007; Roco, 2005). Consequently, academics working in biotechnology are currently more predisposed to working with industry than their nanotechnology colleagues. We can thus assume that for the latter group, given a less compulsory nature of their interactions with industry, individual motivation to interact with industry plays a greater role in moderating social capital activation than for the biotechnology academics.

As a result, the following conditional hypotheses can be formulated.

H7a: For academics from higher hierarchical positions, individual motivation to interact with industry influences the relationship between passive social capital and social capital activation stronger than for academics from lower hierarchical positions.

H7b: For academics with a more basic scientific orientation, individual motivation to interact with industry influences the relationship between passive social capital and social capital activation stronger than for academics with a more applied scientific orientation.

H7c: For academics working in nanotechnology, individual motivation to interact with industry influences the relationship between passive social capital and social capital activation stronger than for academics working in biotechnology.

We now proceed to the next proposed moderator: perceived social influence.

Perceived social influence

Academics' behavior is also suggested to be shaped by the environment in which they are embedded (Bercovitz & Feldman, 2003; Cukierman, Fontana, Sarfatti, & Nuova, 2007; D'Este & Patel, 2007a; Kenney & Richard Goe, 2004; Magnusson, McKelvey, & Versiglioni, 2008). Academics are likely to be affected by local group norms and culture, by group meaning primarily the research department or laboratory within which academics are active (Becher & Kogan, 1992; Goktepe-Hultan, 2008; Kenney & Richard Goe, 2004). Existing research highlights the influence of both peer colleagues and chairs of departments on the academics' actual engagement in interaction with industry (Bercovitz & Feldman, 2003; D'Este & Patel, 2007a; Goktepe-Hultan, 2008; Stuart & Ding, 2006). We thus hypothesize that the presence of perceived social influence increases the odds of the behavior in question.

H8: The higher the perceived social influence to interact with industry, the stronger the relationship between the academic's passive social capital with industry in the past and social capital activation in the future.

The influence of both the chair and peer colleagues on the behavior of academics is likely to vary depending on their hierarchical position. For less senior academics, the chair plays a direct and powerful role in, among others, reviewing and evaluating individual performance related to promotion and tenure (Bercovitz & Feldman, 2008). If the chair is active in interactions with industry, then he or she sends a signal that interaction with industry is a valid activity. In this case, less senior members of the department might be more likely to engage in interaction with industry. Less senior academics are also likely to adopt the behavior of local colleagues, i.e., these colleagues act as role models and, together with the decisions taken within the research group, influence the behavior of individual academics (Goktepe-Hultan, 2008; Stuart & Ding, 2006).

In addition, the influence of chairs and peer colleagues on academics' social capital activation with industry is likely to vary depending on the scientific orientation of the university department. Academics from university departments in which interaction with industry is not a norm are less likely to collaborate with industry than academics from more 'non-traditional' departments (Stuart & Ding, 2006). It is thus reasonable to assume that in departments with more basic scientific orientation, academics will feel less social pressure to interact with industry than in departments with more applied orientation.

Finally, the influence of chairs and peer colleagues on academics' social capital activation with industry may vary depending on the scientific domain. Biotechnology demonstrates a higher degree of maturity of university-industry interactions when compared to nanotechnology (Miyazaki & Islam, 2007; Roco, 2005). Thus, for biotechnology academics, we can expect a stronger imprint of social capital activation with industry into group's norms than for their nanotechnology colleagues. Consequently, perceived social influence in the first case is likely to play a bigger role.

The following conditional hypotheses can thus be formulated.

H8a: For academics from lower hierarchical positions, perceived social influence to interact with industry affects the relationship between passive social capital and social capital activation stronger than for hierarchically more senior academics.

H8b: For academics with a more applied scientific orientation, perceived social influence to interact with industry affects the relationship between passive social capital and social capital activation stronger than for academics with a more basic orientation.

H8c: For academics working in biotechnology, perceived social influence to interact with industry affects the relationship between passive social capital and social capital activation stronger than for academics working in nanotechnology.

We now proceed to the third proposed moderator: perceived ability.

Perceived ability

The decision to activate social capital with industry is also likely to depend on the academic's perceived ability to participate in such interactions. There is a number of skills that academics need to possess in order to succeed in interactions with industry, such the ability to work according to industry standards, integration skills, the ability to cope with contradicting incentive systems etc.(D'Este & Patel, 2007b,; Magnusson, McKelvey, & Versiglioni, 2008; Van Dierdonck, Debackere, & Engelen, 1990). Differences in cultures and incentive systems between academia and industry may thus create a feeling of frustration and insecurity in academics yet considering interactions with industry. We therefore hypothesize that the presence of perceived ability increases the odds of the behavior in question.

H9: The higher the academic's perceived ability to interact with industry, the stronger the relationship between the academic's passive social capital with industry in the past and social capital activation in the future.

The role of perceived ability in academics' social capital activation with industry can first vary depending on their hierarchical position. The higher one is on the academic ladder, the better indication that he or she has shown the capacity to collaborate and attract resources (Lin & Bozeman, 2006). A hierarchical position may also be related to industry experience, especially for those academics actively recruited from industry. It is thus reasonable to assume that, in general, academics from higher hierarchical positions are more likely to be convinced about their ability to interact with industry than their less senior colleagues. The latter may, in turn, prevent less senior academics from actual engagement in university-industry interaction.

In addition, the perceived ability to interact with industry is also likely to depend on a scientific orientation. Academics with a more applied orientation are per definition more predisposed to interaction with industry, and the perceived ability to do it is thus likely to be less of an issue. Academics working in the applied fields must be closely familiar with industry needs (Klevorick, Levin, Nelson, & Winter, 1995) in order to be able to create significantly new designs, concepts, methods and prototypes (Balconi & Laboranti, 2006). For academics doing a more basic research, however, such knowledge and skills are not compulsory, and their absence is likely to hinder academic's interaction with industry.

Finally, we hypothesize that for academics working in biotechnology, perceived ability is likely to have a larger effect on social capital activation than for the academics from the nanotechnology field. This difference can be expected due to the sensitive intellectual property domain related to biotechnology, and the corresponding implications for university-industry projects (Cantor, 2000; Conley & Makowski, 2003; Drahos, 1999). At the same time, nanotechnology represents an emerging field, and the intellectual property domain there is less defined (Bowman, 2007). Consequently, not all academics from the biotechnology field may feel confident when interacting with industry because of IP issues they have to deal with.

This leads us to the next set of conditional hypotheses.

H9a: For academics from lower hierarchical positions, perceived ability to interact with industry influences the relationship between passive social capital and social capital activation stronger than for hierarchically more senior academics.

H9b: For academics with a more basic scientific orientation, perceived ability to interact with industry influences the relationship between passive social capital and social capital activation stronger than for academics with a more applied orientation.

H9c: For academics working in biotechnology, perceived ability to interact with industry influences the relationship between passive social capital and social capital activation stronger than for academics working in nanotechnology.

In this section, we have identified a set of hypotheses to be tested. In the next sections we elaborate on the employed methods and present the results of the analysis.

6.3 METHODS

In this sub-section, we address the aspects of the methodology that specifically refer to the analysis presented in this chapter. For a detailed description of the general methodology, the reader is advised to consult Chapter 3.

6.3.1 Measurement

For the analysis presented in this chapter, only reflective measures were used. Five sets of measures employed in this analysis are as follows. The measures employed for Individual Motivation correspond to IMR1-IMR5 of Annex A. The measures for Perceived Social Influence refer to PSIR1 – PSIR5 of Annex A. The measures employed for Perceived Ability correspond to PAR1-PAR5 of Annex A. Finally, Passive Social Capital and Social Capital Activation measures refer to PSCR1 – PSCR4 and SCAR1 – SCAR4 of Annex A respectively. For a detailed overview of how these measures were developed and how their reflective nature was confirmed, the reader is advised to consult Chapter 3. For positional factors, the measures for Hierarchical Position, Scientific Domain and Scientific Orientation correspond to POS1, POS2 and POS3 of Annex A respectively.

We first assessed the reliability and validity of reflective measures. For all our latent variables, both Cronbach's α (Cronbach, 1951) and the composite reliability ρ_c (Werts, Linn, & Jöreskog, 1974) passed the required threshold of 0.7 (Nunnally & Bernstein, 1978). Consequently, the internal consistency reliability of the employed measures can be regarded as acceptable. The squared loadings confirmed the reliability of our indicators, as most of our latent variables explain more than 50% of each of their indicator's variance (Henseler, Ringle, & Sinkovics, 2009). The only exception refers to PSIR2 ($\lambda^2 = 0.374$) corresponding to the statement "I am under social pressure to collaborate with industry". The reason for a low reliability of this indicator can be explained by a sensitive formulation of the statement corresponding to it. The respondents are likely to perceive "social pressure" in a more negative way than measures related, for instance, to expectations and duty, and the scores obtained for this measure are thus likely to be biased. However, this indicator was not removed from further analysis.

The convergent validity of all our latent variables also proved to be sufficient. All latent variables satisfy the Fornell-Larcker criterion, meaning that they share more variance with their assigned indicators than with each other (Henseler, Ringle, & Sinkovics, 2009). Finally, the loading of each indicator on its assigned latent variable is greater than all of its cross-loadings (Chin, 1998b) for all our indicators. Consequently, proposed measurement models proved to be reliable and valid.

As for positional variables, those were assigned points that ascend with a higher likelihood of a certain position to support academic's social capital interaction with industry. For hierarchical position: PhD students were assigned 1 point with an increase of 1 point for each next level up to 5 points for full professor. Similarly, Purely Basic Scientific orientation was assigned 1 point, while Purely Applied Scientific orientation received 5 points. Finally, for the scientific domain, Nanotechnology was assigned 1 point, and Biotechnology corresponded to 2 points, as Nanotechnology is a newer technology when compared to Biotechnology; and the latter has a significantly closer link to the market than the first one (Mehta, 2004; Bowman, 2007).

6.3.2 Sample and Procedures

For a detailed description of sample and procedures, the reader is advised to consult Chapter 3. The analysis presented in this chapter was conducted using the PLS path modeling in SmartPLS. The PLS path modeling methodology was chosen as it implies no distributional assumptions, it is appropriate for a small sample size, it is robust with different scale types, and it allows for the analysis of moderating effects for reflective constructs (Henseler, Ringle, & Sinkovics, 2009).

Since the measurement models of both the independent and the moderator variables are reflective, the moderating effects were analyzed by means of product-indicator approach (see Chin, Marcolin, & Newsted, 2003; Henseler & Chin, 2010; Kenny & Judd, 1984). The approach implied building product terms using the indicators of the independent latent variable (in our case, passive social capital) and the indicators of the moderator latent variable (in our case, individual motivation, perceived social influence and perceived ability). These product terms then served as indicators of the interaction term in the structural model (Henseler & Chin, 2010). The indicator values were standardized before multiplication.

Table 6-1: Sample characteristics based on positional factors

Positional factor	**1. Hierarchical position**		
Sub-groups	High (Full professors and Associate professors); a_1	Medium (Assistant professors, Postdocs, Other); a_1	Low (PhD candidates); a_2
n	47	53	83
%	26	29	45
Positional factor	**2. Scientific orientation**		
Sub-groups	More Basic than Applied; b_1	Equally Basic and Applied; b_2	More Applied than Basic; b_3
n	66	61	57
%	36	33	31
Positional factor	**3. Scientific domain**		
Sub-groups	Biotechnology; c_1	Nanotechnology; c_2	Other; c_3
n	71	65	47
%	39	36	25

For the first proposition, in total, 24 path models were created corresponding to all relevant groups of respondents for each hypothesis, or 8 path models for each of the proposed moderators, (see Table 6-1, groups a_1 – a_2; b_1 – b_3; c_1 – c_3). In addition, 8 path models were created without moderating effects. In case of hierarchical position, the original three groups were merged into two: PhD candidates (n_1 = 83) and academics having a position higher than PhD candidate, i.e., full professors, associate professors, assistant professors, postdocs and other (n_2 = 101). As a result, the total number of academics in each of the groups satisfied the requirement of the minimum sample size (Barclay, Higgins, & Thompson, 1995; Henseler, Ringle, & Sinkovics, 2009). The analysis was conducted following the algorithm by Henseler et al. (Henseler & Chin, 2010; Henseler & Fassott, 2010). Effect sizes of 0.02, 0.15 and 0.35 were regarded as weak, moderate and strong respectively (Cohen, 1988). To identify the confidence intervals for all parameter estimates, we have applied the bootstrapping procedure (Davison, Hinkley, & Young, 2003; Efron, Tibshirani, & Tibshirani, 1993; Henseler, Ringle, & Sinkovics, 2009). We created 500 sub-samples each containing the number of cases equal to the number of cases in the original sample. In the next section, we interpret the results of the PLS path modeling.

For the second proposition, in total, 13 path models were created corresponding to each of the exploratory hypotheses presented in the theoretical section. The data used for analysis in this sub-section refers to the whole sample.

6.4 RESULTS

In this section, we analyze under which circumstances the proposed moderating effects are strong or weak. We first examined the strength of the relationship between passive social capital (i.e., social capital characteristics corresponding to the results of previous interactions by September 2009) and social capital activation (actual interactions between September 2009 and September 2010). In all path models (see Table 6-2), the coefficients of determination of social capital activation indicate either moderate-strong or strong effects (Chin, 1998b; Cohen, 1988). The coefficients of determination without moderating effects are also either moderate or strong. The results therefore confirm H1 that academic's passive social capital with industry by a certain moment of time explains a significant portion of variance in social capital activation in the future.

Table 6-2: Coefficients of determination

Group	R^2 without moderator	R^2 with moderator H2	R^2 with moderator H3	R^2 with moderator H4
a_1 (Higher)	0.560^	0.574^	0.587^	0.570^
a_2 (PhD)	0.703^^	0.707^^	0.703^^	0.713^^
b_1 (Basic)	0.753^	0.756^^	0.756^^	0.775^^
b_2 (Equal)	0.544^	0.588^	0.564^	0.572^
b_3 (Applied)	0.604^	0.599^	0.624^	0.624^
c_1 (Bio)	0.612^	0.646^	0.701^^	0.679^^
c_2 (Nano)	0.628^	0.676^^	0.603^	0.770^^
c_3 (Other)	0.729^^	0.748^^	0.732^^	0.741^^

^^ - strong (values of 0.67, 0.33 and 0.19 correspond to strong, moderate and weak, see Chin, 1998b)

^ - moderate-strong

6.4.1 Moderating effects of positional vs. dispositional factors

The objective of this part of analysis was to test whether the difference between the moderating effects of positional and dispositional factors is significant. We begin by comparing the moderating effects of the whole two groups. Figure 6-3 visualizes the estimated path model for product-indicator approach for H2.

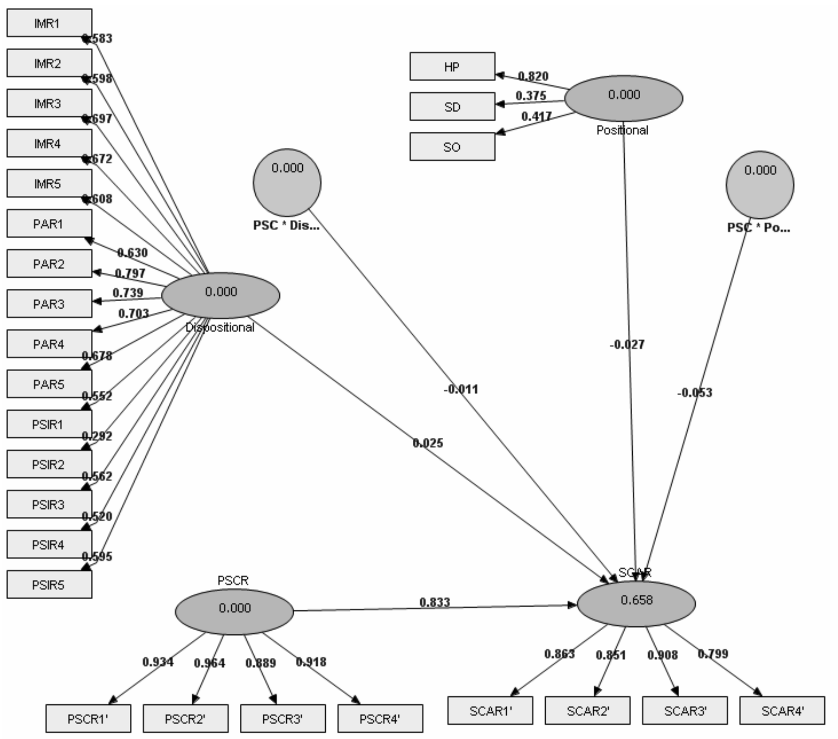

Figure 6-3: Estimated path model for product-indicator approach for the moderating effects of positional and dispositional factors

The analysis was conducted by bootstrapping the difference between two path coefficients corresponding to the moderating effects of positional and dispositional factors. We created 500 sub-samples each containing the number of cases equal to the number of cases in the original sample. We then calculated 500 differences between the moderating effects in question and obtained the standard deviation of those differences. Finally, a t-value was calculated by dividing the original difference ($\beta_4^* - \beta_5^*$ = 0.042; where β_4^* = -0.011; and β_5^* = -0.053) by the standard deviation of bootstrapped differences (sd($\beta_4^* - \beta_5^*$ $_{\text{bootsrt}}$) = 0.080). A t-value of 0.52 ($t_{0.05,\ 499}$ = 1.96) was obtained indicating the absence of a significant difference between the two moderating effects in question. As a result, H2 was rejected. These results can be explained by a large variety of factors included in the model, and the tendency of these factors to neutralize the effects of each other when they are all taken into account.

To decrease the neutralizing effects, we have additionally conducted a similar type of analysis, but each time exclusively looking at the moderating effect of one type of dispositional factors (IMR, PSIR or PAR) vs. the original set of positional factors (H3 – H5). The results of this analysis are presented in Table 6-3. No significant differences in moderating effects were identified.

Table 6-3: Statement of null hypotheses and results for one type of dispositional factors vs. positional factors

Hypothesis	β_4^*	β_5^*	$\beta_4^* - \beta_5^*$	Sd $(\beta_4^* - \beta_{5\,bootstr.}^*)$	Significance test ($t_{0.05,\,499} = 1.96$)	
					t value bootstrap	Interpretation
H3$_0$: The moderating effects of *Individual Motivation* and positional factors on the relationship between Passive Social Capital and Social Capital Activation do not differ significantly.	0.017	-0.058	0.075	0.095	0.790	The difference between the moderating effects does not differ from 0
H4$_0$: The moderating effects of *Perceived Social Influence* and positional factors on the relationship between Passive Social Capital and Social Capital Activation do not differ significantly.	-0.015	-0.057	0.042	0.089	0.471	The difference between the moderating effects does not differ from 0
H5$_0$: The moderating effects of *Perceived Ability* and positional factors on the relationship between Passive Social Capital and Social Capital Activation do not differ significantly.	-0.025	-0.058	0.033	0.092	0.357	The difference between the moderating effects does not differ from 0

The absence of significant differences between the moderating effects was also confirmed when comparing each type of dispositional factors with each type of positional factors (H3a – H3b, H4a – H4b, H5a – H5b). Table 6-4 presents the results of this analysis.

Table 6-4: Statement of hypotheses and results for each type of dispositional factors vs. each type of positional factors

Hypothesis	β_4^*	β_5^*	$\beta_4^* - \beta_5^*$	Sd $(\beta_4^* - \beta_{5\,bootstr.}^*)$	Significance test ($t_{0.05,\,499} = 1.96$)	
					t value bootstr.	Interpretation
H3a$_0$: The moderating effects of *Individual Motivation* and *Hierarchical Position* on the relationship between Passive Social Capital and Social Capital Activation do not differ significantly.	0.019	-0.096	0.115	0.084	1.364	The difference between the moderating effects does not differ from 0

Hypothesis	β_4^*	β_5^*	$\beta_4^* - \beta_5^*$	**Sd** $(\beta_4^* - \beta_{5\,bootstr.}^*)$	**Significance test ($t_{0.05,\,499}$ = 1.96)**	
					***t* value bootstr.**	**Interpretation**
H3b$_0$: The moderating effects of *Individual Motivation* and *Scientific Orientation* on the relationship between Passive Social Capital and Social Capital Activation do not differ significantly.	0.039	-0.114	0.153	0.095	1.613	The difference between the moderating effects does not differ from 0
H3c$_0$: The moderating effects of *Individual Motivation* and *Scientific Domain* on the relationship between Passive Social Capital and Social Capital Activation do not differ significantly.	0.010	-0.141	-0.131	0.077	1.706	The difference between the moderating effects does not differ from 0
H4a$_0$: The moderating effects of *Perceived Social Influence* and *Hierarchical Position* on the relationship between Passive Social Capital and Social Capital Activation do not differ significantly.	-0.014	0.085	0.071	0.085	0.838	The difference between the moderating effects does not differ from 0
H4b$_0$: The moderating effects of *Perceived Social Influence* and *Scientific Orientation* on the relationship between Passive Social Capital and Social Capital Activation do not differ significantly.	0.009	-0.108	0.117	0.113	1.033	The difference between the moderating effects does not differ from 0
H4c$_0$: The moderating effects of *Perceived Social Influence* and *Scientific Domain* on the relationship between Passive Social Capital and Social Capital Activation do not differ significantly.	-0.019	0.137	0.118	0.081	1.461	The difference between the moderating effects does not differ from 0
H5a$_0$: The moderating effects of *Perceived Ability* and *Hierarchical Position* on the relationship between Passive Social Capital and Social Capital Activation do not differ significantly.	-0.037	0.088	0.051	0.096	0.532	The difference between the moderating effects does not differ from 0

Hypothesis	β_4^*	β_5^*	$\beta_4^* - \beta_5^*$	Sd $(\beta_4^* - \beta_{5\,bootstr.}^*)$	Significance test ($t_{0.05,\,499} = 1.96$)	
					t value bootstr.	Interpretation
H5b$_0$: The moderating effects of *Perceived Ability* and *Scientific Orientation* on the relationship between Passive Social Capital and Social Capital Activation do not differ significantly.	0.012	-0.110	0.122	0.106	1.154	The difference between the moderating effects does not differ from 0
H5c$_0$: The moderating effects of *Perceived Ability* and *Scientific Domain* on the relationship between Passive Social Capital and Social Capital Activation do not differ significantly.	-0.026	0.130	-0.156	0.087	1.793	The difference between the moderating effects does not differ from 0

Consequently, no significant differences were found between the moderating effect of each type of dispositional factors and the one of positional factors. Such results can be explained by a low significance of all of the examined moderating effects themselves which, in turn, makes the difference between these effects less likely to be significant for the relationship in question. Furthermore, the abovementioned effects were tested based on the whole sample without taking into account its high level of heterogeneity. In order to minimize these limitations, the moderating effects of dispositional factors need to be tested through the prism of positional factors thereby addressing the issue of heterogeneity of academics and increasing the likelihood of detecting significant effects. The latter approach will be applied in the second part of the analysis presented in this chapter.

6.4.2 The role of positional factors in influencing the moderating effect of dispositional factors

We now examine the results related to each of the conditional hypotheses of the first proposition (see Table 6-5 for the key outputs of the analysis). The moderating effect of individual motivation on the relationship between passive and activated social capitals was not confirmed for academics from both lower and higher hierarchical positions, thus rejecting H7a. Interestingly, no moderation effect of individual motivation was detected for academics whose scientific orientation is more basic than applied. The results thus suggest that for academics who are per definition less predisposed to interact with industry, actual interactions occur without significant influence of their own motivation on it.

These results are somewhat surprising, since for those academics, interaction with industry is not a compulsory task, and one might expect that own willingness to do it plays a crucial role. The moderating effect of individual motivation was detected though for academics whose scientific orientation is equally basic and applied. We hypothesized that given a relative freedom to decide whether to interact with industry or not, also for this group of academics, the individual motivation is likely to play a more significant role than for academics with a more applied orientation. The detected effect holds for the population. H7b was therefore partly confirmed. H7c related to the role of scientific orientation was confirmed too. However, the reversed effect of individual motivation was detected for nanotechnology academics. For this group, lower values of motivation prove to strengthen the relationship in question, which represents a somewhat illogical finding. The detected effect did pass the significance test and proved to hold for the whole population. Consequently, for the nanotechnology field, academics' engagement in interaction with industry is likely to be driven by factors other than their genuine enthusiasm about university-industry collaboration. Given that the detected effect is not large, we can assume that it is a side-effect of other more powerful predictors of the behavior in question.

We now move on to the results related to the role of perceived social influence. A moderating effect of perceived social influence was detected for academics from higher hierarchical positions, representing an effect opposite to the one we predicted in H8a. The detected effect holds for the whole population. Consequently, perceived social influence proves to have a negative effect on academics with hierarchical positions higher than PhD. This result can be explained by the fact that academics from higher levels of hierarchy possess more decision-making autonomy. We can assume that they are not only likely to be less affected by their peer colleagues and chair than their junior colleagues, but they also may 'dare' to go against the common rules and norms of their research group. Interestingly, no moderating effect was detected for PhD candidates. H8b related to the larger role of perceived social influence for academics with a more applied scientific orientation was confirmed. The effect was also detected for academics whose scientific orientation is equally basic and applied. However, the latter is weaker than for the first group. As for H8c, the role of perceived social influence proved to be stronger for academics from the biotechnology field. However, the coefficient of the interaction term had a large standard error that produced a poor t-statistic despite the high absolute value of the coefficient estimate. As a result, the detected effect did not pass the significance test, and thus cannot be generalized to the whole population.

Finally, no moderating effects of perceived ability were detected for academics from both higher and lower hierarchical positions. Consequently, H9a was not confirmed. When examining the same effect but for academics from different scientific orientations, the effect was confirmed in all three groups (i.e., more basic, equally basic and applied, and more applied than basic). As predicted, for academics with a more basic scientific orientation, the perceived ability to interact with industry influences the relationship between passive social capital and social capital activation stronger than for academics with a more applied orientation. H9b was therefore confirmed. H9c related to a greater role of perceived ability for biotechnology academics was also confirmed. The effect proved to be moderate in size.

As a result, five out of nine conditional hypotheses were confirmed. Three hypotheses were partially supported by the data from the sample, but did not withstand the significance test for the whole population. For one hypothesis, a reversed effect was detected.

Table 6-5: Statement of hypotheses and results

Hypothesis	Group	β_3^*	Effect size f^2	Significance test ($t_{0.05,\ 499}$ = 1.96): t value	Significance test ($t_{0.05,\ 499}$ = 1.96): Interpretation	Conclusion
H7a: For academics from higher hierarchical positions, the individual motivation to interact with industry influences the relationship between passive social capital and social capital activation stronger than for academics from lower hierarchical positions.	a_1 (Higher)	0.088	0.033 (weak)	1.073	path does not differ from 0	Not confirmed. The effect did not pass the significance test.
	a_2 (PhD)	0.029	0.014	0.378	path does not differ from 0	
H7b: For academics with a more basic scientific orientation, the individual motivation to interact with industry influences the relationship between passive social capital and social capital activation stronger than for academics with a more applied scientific orientation.	b_1 (Basic)	-0.003	0.012	0.068	path does not differ from 0	Partially confirmed. The effect holds for academics whose scientific orientation is equally basic and applied. No moderation effect detected for academics with a more basic orientation.
	b_2 (Equal)	0.170	0.110 (weak)	2.388	**path does differ from 0**	
	b_3 (Applied)	0.086	-0.012 (0)	1.305	path does not differ from 0	
H7c: For academics working in nanotechnology, individual motivation to interact with industry influences the relationship between passive social capital and social capital activation stronger than for academics working in biotechnology.	c_1 (Bio)	0.213	0.096 (weak)	2.173	**path does differ from 0**	Confirmed, however the reversed effect of motivation was detected for nanotechnology academics. Lower values of motivation strengthen the relationship in question.
	c_2 (Nano)	-0.247	0.148 (mod.)	3.800	**path does differ from 0**	
	c_3 (Other)	0.118	0.075 (weak)	3.278	**path does differ from 0**	
H8a: For academics from lower hierarchical positions, the perceived social influence to interact with industry affects the relationship between passive social capital and social capital activation stronger than for hierarchically more senior academics.	a_1 (Higher)	-0.197	0.065 (weak)	3.356	**path does differ from 0**	Not confirmed, but reversed effect detected. Perceived social influence proved to affect social capital activation for academics from senior positions.
	a_2 (PhD)	-0.011	0	0.276	path does not differ from 0	
H8b: For academics with a more applied scientific orientation, the perceived social influence to interact with industry affects the relationship between passive social capital and social capital activation stronger than for academics with a more basic orientation.	b_1 (Basic)	-0.051	0.012	1.253	path does not differ from 0	Confirmed. The moderation effect was detected for academics with both equally basic and applied, and applied orientation. The effect is stronger for the latter group.
	b_2 (Equal)	0.158	0.046 (weak)	2.520	**path does differ from 0**	
	b_3 (Applied)	0.235	0.053 (weak)	3.638	**path does differ from 0**	

					Significance test ($t_{0.05,\ 499}$ = 1.96)	
H8c: For academics working in biotechnology, perceived social influence to interact with industry affects the relationship between passive social capital and social capital activation stronger than for academics working in nanotechnology.	c_1 (Bio)	0.332	0.298 (mod.)	1.074	path does not differ from 0	Not confirmed in the population. The coefficient of the interaction term has a large standard error that produces a poor t-statistic despite the high absolute value of the coefficient estimate.
	c_2 (Nano)	0.015	0	0.183	path does not differ from 0	
	c_3 (Other)	0.021	0.011	0.309	path does not differ from 0	
H9a: For academics from lower hierarchical positions, the perceived ability to interact with industry influences the relationship between passive social capital and social capital activation stronger than for hierarchically more senior academics.	a_1 (Higher)	0.052	0.023 (weak)	0.422	path does not differ from 0	Not confirmed. The effect did not pass the significance test.
	a_2 (PhD)	-0.107	0.034 (weak)	1.055	path does not differ from 0	
H9b: For academics with a more basic scientific orientation, the perceived ability to interact with industry influences the relationship between passive social capital and social capital activation stronger than for academics with a more applied orientation.	b_1 (Basic)	-0.186	0.097 (weak)	4.208	**path does differ from 0**	Confirmed. The moderation effect was detected in all three groups, but it proved to increase with a more basic scientific orientation.
	b_2 (Equal)	-0.186	0.065 (weak)	2.957	**path does differ from 0**	
	b_3 (Applied)	0.223	0.053 (weak)	2.569	**path does differ from 0**	
H9c: For academics working in biotechnology, perceived ability to interact with industry influences the relationship between passive social capital and social capital activation stronger than for academics working in nanotechnology.	c_1 (Bio)	0.269	0.209 (mod.)	3.057	**path does differ from 0**	Confirmed. The moderation effect in the whole population was detected only for biotechnology academics, and was moderate in size.
	c_2 (Nano)	-0.347	0.617 (str.)	1.222	path does not differ from 0	
	c_3 (Other)	-0.016	0.046 (weak)	0.292	path does not differ from 0	

6.5 CONCLUSIONS

Academics' passive social capital with industry by a certain moment of time proved to be a strong predictor of social capital activation in the future. Our results confirmed that academics' future decisions to interact with industry are based on their past experiences (see also Audretsch, Bönte, & Krabel, 2010; Hite, 2005). We empirically showed that the past behavior of academics regarding their participation in university-industry interactions generates a strong imprint and leads to an expectation to continue these activities in the future. These results are also in line with the arguments by Bercovitz & Feldman (2003) and D'Este & Patel (2007a). In addition, we showed that all three dispositional factors (i.e., academic's individual motivation to interact with industry, perceived social influence and perceived ability) proved to be moderators of the relationship in question. As predicted, the effects of these moderators proved to vary depending on academics' positional factors such as hierarchical position, scientific orientation and scientific domain. Although most of the detected moderating effects are small, they can still be meaningful in explaining the entrepreneurial behavior in question (Chin, Marcolin, & Newsted, 2003).

We examined under which circumstances entrepreneurial academics decide to exploit opportunities provided by their social capital with industry. We analyzed previously unexplored moderating effects of dispositional factors such as academics' individual motivation to interact with industry, as well as perceived influence from their direct social environment and their perceived ability. No significant differences were found between the moderating effects of positional and dispositional factors. A possible explanation for these results refers to a low significance of all of the examined moderating effects themselves which, in turn, makes the difference between these effects less likely to be significant for the relationship in question. Furthermore, testing the exploratory hypotheses based on the whole sample does not take into account the issue of high heterogeneity of academics, thereby decreasing the likelihood of detecting significant effects. One of the ways to minimize these limitations is to test the moderating effects of dispositional factors through the prism of positional factors, as was presented in the first part of the analysis in this chapter. Although the effects detected by the second approach are small, they prove to be significant and are worth further examination.

Our empirical results confirmed that since entrepreneurial academics represent a highly heterogeneous population, the strength of the relationship in question and the abovementioned moderating effects depends on a number of positional characteristics. We were able to identify the influence of hierarchical position, scientific orientation and scientific domain.

A lack of impact of motivational dimension on the behavior of academics from higher hierarchical positions was also suggested by Lee (2000). In addition, contrary to our predictions, for the same group of academics, the perceived social influence to interact with industry proved to affect the relationship between passive social capital and social capital activation in a negative way. These findings can be explained by the fact that professors and other senior academics often already have their "own agenda" with regard to their teaching, research and commercialization activities, and a more powerful position in academia and in the network with industry (Van Dierdonck, Debackere, & Engelen, 1990). As a result, they may 'dare' to go against the accepted norms of the research group they are in.

Our results also suggest that for academics with a more basic scientific orientation, interactions with industry occur without significant influence of their own motivation on it. The moderator role for this group of academics proves to belong to their perceived ability to interact with industry. Consequently, motivation may be an important factor, but it is not sufficient for behavior to occur. The perceived ability is needed, which, among others, is associated with the academics' ability to work according to industry standards, operate with a wide bodies of knowledge, balance conflicting interests of incentive systems between academia and industry, and have a good understanding of practical applicability of scientific concepts. These findings are in line with Lockett et al. (2005) who argued that many academics who are willing to commercialize their research do not have the necessary capabilities to do so. Therefore it is important to differentiate between the academics who are willing to engage in entrepreneurial activities and the ones who are capable of doing it (Magnusson, McKelvey, & Versiglioni, 2008). In addition, our findings show that especially for academics with a more basic orientation, perceived ability plays a more important role in moderating the behavior in question than their own motivation.

To our knowledge, this study represents the first attempt to introduce the notion of passive and active modes of social capital to the entrepreneurship literature. It presents social capital as a dynamic asset that is itself an exogenous force. Our results confirm that decisions an academic faces with regard to interaction with industry are determined by the decisions he or she has made in the past (Audretsch, Bönte, & Krabel, 2010; D'Este & Perkmann, 2010). These findings are in line with the suggestion of various scholars that many crucial social phenomena can be adequately explained only in terms of prior experience (Aminzade, 1992; Griffin, 1992, 1993; Isaac, 1997; Mahoney, 2000; McDonald, 1996; Somers, 1998; Tilly, 1988).

Our results also suggest that one of the key moderators of academics' social capital activation with industry refers to their perceived ability to do so. This effect holds for academics with all scientific orientations, i.e., more basic than applied, equally basic and applied, and more applied than basic. Consequently, policy makers and university administrators wishing to design public policies and measures that effectively stimulate university-industry interactions need to invest in academics' skills related to these activities. Such measures imply, among others, soft skill trainings and coaching programs, as well as assistance by more experienced colleagues.

Finally, the results suggest that once academics start interacting with industry and if these interactions start delivering increasing benefits, the process of interaction with industry obtains the properties of inertia. Once they are in, there is a great chance they will continue doing so in the future. The key challenge is therefore not to make sure that academics keep collaborating with industry, but to make sure they 'enter the playing field'. Policies and measures building on prior experience thus need to aim at creating opportunities for newcomers to get involved in projects with industry. The assistance and reputation of their more experienced colleagues and supervisors is crucial for linking them with industrial partners.

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7 Examining the role of trigger

"Ideas pull the trigger, but instinct loads the gun."
Don Marquis (1878-1937), American writer and poet

So far we have examined the role of all factors presented in the theoretical chapter but one: trigger. In this chapter we analyze how trigger influences the relationship between passive social capital and social capital activation (Research question 4). We develop and test two sets of hypotheses. The first set models the trigger as a moderator of the relationship in question, while the second set presents the trigger as a mediator in the same relationship. Thereby we aim to improve our understanding of the antecedents of social capital activation. The empirical results, however, indicate the absence of most of the proposed effects. The role of the trigger in the actual 'triggering' of social capital activation proves to be insignificant also when analyzing the abovementioned effects for specific sub-groups (i.e., academics with various hierarchical positions, scientific domains and scientific orientations). We conclude this chapter with our interpretation of the obtained results and offer suggestions for future studies.

7.1 INTRODUCTION

The trigger here refers to an idea, event, action or occasion that serves as a reason for social capital activation to occur. The notion of trigger is partially comparable to the idea of opportunity recognition from the entrepreneurship literature (see Baron & Ensley, 2006; Krueger Jr & Dickson, 1994; Ozgen & Baron, 2007; Singh, 2000), with one key difference. While opportunity recognition refers to cognitive processes through which individuals identify meaningful patterns in complex arrays of events or trends (Baron et al., 2006), the notion of trigger applies to both planned and unplanned behaviors, and thus represents a broader concept. Social capital activation can be considered planned in cases when a triggering idea, event, action or occasion make an individual initiate an interaction. For example, an academic proactively approaches an industry representative because a large governmental program issued a new call for tenders, and reciprocal exchange of resources occurs between both actors. In this case, a new call for tenders serves as a trigger for an academic to initiate an interaction, and academic's behavior is the result of noticing connections between seemingly independent events and detecting meaningful patterns in these connections. At the same time, the behavior can also be unplanned when the initiative to start an interaction comes from an interaction partner. Such initiative serves as a triggering event for an academic to activate his or her social capital with industry in an unplanned way, without his or her own cognitive efforts. Social capital activation can thus be considered a result of unplanned behavior to extent that it might be caused by triggers that are beyond individual's control while an individual is still potentially ready for this behavior.

The notion of trigger originates from Shapero's Model of Entrepreneurial Event (Krueger, Reilly, & Carsrud, 2000; Shapero, 1982) and is argued to be an imperative component of a broad range of entrepreneurial behaviors. In this chapter, we aim to empirically examine the role of the trigger in the process of academics' social capital activation with industry. We analyze two types of possible effects that the trigger can have on the relationship between passive social capital and social capital activation. We first model the trigger as a moderator variable, and analyze how its presence influences the relationship in question for academics from various hierarchical positions, scientific domains and orientations. We then model the trigger as a mediator variable partially resulting from passive social capital, and examine how much variance in social capital activation can be explained by this mediation. Also here we compare the results of academics from various hierarchical positions, scientific domains and orientations.

7.2 THEORETICAL BACKGROUND

In this section, we first derive a set of hypotheses on possible moderating effects of the trigger and then move on to the mediation aspects.

7.2.1 Hypotheses for moderating effects

When viewing the trigger as a moderator of social capital activation, the following analogy can be drawn. Social capital activation can be compared with making a fire, where passive social capital would represent dry wood and trigger would play the role of matches. As mentioned in the theoretical chapter, various types of triggers can be identified. First, an academic him- or herself may spot ideas that are potentially interesting for industry (D'Este & Perkmann, 2010). Second, an academic may get an opportunity to be connected with industry by the head of research group/peer colleagues/academic research partners (Lazega, Mounier, Jourda, & Stofer, 2006). Third, industry representatives may approach an academic directly (David & Metcalfe, 2008). Finally, academics can also be offered to get connected to industry by third parties such as university-industry match-making services provided by governmental agencies, as well as cluster organizations, TTOs etc. (Goktepe-Hultan, 2008). The occurrence of these situations is likely to increase the chance that an academic will activate his or her social capital with industry, as these are all certain reasons for such behavior to occur. This leads us to the first hypothesis.

H1: The higher the trigger to interact with industry, the stronger the relationship between the academic's passive social capital with industry in the past and social capital activation in the future.

However, the trigger in this case does not guarantee the actual behavior since in each specific case, first a decision needs to be taken whether the reason is sufficient for behavior to occur. For example, an academic may identify ideas that are potentially interesting for industry, but he or she may see it as an insufficient reason for proactively initiating an interaction with industry. Similarly, an academic may be offered to get connected to industry by his colleagues or third parties, but it does not yet guarantee that he or she will pursue this opportunity. Finally, even if an academic is already approached by industry, for example, by means of an email, it is his or her decision whether reciprocal exchange of (information) resources (i.e., social capital activation) will occur or not. Consequently, the trigger predisposes an academic to activate social capital with industry, but it does not guarantee the behavior.

Existing research also suggests that university-industry collaborations are often initiated by industry representatives (David et al., 2008). Instead of academics or university administrators approaching firms with proposals to engage in particular research projects, the research directors of companies often take the initiative of approaching the potential academic partners to discuss a collaboration opportunity. Therefore, in our empirical section, we will examine if this particular type of trigger demonstrates a strong effect on the relation between passive social capital and social capital activation than the trigger's general manifestation.

The ability to spot opportunities and the likelihood of getting informed about opportunities is reported to depend on a wide range of factors (Baron et al., 2006). One of such factors corresponds to increasing experience that, in turn, is closely linked to the hierarchical position of an individual (Knowlton, 1997; Nosofsky & Palmeri, 1998). Academics from higher hierarchical positions are typically more concerned with issues and processes that would be of interest to major stakeholders including their industrial acquaintances (Nosofsky et al., 1998). In other words, they think about opportunities in more sophisticated and pragmatic ways than junior academics. Consequently, one can expect that, in general, academics from higher hierarchical positions will have more triggers for social capital activation to occur than their less senior colleagues. Furthermore, within a research group, professors are likely to have the highest autonomy regarding their decision to interact with industry, followed by associate professors and assistant professors (Bercovitz & Feldman, 2008; Stephan & Levin, 1992), and therefore senior academics have more power to decide whether to pursue the identified opportunity. Less senior academics, in turn, are suggested to demonstrate a relative lack of participation in decision making (Gaston, 1975), and consequently they have less ‘freedom’ to pursue the opportunities that arise. This leads us to the next hypothesis.

H2: For academics from higher hierarchical positions, the trigger influences the relationship between passive social capital and social capital activation stronger than for academics from lower hierarchical positions.

Additionally, the academic’s decision to follow or not to follow triggers is also likely to be related to the academics’ scientific orientation, i.e., basic vs. applied research. Academics mainly working on applied research are per definition predisposed to actively interact with industry, while academics with a more basic orientation have more space to decide whether to engage in interactions with industry or not (Stokes, 1997). Consequently, the presence of the trigger is more likely to lead to the actual behavior for academics in applied research. In addition, as introduced by Stokes, there is also a type of research that lies in between purely basic and purely applied research, and that often links semi-autonomous domains of science and technology (Balconi & Laboranti, 2006). Given a relative freedom to decide whether to interact with industry or not, also for this group of academics, the presence of a trigger is likely to play a less significant role than for academics with a more applied orientation. The following hypothesis can be formulated.

H3: For academics with a more applied scientific orientation, the trigger influences the relationship between passive social capital and social capital activation stronger than for academics with a more basic scientific orientation.

Finally, the effect of the trigger on the relationship in question may also be influenced by the scientific domain. When comparing bio- and nanotechnology, it has been suggested that nanotechnology is currently at the level of development similar to the emergence of biotechnology in 1980s, with biotechnology offering considerably more industrial applications (Miyazaki & Islam, 2007; Roco, 2005). Consequently, academics working in biotechnology are currently more predisposed to working with industry than their nanotechnology colleagues. We can therefore expect that for the latter group, given a less compulsory nature of their interactions with industry, the presence of the trigger is less likely to stimulate the actual behavior than for the biotechnology academics. This leads us to the final hypothesis in this sub-section.

H4: For academics working in biotechnology, the trigger influences the relationship between passive social capital and social capital activation stronger than for academics working in nanotechnology.

Figure 7-1 presents a conceptual framework for analyzing the abovementioned moderating effects.

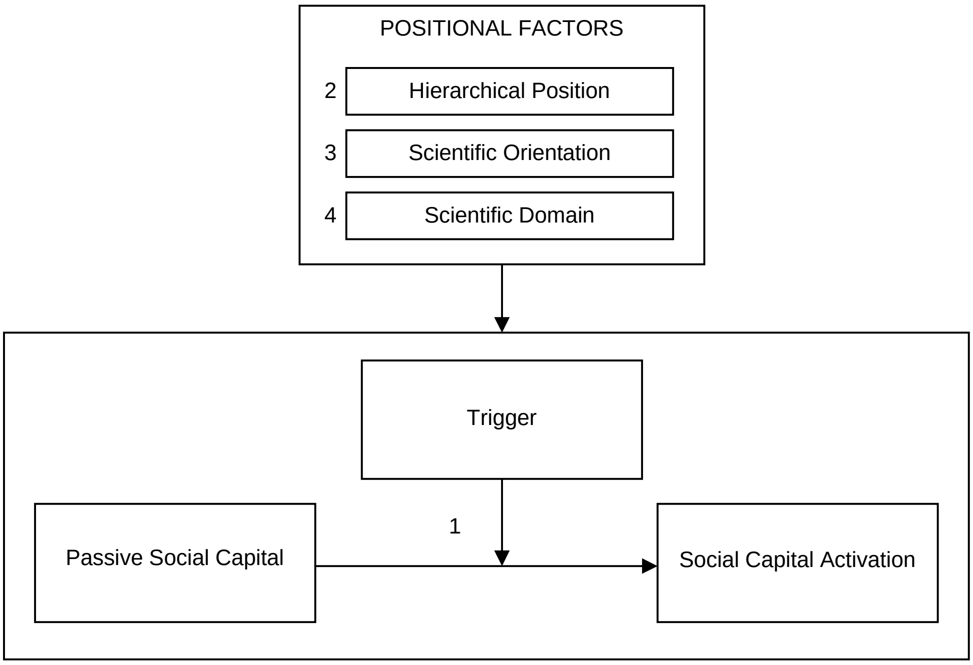

Figure 7-1: Conceptual framework for examining moderating effects of trigger

We now move on to hypothesizing on the role of the trigger as a mediator in the relationship in question.

7.2.2 Hypotheses for mediation

Only if possible mediation is taken into account, a phenomenon can be fully understood, and the 'true' cause can be singled out (Baron & Kenny, 1986). Mediating variables can facilitate the search for success factors and therefore should not be skipped in the current study. Mediator role of the trigger in this case implies that academic's passive social capital leads to the emergence of trigger, and the latter, in turn, leads to social capital activation with industry. However, given that social capital activation implies the presence of passive social capital, we can expect only partial mediation, i.e., a trigger alone cannot lead to social capital activation. When returning to the analogy with making fire, this situation can be compared with making fire by friction. While passive social capital can still be assigned a role of dry wood, the trigger in this case plays a role of a wooden stick found among this dry wood. This stick is then rubbed against a hole in another peace of wood until it creates a smoke.

Existing research suggests that access to and attainment of appropriate information plays a vital role in enabling an individual to spot opportunities (Baron et al., 2006; Gaglio & Katz, 2001; Hills & Shrader, 1998; Kaish & Gilad, 1991; Shane, 2003). One potential source of such information refers to individual's contacts with other people, i.e., social networks (Ozgen et al., 2007). Empirical studies show that the larger the entrepreneur's social network, the more opportunities or triggers he or she recognizes (Singh, 2000). Empirical evidence also suggests that when considering pursuing entrepreneurial opportunities academics may benefit from information provided by their informal networks with industry (Ozgen et al., 2007). Such sources may include current and previous industry collaboration partners, industry representatives met at conferences and business events, as well as during other formal and informal occasions. Given that academics' engagement in interaction with industry represents a specific manifestation of entrepreneurial behavior, we can expect that larger passive social capital serves as an exogenous factor for the trigger to emerge. At the same time, the higher the trigger, the higher the chance for social capital activation to occur, as triggers represent 'reasons' for social capital activation. This leads us to the next hypothesis.

H5: The indirect effect of passive social capital on social capital activation via trigger as the mediator variable is significant.

Figure 7-2 presents the conceptual framework for the second part of our analysis in this chapter. We aim to test a set of hypotheses regarding the mediating role of the trigger in the relationship in question. We first examine whether the mediation effect can be detected in the whole sample. We then move on to examining the mediation effect for academics with various hierarchical positions, scientific orientations and scientific domains.

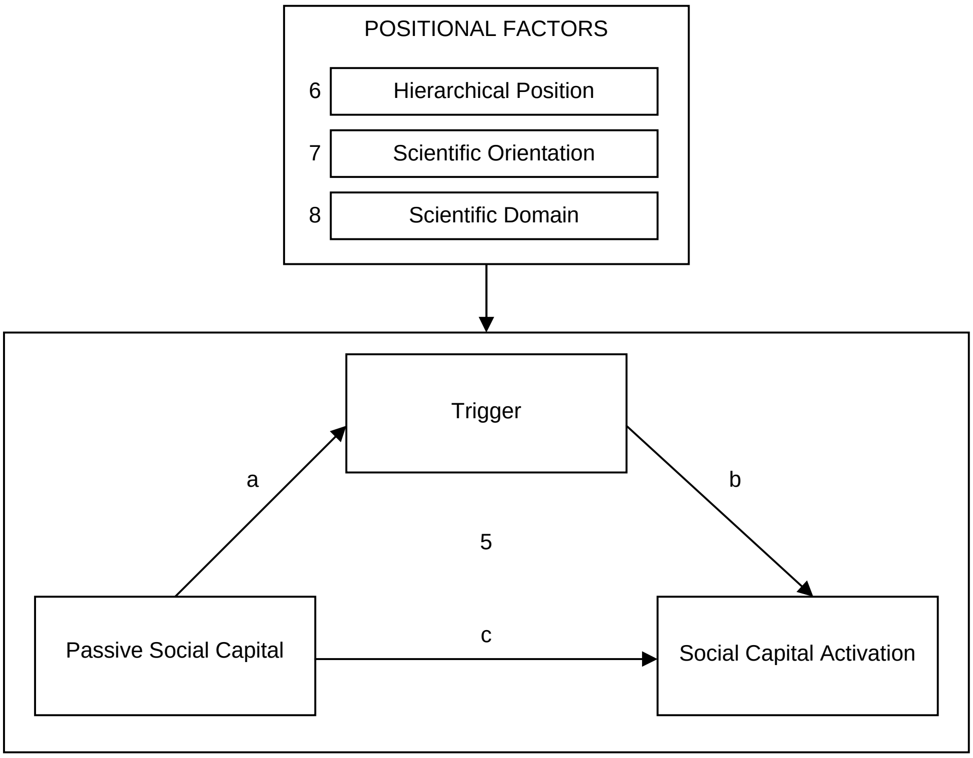

Figure 7-2: Conceptual framework for examining mediating effects of trigger

The first positional factor that is likely to have influence on the mediating role of the trigger refers to the hierarchical position. When young researchers join a research group / laboratory / department, they usually do not yet have their own social networks with industry and exploit the ones of their bosses (Lazega, Mounier, Jourda, & Stofer, 2006). It is reasonable to expect that when relations with industry are not yet well established, the presence of a significant triggering event is needed in order to activate social capital; otherwise activation is less likely to occur. By this we mean that for less senior academics, proactively approaching industry representatives (or being approached by industry representatives) is unlikely to occur without a particular reason (trigger). Academics from higher hierarchical positions, in turn, are more likely to have experience of collaboration with industry, with a higher chance of having well established relationships (Knowlton, 1997; Nosofsky & Palmeri, 1998). The latter increases the chance of informal communication (Adler et al., 2002; Granovetter, 1973, 2005; Hansen, 1999), i.e., "scanning the field" and chatting about potential opportunities while not necessarily having a particular reason for initiating collaboration at the moment of communication. This brings us to the following hypothesis.

H6: For academics from lower hierarchical positions, the trigger mediates the relationship between passive social capital and social capital activation stronger than for academics from higher hierarchical positions.

Additionally, the mediator role of the trigger is also likely to be related to the academics' scientific orientation, i.e., basic vs. applied research. As mentioned above, academics mainly working on applied research are per definition predisposed to actively interact with industry contrary to their colleagues with a more basic orientation (Stokes, 1997). Similarly to academics from higher hierarchical positions, academics with a more applied orientation are thus more likely to have experience of collaboration with industry and well established relationships. The latter again increases the chance of informal communication (Adler et al., 2002; Granovetter, 1973, 2005; Hansen, 1999), i.e., the chance of discussing potential opportunities while not necessarily having a particular reason for initiating collaboration at the moment of communication. Consequently, for this group of academics, the direct effect of passive social capital on social capital activation is less likely to become insignificant if the mediator variable trigger is included in the model.

H7: For academics with a more basic scientific orientation, the trigger mediates the relationship between passive social capital and social capital activation stronger than for academics with a more applied scientific orientation.

Finally, the mediator role of the trigger in the relationship in question is likely to be influenced by the academics' scientific domain. As mentioned above, academics actively working within biotechnology have to deal with considerably more industrial applications than their nanotechnology colleagues (Miyazaki & Islam, 2007; Roco, 2005). Following similar line of reasoning as for other positional factors described above, we can expect that the chance of informal communication with industry without particular reason of initiating collaboration at the moment of communication (trigger) is higher for biotechnology academics than for the ones working in nanotechnology. Consequently, for nanotechnology academics, the direct effect of passive social capital on social capital activation is more likely to become insignificant if the mediator variable trigger is included in the model. This leads us to the next hypothesis.

H8: For academics working in nanotechnology, the trigger mediates the relationship between passive social capital and social capital activation stronger than for academics working in biotechnology.

In this section, we have identified a set of hypotheses to be tested. In the next sections we elaborate on the employed methods and present the results of the analysis.

7.3 METHODS

In this sub-section, we address the aspects of the methodology that specifically refer to the analysis presented in this chapter. For a detailed description of the general methodology, the reader is advised to consult Chapter 3.

7.3.1 Measurement

For the analysis presented in this chapter, only reflective measures were used. Three sets of measures employed in this analysis are as follows. The measures employed for Trigger refer to TRR1-TRR4 of Annex A. The measures for Passive Social Capital and Social Capital Activation correspond to PSCR1 – PSCR4 and SCAR1 – SCAR4 of Annex A respectively. For a detailed overview of how these measures were developed and how their reflective nature was confirmed, the reader is advised to consult Chapter 3. The measures for Hierarchical Position, Scientific Domain and Scientific Orientation correspond to POS1, POS2 and POS3 of Annex A respectively.

7.3.2 Sample and procedures

For a detailed description of the sample and procedures, the reader is advised to consult Chapter 3. The analysis presented in this chapter was conducted using the PLS path modeling in SmartPLS.

7.4 ANALYSIS

In the first part of this sub-section, we examine the moderating effect of the trigger by means of group comparisons and product-indicator approach, thereby combining various approaches and thus increasing the reliability of obtained results (see Henseler & Chin, 2010a; Henseler & Fassott, 2010b). In the second part of this sub-section, we turn to the analysis of mediating effects.

7.4.1 Moderating effect: group comparison

Two types of group comparison approach were employed in this analysis: group comparison using median split and group comparison ignoring middle third.

(1) Group Comparison Using Median Split

The main steps of this approach include:

(1) Categorizing observations according to the level of the moderator variable (i.e., TRR);
(2) Splitting the sample in two sub-samples: below and above the median;
(3) Estimating the path coefficients through PLS path modeling for each sub-sample;
(4) Interpreting the differences between path coefficients as a moderating effect.

Figure 7-3 presents an estimated PLS path model for Low Trigger (i.e., for the observations that are below the median), whereas Figure 7-4 reflects the same model for High Trigger (i.e., for the observations that are above the median). For Low Trigger, the path coefficient $\beta_{1(LOW)}$ = 0.873, and for High Trigger $\beta_{1(HIGH)}$ = 0.818, and the corresponding effect β_3 is equal to the differences between those, i.e., -0.055. Consequently, the trigger has a trivial negative influence on the relation between passive social capital and social capital activation. When trigger is low, passive social capital predicts social capital activation slightly better than when trigger is high.

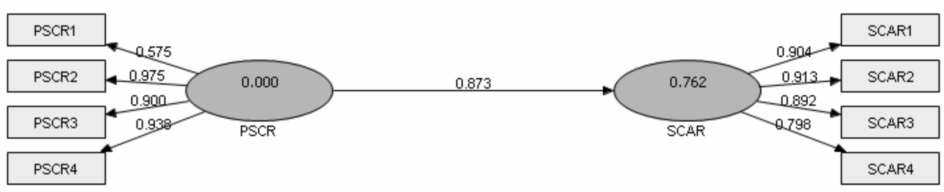

Figure 7-3: Estimated PLS Path Model for Low Trigger (Median Split)

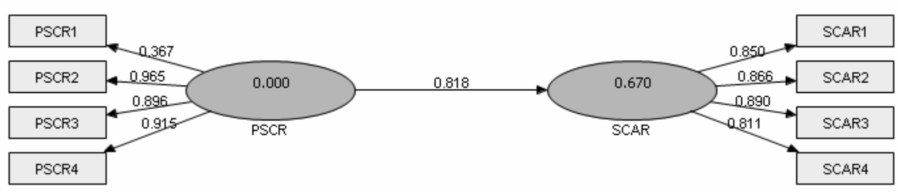

Figure 7-4: Estimated PLS Path Model for High Trigger (Median Split)

(2) Group Comparison Ignoring Middle Third

The 'Ignoring Middle Third' approach implies examining only high and low values of Trigger, and thus better enables us to detect the influence of Trigger on the relation in question. The main steps of this approach include:

(1) Categorizing observations according to the level of the moderator variable (i.e., TRR);
(2) Splitting the sample in three sub-samples: low, middle and high thirds;
(3) Estimating the path coefficients through PLS path modeling for low and high thirds;
(4) Interpreting the differences between path coefficients as a moderating effect.

Figure 7-5 presents an estimated PLS path model for Low Third (i.e., a third of observations with the lowest levels of Trigger), while Figure 7-6 reflects the same model for High Third (i.e., a third of observations with the highest levels of Trigger). For Low Third, the path coefficient $\beta_{1(LOW)}$= 0.863, and for High Third $\beta_{1(HIGH)}$= 0.801, and the corresponding effect β_3 is equal to -0.062. Consequently, also this approach suggests that trigger has a trivial negative influence on the relation between passive social capital and social capital activation. When trigger is low, passive social capital predicts social capital activation slightly better than when trigger is high.

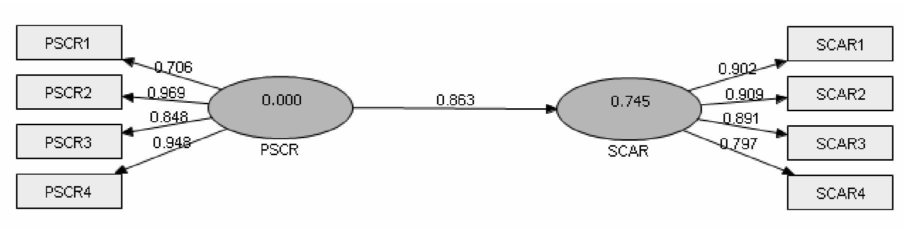

Figure 7-5: Estimated PLS Path Model for Low Third

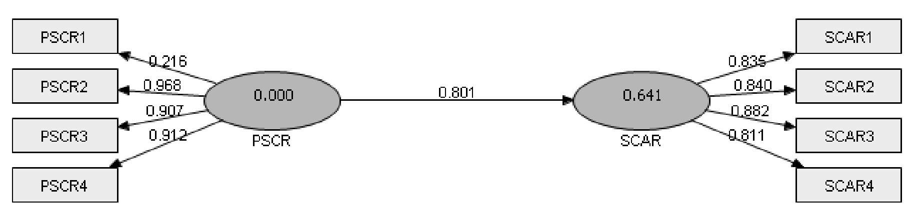

Figure 7-6: Estimated PLS Path Model for High Third

These results can be interpreted in the following way. In situations when there are not many reasons and opportunities for academics to interact with industry, these interactions are more likely to occur in the future if academics are already actively involved in collaboration with industry. In case academics are hardly engaged in collaboration with industry and if there are hardly any opportunities for them to do so, the likelihood that these interactions will occur in the future is low. In situations when there are many reasons and opportunities for academics to interact with industry, the actual occurrence of such interactions still strongly depends on the existing social networks. However, this relation is slightly weaker than in case of low trigger. Consequently, if trigger is high, academics with lower levels of passive social capital have a slightly better chance of social capital activation than in cases when trigger is low.

(3) Specific case: Industry's initiative

As mentioned above, existing research suggests that university-industry collaborations are typically initiated by industry representatives (David et al., 2008). Thus, instead of academics or university administrators approaching firms with proposals to engage in particular research projects, the research directors of companies often take the initiative of approaching the potential academic partners to discuss a collaboration opportunity. Consequently, it is important to test whether in our data, this particular type of trigger demonstrates a stronger effect on the relation between passive social capital and social capital activation than the trigger's general manifestation.

For this purpose, we applied the 'Ignoring Middle Third' group comparison approach. The observations were categorized according to the values of the corresponding formative measure TR3 of Annex A ("Industry representatives approach me directly"; scale 1 (Never) – 7 (Very often)). Figures 7-7 and 7-8 present the PLS path models for Low and High thirds respectively.

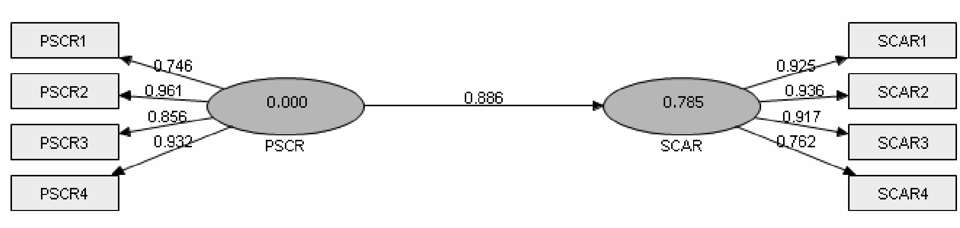

Figure 7-7: Estimated PLS Path Model for Low Third for Industry's Initiative

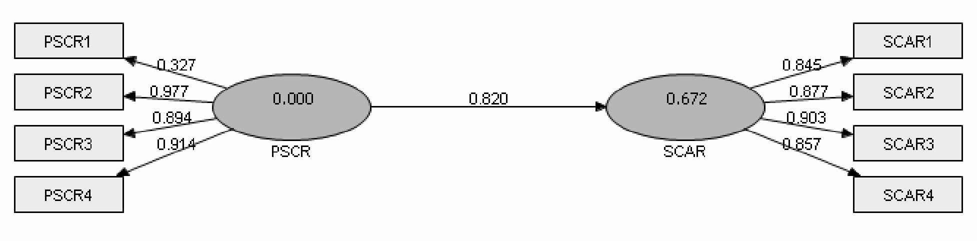

Figure 7-8: Estimated PLS Path Model for High Third for Industry's Initiative

For Low Third, the path coefficient $\beta_{1(LOW)}$ = 0.886, and for High Third $\beta_{1(HIGH)}$= 0.820, and the corresponding effect β_3 is thus equal to -0.066. Consequently, our data suggest that industry's initiative has a trivial negative influence on the relation between passive social capital and social capital activation. When industry's initiative is low, passive social capital predicts social capital activation slightly better than when industry's initiative is high.

7.4.2 Moderating effect: product-indicator approach

The product-indicator approach is appropriate since the measurement model of both the independent and the moderator variable is reflective (see Chin, Marcolin, & Newsted, 2003; Henseler et al., 2010a; Kenny & Judd, 1984). The approach implies building product terms using the indicators of the independent latent variable (in our case, PSCR) and the indicators of the moderator latent variable (in our case, TRR). These product terms then serve as indicators of the interaction term in the structural model (Henseler et al., 2010a).

In SmartPLS, we created an interaction term using standardized indicator values before multiplication. Figure 7-9 presents an estimated PLS path model. The results suggest that Trigger has no effect on the relation between passive social capital and social capital activation (β_3^*= -0.021 which can be considered as a trivial effect). The results of the previous approach have thus been confirmed.

The examination of the moderating effect suggests that the trigger has a trivial negative influence on the relation between passive social capital and social capital activation. The role of the trigger in the actual 'triggering' of social capital activation (i.e., in switching social capital from passive to active mode) thus proves to be insignificant. Furthermore, when the trigger is low, passive social capital predicts social capital activation even slightly better than when the trigger is high. However, when passive social capital is not taken into account, the trigger has a significant positive association with social capital activation. Consequently, H1 was not confirmed.

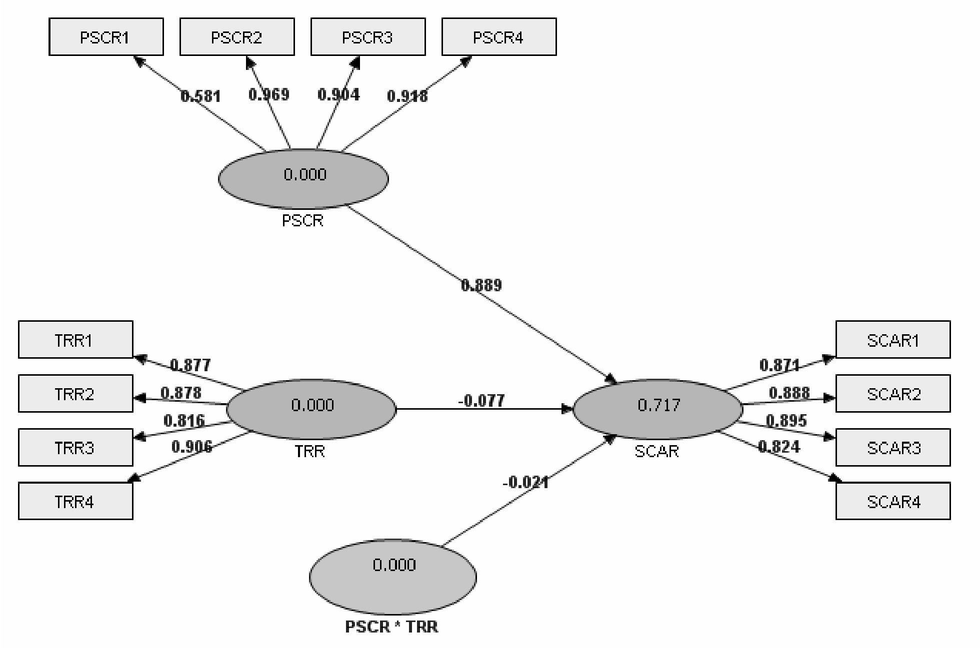

Figure 7-9: Estimated Path Model for Product-Indicator Approach

7.4.3 Moderating effect: specific groups of academics

We first examined the strength of the relationship between passive social capital (i.e., social capital characteristics corresponding to the results of previous interactions by September 2009) and social capital activation (actual interactions between September 2009 and September 2010). In all path models (see Table 7-1), the coefficients of determination of social capital activation indicate either moderate-strong or strong effects (Chin, 1998b; Cohen, 1988). The coefficients of determination with moderating effects are also either moderate or strong.

Table 7-1: Coefficients of determination

Group	R^2 without moderator	R^2 with moderator
2.1 (Higher)	$0.560^{\wedge}$	$0.568^{\wedge}$
2.2 (PhD)	$0.703^{\wedge\wedge}$	$0.711^{\wedge\wedge}$
3.1 (Basic)	$0.753^{\wedge\wedge}$	$0.755^{\wedge\wedge}$
3.2 (Equal)	$0.544^{\wedge}$	$0.567^{\wedge}$
3.3 (Applied)	$0.604^{\wedge}$	$0.612^{\wedge}$
4.1 (Bio)	$0.612^{\wedge}$	$0.615^{\wedge}$
4.2 (Nano)	$0.628^{\wedge}$	$0.715^{\wedge\wedge}$

$^{\wedge\wedge}$ - strong (values of 0.67, 0.33 and 0.19 correspond to strong, moderate and weak, see Chin, 1998b); $^{\wedge}$ - moderate-strong

We now examine the results related to each of the conditional hypotheses presented in the first part of the theoretical section (H2-H4). The results of the analysis are presented in Table 7-2. H2 and H3 were not confirmed by the data, and no significant moderating effects were detected. H4 was also not confirmed. However, contrary to our expectation, a significant moderating effect of the trigger was detected for academics working in nanotechnology. The results suggest that the trigger has a negative moderate-strong effect on the relationship between passive social capital and social capital activation. Consequently, when more triggers occur, passive social capital is less likely to lead to social capital activation than if there are fewer triggers. These findings need to be treated with caution as the reason for this counterintuitive result is likely to be related to other factors not taken into account by this model. For example, it may be not only the quantity of triggers that matters, but also the quality of emerging opportunities (e.g., long-term engagements with industry vs. short informal contacts).

Table 7-2: Moderation effects for various sub-groups

Hypothesis	**Group**	β_3^*	**Effect size** f^2	**Sd** β_3^* **bootstrap**	**Significance test ($t_{0.05,\ 499}$ = 1.96)**	
					***t* value**	**Interpre-tation**
H2: For academics from higher hierarchical positions, the trigger influences the relationship between passive social capital and social capital activation stronger than for academics from lower hierarchical positions.	2.1 (Higher)	-0.039	0.018 (weak)	0.063	0.619	path does not differ from 0
	2.2 (PhD)	-0.108	0.013	0.091	1.182	path does not differ from 0
H3: For academics with a more basic scientific orientation, the trigger influences the relationship between passive social capital and social capital activation stronger than for academics with a more applied scientific orientation.	3.1 (Basic)	0.008	0.008	0.037	0.214	path does not differ from 0
	3.2 (Equal)	0.067	0.053 (weak)	0.066	1.017	path does not differ from 0
	3.3 (Applied)	-0.114	0.021 (weak)	0.068	1.684	path does not differ from 0
H4: For academics working in biotechnology, the trigger influences the relationship between passive social capital and social capital activation stronger than for academics working in nanotechnology.	4.1 (Bio)	-0.044	0.008	0.069	0.638	path does not differ from 0
	4.2 (Nano)	-0.327	0.305 (moderate-strong	0.076	4.302	**path does differ from 0**

7.4.4 Mediation effects

In the second part of our analysis, we examined the mediation effects of trigger in the relationship between passive social capital and social capital activation. Table 7-3 provides the results of this analysis.

Table 7-3: Mediation effects for the whole sample and specific sub-groups

Group	a	b	a x b	Sd a_ib_i bootstrap	Significance test ($t_{0.05,\ 499}$ = 1.96)	
					t value	Interpretation
H5 All sample	0.521	-0.087	-0.045	0.021	**2.158**	**Mediation, VAF = 0.055, suppressor effect**
H6.1 (Higher)	0.514	0.031	0.016	0.020	0.800	no mediation
H6.2 (PhD)	0.553	-0.006	0.003	0.015	0.200	no mediation
H7.1 (Basic)	0.433	0.016	0.007	0.011	0.636	no mediation
H7.2 (Equal)	0.604	0.142	0.086	0.042	2.045	**Mediation, VAF = 0.117**
H7.3 (Applied)	0.570	-0.033	-0.019	0.019	1.000	no mediation
H8.1 (Bio)	0.498	0.027	0.013	0.020	0.650	no mediation
H8.2 (Nano)	0.637	-0.007	-0.004	0.020	0.200	no mediation

H5 related to the mediator role of the trigger in the whole sample was confirmed; however a suppressor effect was detected. Further analysis showed that Passive Social Capital represents a negative suppressor variable, and suppresses the irrelevant variance in Trigger. In other words, Passive Social Capital controls for variance in trigger not directly associated with Social Capital Activation. This reduces the common variance between Trigger and Social Capital Activation in the complete model.

No hypotheses for particular groups of academics were confirmed. The data did not indicate mediation in case of academics from either higher or lower hierarchical positions (H6). Similarly, no mediation was detected for academics from both bio- and nanotechnology fields (H8). One of the key reasons for the absence of effects could be related to an insufficient sample size when split into groups.

As can be seen from the table, another mediation effect that was detected refers to academics whose scientific orientation is equally basic and applied. In this sub-group, about 12% of the total effect is due to the indirect effect (passive social capital -> trigger -> social capital activation). Consequently, for this group of academics, the direct effect of passive social capital on social capital activation is more likely to become insignificant if the mediator variable trigger is included in the model than for academics with more basic or more applied scientific orientation. Our result can thus be explained as follows. Academics with more basic scientific orientation, even when a significant reason (trigger) is present to interact with industry, are less likely to activate their social capital since they are in general less predisposed to do so. This diminishes the role of the trigger as a mediator. Academics with more applied orientation, in turn, are per definition predisposed to interaction with industry, with or without (e.g., informal communication) a significant reason (trigger) to do so. This again diminishes the role of the trigger as a mediator. As mentioned above, equally basic and applied type of research lies in between purely basic and purely applied research, and often links semi-autonomous domains of science and technology offering academics "more freedom" to choose whether to interact with industry or not (Balconi & Laboranti, 2006). Therefore, in this case, a significant reason to do so (trigger) proves to have a mediator role in the relationship in question.

7.5 CONCLUSIONS

The examination of moderating effects suggested that the trigger has a trivial influence on the relation between passive social capital and social capital activation. The role of the trigger in the actual 'triggering' of social capital activation (i.e., in switching social capital from passive to active mode) thus proves to be insignificant. Furthermore, when the trigger is low, passive social capital predicts social capital activation even slightly better than when the trigger is high. However, when passive social capital is not taken into account, the trigger has a significant positive association with social capital activation.

These results can be explained by the measurement approach employed in this study. The data for academics' passive social capital have been gathered on five industrial partners with whom academics had the strongest connections, instead of the whole network. Ideally, it would be necessary to gather data for all contacts from the individuals' social networks at the beginning of the year in question. In our case, however, it was not possible as some of the respondents had more than fifty industrial partners. At the same time, the trigger refers to all possible reasons and opportunities for academics to engage in interaction with industry during the year in question. Hence, when analyzing moderating effects, we examined how this *total* pool of opportunities influences the relation between passive social capital and social capital activation for academics' relations with a *limited* selection of industrial partners. The fact that we looked at a limited selection of industrial partners inevitably creates a certain bias in our approach.

The obtained results thus mean that the total pool of opportunities for academics to interact with industry does not significantly influence the relation between passive social capital and social capital activation, given that the latter two are related to the five industrial partners with whom academics had the strongest connections at the beginning of the year in question. Most of the opportunities from the total pool are thus likely to be irrelevant for those particular connections. Furthermore, some opportunities may even distract academics from interaction with those particular connections, thereby explaining a slight negative effect.

The mediator role of the trigger in the relationship between passive social capital and social capital activation was confirmed; however a suppressor effect was detected. These results suggest that the notion of a trigger in the process of social capital activation should not be abandoned. The future studies should ensure a better consistency in measuring trigger, passive and activated social capitals. When feasible, the future studies should aim at capturing the whole network and the whole pool of triggering opportunities. In most cases, however, such approach will represent a challenge, and instead, more specific measures of a trigger will need to be employed. These measures should refer to the reasons and opportunities related to a limited selection of industrial partners included in the analysis. Future studies thus should aim at developing a more detailed typology of triggering events and examine the moderating and mediating role of specific types of triggers instead of treating it as one general pool.

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8 Developing a parsimonious model of social capital activation

> *"For many people, one of the most frustrating aspects of life is not being able to understand other people's behavior."*
>
> Johann Wolfgang von Goethe (1749-1832), German writer

In the previous empirical chapters, we have examined how social capital activation is influenced by a broad set of factors. We conducted our analyses by means of the reciprocal confrontation of those factors, as well as by locking them into various combinations and assigning them various roles (e.g., exogenous variable or moderator variable). These analyses brought us closer to achieving the general objective of our research, i.e., developing a comprehensive but parsimonious model that provides insight into the key determinants of academics' social capital activation with industry, and to understand and explain the way these determinants lead to actual behavior. In this chapter, we take the final step and, based on the results of the previous chapters, examine the feasibility of developing a parsimonious model of social capital activation. The results suggest that, when taken individually, the proposed factors have a considerable effect on social capital activation. However, when all taken into account, the only factor that demonstrated a substantial effect on the exploitation of networks in the future refers to the characteristics of the existing social networks of academics or passive social capital, while the effects of other factors prove to be insignificant. We also show that considerable differences can be observed between academics from different hierarchical positions, scientific orientations and scientific domains.

8.1 INTRODUCTION

As emphasized in Chapter 1, existing research lacks testable and, at the same time, comprehensive explanations of why academics actually activate their social capital with industry (Adler & Kwon, 2002), which, in turn, makes it difficult for policy makers and university administrators to design effective policies and measures to support university-industry interactions. Therefore a comprehensive but parsimonious model needs to be developed that provides insight into the key determinants of academics' social capital activation with industry, and allows us to understand and explain the way these factors lead to actual behavior.

In order to develop such model, in Chapters 2, 4 – 7, we called upon a broad range of relevant theories some of which had been outside the scope of existing literature on university-industry interactions. We consulted existing behavioral theories, including entrepreneurship theories (Ajzen's Theory of Planned Behavior (Ajzen, 1991); Shapero's Model of Entrepreneurial Event (Shapero, 1982) and more general models of behavior such as the MOA framework and other models (Adler et al., 2002; Argote, McEvily, & Reagans, 2003; Blumberg & Pringle, 1982; Boudreau, Hopp, McClain, & Thomas, 2003; Lawshe, 1945; MacInnis, Moorman, & Jaworski, 1991; Siemsen, Roth, & Balasubramanian, 2008; Wu, Balasubramanian, & Mahajan, 2004; Wyatt, Frost, & Stock, 1934). Building on a broad literature base and various empirical analyses, our objective was to identify the key factors that are likely to lead to social capital activation, as well as the most important relations between those factors.

More specifically, we approached the question of why academics activate their social capital with industry from the following perspectives:

- by examining the role of specific motives in forming the general motivation of academics to activate their social capital with industry (Chapter 4);
- by examining the role of three key predictors of academics' engagement in interaction with industry suggested by the literature on university-industry interactions (Chapter 5);
- by examining the moderating effects of dispositional factors (perceived social influence, motivation and perceived ability) on social capital activation, and the influence of positional factors (hierarchical position, scientific orientation, scientific domain) on this relationship, as well as by comparing these effects with each other (Chapter 6); *and*
- by examining the moderating and mediating roles of trigger in the relationship between passive social capital and social capital activation (Chapter 7).

As the final step of our analysis, in this chapter, we consolidate the findings from the abovementioned research questions into one model of social capital activation. By doing so we aim to obtain a comprehensive answer to the question of why academics activate their social capital with industry. As mentioned in Chapter 1, by developing and integrating multiple perspectives, we aim to acquire a comprehensive understanding of the phenomenon in question. Such approach is likely to result in a stronger research design and more valid and reliable research findings. It minimizes the inadequacies of individual perspectives and addresses the threats to internal validity.

When developing a model for social capital activation, we built on the four essential elements of theory development by Dubin (1978):

(1) *What*. We looked at factors (variables, constructs, concepts) that logically should be considered as part of the explanation of social

capital activation. We employed two criteria for judging the extent to which we have included the "right" factors in the model: comprehensiveness (i.e., whether all relevant factors are included), and parsimony (i.e., whether some factors can be removed because they add little additional value to our understanding). When we began to map out the conceptual landscape for the topic in question, we included many different factors, recognizing that after the analyses in Chapters 4-7 our ideas are likely to be refined (for arguments in favor of such approach see Whetten, 1989).

(2) *How*. After identifying a set of relevant factors, we turned to the relationships between them. This step in theory building adds order to the conceptualization by explicitly delineating patterns (Whetten, 1989). In addition, it introduces causality. Thus at this stage, we identified the causal relationships between the factors and developed a set of testable hypotheses.

(3) *Why*. At this stage, we examined the underlying dynamics that justify the selection of factors and the proposed causal relationships. While What and How describe the model, Why explains it (why we should expect certain relationships in our data).

(4) *Who, Where, When*. Finally, we examined the conditions that place limitations on the propositions generated from a theoretical model. We examined how certain positional factors and control variables set the boundaries of generalizability of our model. In the process of testing our ideas in various settings, we were able to discover the inherent limiting conditions of the model. This provided us with foreknowledge of possible limitations of theory's applicability.

The remainder of this chapter is organized as follows. In the next section, we briefly address the proposed model. We focus on What, How and Why. In the third section, we explain the main aspects of the employed methodology. The fourth section presents the results of the PLS path modeling including the reliability and validity checks of the employed measures and the test of our hypotheses. Our findings show that, when all taken into account, most of the traditional predictors of behavior have a considerably weak relation to actual social capital activation. The only factor that demonstrated a substantial effect on the behavior in question refers to passive social capital or existing social networks of academics. We also pay attention to Who, Where and When. We show that considerable differences can be observed between academics from different hierarchical positions, scientific orientations and scientific domains.

8.2 CONCEPTUAL FRAMEWORK

Figure 2-4 and Chapter 2 briefly presented the proposed model for social capital activation. In the remainder of this section, both the building blocks of the model and the proposed relationships between them will be explained in more detail.

8.2.1 Components and structural logic of the model (What)

As can be seen from the figure, we model social capital activation as the result of four antecedents: (1) the individual motivation of academics to engage in interaction with industry, (2) the influence of their direct social environment (i.e., the behavior and opinions of their bosses, colleagues and research partners), (3) the ability of academics to interact with their industrial acquaintances (i.e., the relevant competences and skills), and (4) the characteristics of their social networks with industry (Adler et al., 2002; Smith, 2005). The first three antecedents refer to the dispositional factors previously examined in Chapters 4 – 6. The fourth antecedent refers to passive social capital previously examined in Chapters 5 – 7. Additionally, we have also included the trigger, the role of which was previously analyzed in Chapter 7[8].

As explained in Chapter 2, the structural logic of the model is as follows. To act in either planned or unplanned way, an academic has to demonstrate a certain *readiness* to perform a given behavior (Ajzen, 1991; Shapero, 1982). Therefore, an academic has to be potentially ready to engage in interaction with industry; otherwise, social capital activation is much less likely to occur. However, even exceptionally strong readiness does not necessarily have to lead to actual behavior (Triandis, 1967, Katz, 1989 quoted in Krueger & Carsrud, 1993). Therefore, an extra set of factors needs to be considered that may ‘precipitate’ or trigger individual’s behavior (Krueger et al., 1993; Shapero, 1982). The occurrence of the *trigger* can be illustrated by the following situations. First, an academic may spot ideas that are potentially interesting for industry him- or herself and then approach industry proactively to communicate those ideas. Second, an academic may get

[8] The examination of both moderating and mediating effects in Chapter 7 suggested that the trigger has a trivial influence on the relation between passive social capital and social capital activation. However, the obtained results can be partly explained by the drawbacks of the measurement procedure and do not provide the sufficient grounds to abandon the notion of a trigger in the process of social capital activation. Moreover, the mediator role of the trigger on the relationship between passive social capital and social capital activation was confirmed, although a suppressor effect was detected. Therefore, the trigger was included in the model based on both logical and empirical justifications (for arguments supporting the soundness of such approach see Whetten, 1989).

connected with industry by the head of the research group/peer colleagues/academic research partners. Third, industry representatives may approach an academic directly. Finally, academics can also be connected to industry by third parties (e.g., university-industry match-making services, cluster organizations, TTOs).

The main components of readiness in the model correspond to Adler and Kwon's (2002) key sources of social capital: motivation, ability and opportunity which need to be present simultaneously for social capital to be activated. In our model, Adler and Kwon's motivation, ability and opportunity correspond to Individual Motivation, Perceived Ability and Passive Social Capital respectively. By Passive Social Capital or opportunity here one should understand the presence of certain structural configurations of a network allowing one to engage in interaction (Adler et al., 2002).

As the fourth component of readiness, we have added Perceived Social Influence, since academics are not independent from their environmental context (D'Este et al., 2007; Magnusson, McKelvey, & Versiglioni, 2008). Based upon the sociological literature on embeddedness (Granovetter, 1985; Kenney & Richard Goe, 2004), we can distinguish between the efforts devoted to creating and maintaining a wide range of linkages with industry as a result of individual characteristics or as a function of the individual's environment (D'Este et al., 2007). Therefore, when examining factors that determine academic's readiness to activate social capital, we take into account both individual motivation and group's influences, by 'group' meaning laboratories that academics are affiliated with (for similar approach, see, for example, Lazega, Mounier, Jourda, & Stofer, 2006).

8.2.2 Causal relationships and hypotheses (How and Why)

In this sub-section, we focus on the causal relationships between the main building blocks of the model. We elaborate on the hypotheses that have not yet been examined in the previous chapters, i.e., the hypotheses on the relationship between the four proposed antecedents and the trigger. For the theoretical grounds of hypotheses on the relationship between the four antecedents and social capital activation, the reader is advised to consult Chapters 5 and 6, while Chapter 4 contains more detailed information on the notion of motivation. For the theoretical grounds of hypotheses on the mediator role of the trigger in the process of social capital activation, the reader is advised to consult Chapter 7.

Causal Relationship between Individual Motivation and Trigger

As mentioned in Chapter 3, individual motivation refers to academic's willingness to engage in interaction with industry. In this sub-section, we elaborate on how such willingness is likely to influence the occurrence of the aforementioned triggering events. Firstly, we can expect that an academic who is in general motivated to engage in interaction with industry is more likely to proactively search for opportunities to interact with industry than his or her less motivated colleagues. Secondly, a motivated academic is also more likely to communicate his or her motives to the head of research group and/or peer colleagues and/or academic research partners. Consequently, the likelihood increases that his or her academic partners will connect him or her with industry if the opportunity arises (for strong interdependencies between academics and their colleagues see, for example, Lazega et al., 2006). Thirdly, a motivated academic is also more likely to communicate his or her motives to industrial partners from the network, thereby increasing the chance that industrial partners will approach him or her directly when the opportunity occurs (David & Metcalfe, 2010). Finally, a motivated academic is also more likely to make use of university-industry match-making services provided by third parties than his less motivated colleagues (Baldini, Grimaldi, & Sobrero, 2007).

Hypothesis 1a: The higher the motivation of an academic to engage in interaction with industry, the higher the likelihood for a trigger to occur.

Causal Relationship between Perceived Social Influence and Trigger

As mentioned in Chapter 3, existing literature suggests that among the main groups that are likely to have the greatest influence on the behavior of academics, chairs and peer colleagues usually have the highest impact (Bercovitz et al., 2008; Goktepe-Hultan, 2008; Stuart & Ding, 2006). The chair plays a direct and oftentimes powerful role in, among others, reviewing and evaluating individual performance related to promotion and tenure (Bercovitz et al., 2008). If the chair is active in interactions with industry, then he or she sends a signal that interaction with industry is a valid activity. In this case, other members of the department might be more likely to engage in interaction with industry.

Furthermore, academics are likely to adopt the behavior of local colleagues, i.e., these colleagues act as role models and, together with the decisions taken within the research group, influence the behavior of individual academics (Bercovitz et al., 2008; Goktepe-Hultan, 2008; Stuart et al., 2006). This leads us to expect that academics who are trained at university departments in which interaction with industry is not a norm are less likely to collaborate with industry than their 'non-traditional' colleagues (Stuart et al., 2006).

Consequently, we can expect that an academic whose boss and/or academic peer colleagues are engaged in interaction with industry is more likely to proactively search for opportunities to interact with industry than his or her colleagues from more ‘traditional’ groups (Bercovitz et al., 2008; Goktepe-Hultan, 2008; Stuart et al., 2006). Secondly, the likelihood increases that his or her academic partners will connect him or her with industry if the opportunity arises since they are actively engaged in interactions with industry themselves (Lazega et al., 2006). Thirdly, a socially encouraged academic is also more likely to communicate to industrial partners him- or herself, thereby increasing the chance that industrial partners will approach him or her directly when the opportunity occurs. Finally, such academic is also more likely to make use of university-industry match-making services provided by third parties.

Hypothesis 1b: The higher the perceived social influence with regard to interaction with industry, the higher the likelihood for a trigger to occur.

Causal Relationship between Perceived Ability and Trigger

As presented in Chapter 3, existing literature suggests a number of skills that academics need to possess in order to succeed in interactions with industry, such as the ability to work according to industry standards, integration skills, the ability to cope with contradicting incentive systems etc. (for an overview, see, for example, D’Este et al., 2007; Magnusson et al., 2008).

Perceived ability is likely to influence the trigger in a number of ways. First, for an academic convinced of possessing the necessary skills, the chance of spotting ideas that are potentially interesting for industry and then approaching industry proactively to communicate those ideas is likely to be higher than for his or her colleague who is less skilled (for a similar line of reasoning, see, for example, D'Este & Fontana, 2007). Second, if the academic possesses the necessary skills, the chance that the head of research group and/or peer colleagues and/or academic research partners will connect him or her with industry will be higher should the opportunity occur. The same refers to the chance that industry will approach the academic directly. It can be explained by the fact that the academic will then be known for his or her ability to successfully interact with industry which makes him or her an attractive collaboration partner compared to other academics with other conditions being equal (for a similar line of reasoning, see, for example, Baron & Markman, 2003).

Hypothesis 1c: The higher the perceived ability of an academic to interact with industry, the higher the likelihood for a trigger to occur.

Causal Relationship between Passive Social Capital and Trigger

In the context of this study, by passive social capital one should understand existing social networks that an academic has with industrial partners (and social capital activation occurs only when those networks are actually exploited). Participation in social networks with industry, in turn, is likely to have influence on (1) the likelihood that an academic will be informed of opportunities (access); (2) the likelihood that the academic is the first to see new opportunities created by needs of industry that could be served by skills of academia and the other way around (timing); and (3) the likelihood that the academic will be included in those new opportunities (referral) (Burt, 1997; Jarvis, MacKenzie, & Podsakoff, 2003). All three situations represent the trigger in our model, i.e., they refer to reasons for social capital activation to occur.

Hypothesis 1d: The larger the passive social capital of an academic with regard to industry, the higher the likelihood for a trigger to occur.

In this section, we have identified a set of hypotheses to be tested. In addition to H1a – H1d, we will also test the hypotheses on the relationship between the four antecedents and social capital activation (H2a – H2d), and the hypothesis on the mediator role of the trigger (H3). In the next sections we elaborate on the employed methods and present the results of the analysis.

8.3 METHODS

In this sub-section, we address the aspects of methodology that specifically refer to the analysis presented in this chapter. For a detailed description of general methodology, the reader is advised to consult Chapter 3.

For the analysis presented in this chapter, the reflective measures were used ensuring higher reliability of the analysis (Henseler & Chin, 2010). We tested the reliability and validity of the employed reflective measures and analyzed the effects of our anticipated predictors of behavior on the level of social capital activation of academics with industry. Both types of analysis were conducted using the PLS path modeling in SmartPLS. The PLS path modeling methodology was chosen as it is suitable for prediction-oriented research and complex models, it implies no distributional assumptions and it is appropriate for a small sample size (Henseler, Ringle, & Sinkovics, 2009). Furthermore, PLS is robust with different scale types (Henseler et al., 2009). In the next section, we interpret the results of the PLS path modeling.

8.4 ANALYSIS

Figure 8-1 presents the complete estimated PLS path model with social capital activation and trigger as endogenous variables. We first report the results of the outer model assessment for the whole sample, and then proceed with the inner model assessment (Henseler et al., 2009) for the whole sample and for specific sub-groups.

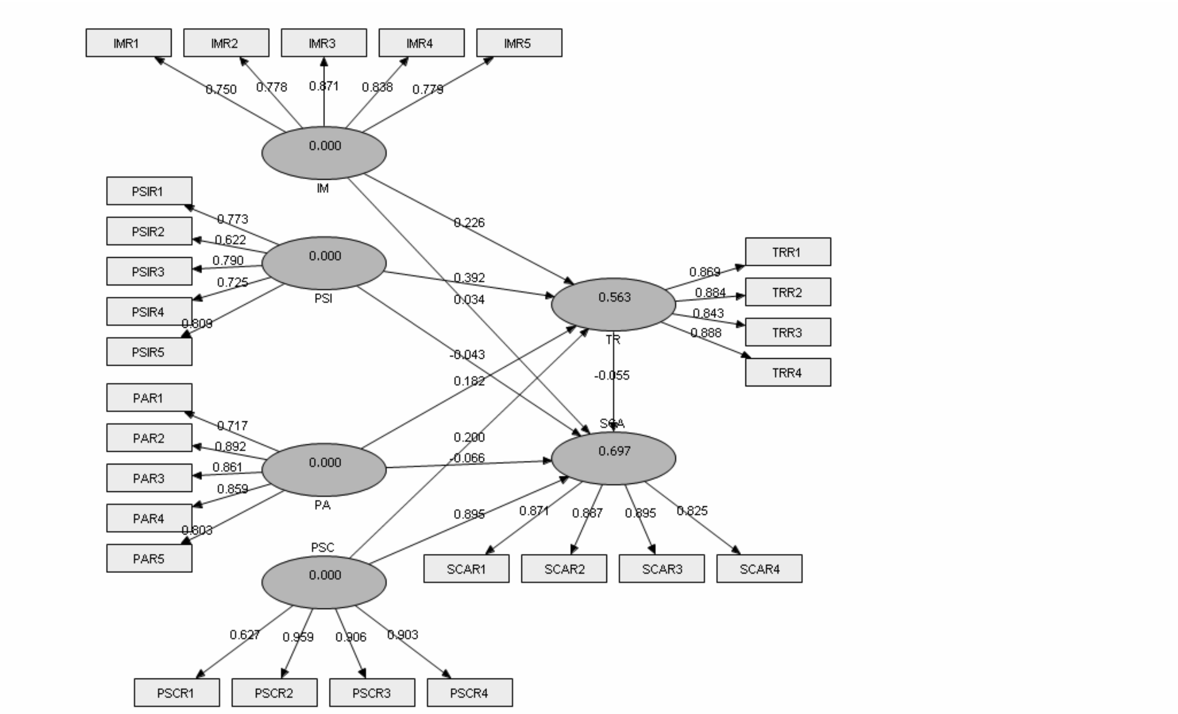

Figure 8-1: Estimated PLS path model

8.4.1 Outer model assessment

Internal consistency reliability

To check the internal consistency reliability, we employed both the traditional Cronbach's α reliability coefficient (Cronbach, 1951) and the composite reliability ρ_c (Werts, Linn, & Jöreskog, 1974). For all our latent variables, both Cronbach's α and the composite reliability ρ_c pass the required threshold of 0.7 (Nunnally & Bernstein, 1978), and most of them are higher than 8.5 (see Table 8-1). Consequently, the reliability of the employed sets of indicators for all latent variables (i.e., IM, PA, PSI, PSC, TR and SCA) can be regarded as acceptable.

Table 8-1: Cronbach's Alpha, Composite reliability and Convergent validity

	Cronbach's Alpha	Composite Reliability	AVE
IM	0.863	0.901	0.647
PA	0.886	0.916	0.687
PSC	0.874	0.917	0.737
PSI	0.804	0.862	0.557
SCA	0.894	0.926	0.757
TR	0.894	0.926	0.759

Indicator reliability

Most of our latent variables explain more than 50% (Henseler et al., 2009) of each of their indicators' variance. Those indicators can thus be considered reliable. Two exceptions refer to PSCR1 and PSIR2.

PSCR1 refers to the actual network size of academics in relation to industry in September 2009. According to our data, PSC shares only 39.3% of variance in the actual network size of academics. This discrepancy can be explained by the fact that the rest of the measures of PSC in our empirical example refer not to the whole actual network, but to a limited part of the network of academics. For PSC2 - PSC4, the respondents were asked to provide detailed information on up to five industrial partners, whereas PSC1 covers all industrial partners in their network. As a result, the PSC latent variable currently is predominantly related to the five industrial partners the academics reported on. This approach has inevitably created a certain bias in the estimates. However, as those five industrial partners are partners with whom the academics have the strongest connections, the cumulative measures such as closeness, multiplexity of roles and history of interactions are expected to cover a representative part of academics' passive social capital.

Another exception refers to PSIR2 corresponding to the statement "I am under social pressure to collaborate with industry". In the complete model, the PSI latent variable explains only 38.7% of the variance in this measure. As mentioned above, the reason for a low reliability of this indicator can be explained by a sensitive formulation of the statement corresponding to it. The respondents are likely to perceive "social pressure" in a more negative way than measures related, for instance, to expectations and duty, and the scores obtained for this measure are thus likely to be biased.

Although the reliability of PSC1 and PSIR2 in this case is low, we will not omit these indicators. Actual network size is a key measure in social network research, and more substantial arguments are needed to remove it from the proposed list of measures.

Validity

For the assessment of validity, we examined two validity subtypes: the convergent validity and the discriminant validity. Convergent validity indicates that a set of indicators represents one and the same underlying construct, which can be demonstrated through their unidimensionality (Henseler et al., 2009). We employed the average variance extracted (AVE) as a criterion of convergent validity (Fornell & Larcker, 1981). Table 8-1 shows that the convergent validity of all our latent variables is sufficient (in all cases, it is higher than 0.5). For example, passive social capital is able to explain 73.7% of the variance of its indicators on average.

For the assessment of discriminant validity, we employed the Fornell-Larcker criterion and the cross-loadings (Henseler et al., 2009). Table 8-2 shows that all latent variables satisfy the Fornell-Larcker criterion, meaning that they share more variance with their assigned indicators than with each other.

Table 8-2: SQRT AVE and correlations matrix

	IM	PA	PSC	PSI	TR
IM	**0.804**				
PA	0.504**	**0.829**			
PSC	0.346**	0.506**	**0.852**		
PSI	0.308**	0.439**	0.440**	**0.746**	
TR	0.502**	0.561**	0.564**	0.625**	**0.871**

**. Correlation is significant at the 0.01 level (1-tailed).

Secondly, the loading of each indicator on its assigned latent variable is expected to be greater than all of its cross-loadings (Chin, 1998b). This condition holds for all our indicators except SCAR1 (the actual size of exploited network). The loading of SCAR1 on the social capital activation latent variable is lower than on passive social capital; however, the difference is not substantial. It can be explained by the fact that most of our measures of passive social capital are directly related to the actual size of exploited network (i.e., these are the measures of the passive social capital of academics in September 2009 *exclusively* for industrial contacts with whom social capital has been activated between September 2009 and September 2010). In order to avoid the situation that the loading of SCAR1 on passive social capital is higher than on social capital activation, it would have been necessary to ask our respondents to provide information on all industrial partners from their social network for all measures of passive social capital. However, in our case, some of the respondents had more than fifty industrial partners, and therefore, gathering data on all of those partners was not possible.

The proposed reflective measurement models proved to be reliable and valid. The only exceptions refer to the validity of PSIR2, which seems to be related to a sensitive formulation of the question, and the larger loading of SCAR1 on passive social capital than on social capital activation. The latter can be explained by the fact that most of our measures of passive social capital are directly related to the actual size of exploited network (SCAR1). However, given that the outer standardized loadings are higher than the threshold, those indicators were not omitted.

8.4.2 Inner model assessment

R^2 of endogenous latent variables

The coefficients of determination of the endogenous latent variables TR R^2 = 0.563 and SCA R^2 = 0.697 indicate moderate-large and large effects respectively (Chin, 1998b; Cohen, 1988). The complete model can thus explain 56.3% of variance in Trigger and 69.7% of variance in Social Capital Activation between September 2009 and September 2010.

Path coefficients

Path coefficients show the influence of one exogenous variable if the effects of other variables are kept constant. Interestingly, if the factors and relationships in the whole model are taken into account, the path coefficients of the Perceived Ability, Perceived Social Influence and Trigger latent variables are negative. At the same time, the Social Capital Activation latent variable has a significant positive correlation with Perceived Ability, Perceived Social Influence and Trigger. Consequently, this change in sign should be interpreted with great caution, as we are likely to deal with a negative suppressor variable. In essence, such variables suppress irrelevant variance in other exogenous variables, by this indirectly allowing for a more concise estimate of the relationship between exogenous and endogenous variables (Lancaster, 1999).

To identify a possible suppressor variable, we estimated the model after removing each of the remaining latent variables - Individual Motivation and Passive Social Capital - one at a time (Lancaster, 1999). The removal of Individual Motivation did not change the situation, and the path coefficients from Perceived Ability, Perceived Social Influence and Trigger to Social Capital Activation still remained negative. Consequently, Individual Motivation is not likely to cause the suppression effect. However, after removing Passive Social Capital from the model, the negative coefficients disappeared. Therefore, we can conclude that Passive Social Capital represents a suppressor variable, and suppresses the irrelevant variance in Perceived Ability, Perceived Social Influence and Trigger. In other words, Passive Social Capital explains significant variance in Perceived Ability, Perceived Social Influence and Trigger not otherwise associated with social capital activation. This reduces the common variance between Perceived

Ability, Perceived Social Influence, Trigger and Social Capital Activation. Thus, for example, while Perceived Ability has a weak positive correlation with Social Capital Activation, once all other factors from the model are taken into account, higher Perceived Ability scores predict lower Social Capital Activation.

Effect size

Calculation of the effect sizes suggests that the individual characteristics of academics such as Individual Motivation, Perceived Ability and Passive Social Capital prove to have a weaker influence on the presence of opportunities to engage in interaction with industry (i.e., Trigger) than Perceived Social Influence. Although in total, the model explains 56.3% of variance in Trigger, none of the individual factors proves to have a large effect on it. Consequently, trigger represents the result of a wide variety of factors instead of being determined by a limited set of strong predictors. Obviously, not all of those factors were included in the model, and future research should look for a broader range of factors. The effect sizes of the individual factors on the trigger are as follows: $f^2_{\text{IM \_> TR}} = 0.08$ (weak effect); $f^2_{\text{PA -> TR}} = 0.04$ (weak effect); $f^2_{\text{PSC -> TR}} = 0.09$ (weak effect); and $f^2_{\text{PSI -> TR}} = 0.25$ (moderate effect).

The analysis of the effect sizes in the complete model clearly shows that the structural relationships in the model are dominated by the presence of the Passive Social Capital latent variable. The effect sizes of the individual factors on the Social Capital Activation are as follows: $f^2_{\text{IM -> SCA whole model}} = 0.000303$ (trivial effect); $f^2_{\text{PA -> SCA whole model}} = 0.000606$ (trivial effect); $f^2_{\text{PSC -> SCA whole model}} = 1.76$ (very large effect); $f^2_{\text{PSI -> SCA whole model}} = 0.000303$ (trivial effect); and $f^2_{\text{TR -> SCA whole model}} = -0.08$ (small effect). As f^2 is always higher than 0, the last result may seem illogical. It can be explained by the fact that in PLS, the computation of constructs is not independent of the paths in the structural model, and removing structural paths leads to changes in the values of constructs. Because the values of the constructs are not fixed, they will vary to some degree with the form of the structural model.

Consequently, based on the results of the total sample, passive social capital of academics by September 2009 is the strongest predictor of the level of their social capital activation with industry between September 2009 and September 2010. However, it does not yet mean that the rest of the factors are not important and should be omitted.

Latent variable correlations

In this sub-section, we examine the individual effects of our latent variables. Table 8-3 presents the latent variable correlations and shows that all the proposed predictors of Social Capital Activation are positively associated with both the trigger and the actual social capital activation. There is also a positive relationship between the Trigger and Social Capital Activation. Furthermore, most of the examined effects are large (following Cohen's guidelines for the social sciences: small effect size $r = 0.1 - 0.23$; medium $r = 0.24 - 0.36$; large $r = 0.37$ or larger (Cohen, 1988, 1992)). Consequently, with other factors being equal, the proposed predictors of social capital activation are highly positively associated with the trigger and the actual social capital activation, by this confirming our hypotheses (H1a – H1d; H2a – H2d).

Table 8-3: Latent variable correlations

	IM	PA	PSC	PSI	SCA	TR
IM	1.000					
PA	0.503**	1.000				
PSC	0.310**	0.475**	1.000			
PSI	0.307**	0.438**	0.414**	1.000		
SCA	**0.238****	**0.327****	**0.829****	**0.275****	1.000	
TR	**0.500****	**0.562****	**0.518****	**0.624****	**0.362****	1.000

**. Correlation is significant at the 0.01 level (1-tailed).

These findings combined with the results above suggest that when taken individually, most of the proposed predictors of Social Capital Activation have a large effect on the actual social capital activation. However, when all taken into account, the effects of those predictors neutralize each other, and most of those predictors do not show a substantial effect on social capital activation anymore.

Mediation

After testing the individual mediation effects of the trigger on the relationships between the four predictors (Individual Motivation, Perceived Social Influence, Perceived Ability and Passive Social Capital) and Social Capital Activation, we were able to conclude that mediation is present in all four cases. The trigger does mediate the relationship between Individual Motivation and Social Capital Activation, between Perceived Social Influence and Social Capital Activation, between Perceived Ability and Social Capital Activation, and finally between Passive Social Capital and Social Capital Activation. In case of the latter, however, the mediation effect is of reversed nature, and there is a suppressor effect.

Table 8-4: Mediation effects of trigger in the relationship between four antecedents and social capital activation

Variable	a	b	a x b	Sd a_ib_i bootstrap	Significance test ($t_{0.05,\,499}$ = 1.96)	
					t **value**	**Interpretation**
IM	0.509	0.327	0.165	4.363	**4.363**	**Mediation, VAF = 0.684**
PA	0.563	0.271	0.153	0.041	**3.695**	**Mediation, VAF = 0.455**
PSC	0.521	-0.087	0.007	-0.045	**2.158**	**Mediation, VAF = 0.055, suppressor effect**
PSI	0.627	0.322	0.013	0.052	**3.879**	**Mediation, VAF = 0.719**

As described in Chapter 7, further analysis suggested that Passive Social Capital represents a negative suppressor variable, and suppresses the irrelevant variance in Trigger. In other words, Passive Social Capital controls for variance in trigger not directly associated with Social Capital Activation. This reduces the common variance between Trigger and Social Capital Activation in the complete model.

These results can be explained by the measurement approach employed in this study. The trigger refers to all possible reasons and opportunities for academics to engage in interaction with industry during the year in question. However, when analyzing mediation effects, we examined how this total pool of opportunities influences the relation between passive social capital and social capital activation for academics' relations with only a limited selection of industrial partners. As a result, most of the triggers proved to be irrelevant for the relationship in question.

Bootstrapping: Student's t-test for the Significance of Path Model Relationships

To identify confidence intervals for all parameter estimates, we have applied the bootstrap procedure (Davison, Hinkley, & Young, 2003; Efron, Tibshirani, & Tibshirani, 1993; Henseler et al., 2009). We created 500 sub-samples each containing 184 cases (equal to the number of cases in the original sample).

The results of bootstrapping suggest that when all taken into account, individual motivation, perceived ability, perceived social influence and passive social capital do have a statistically significant influence on trigger in the total population. Furthermore, the only factor that has a statistically significant influence on social capital activation in the total population is passive social capital. As was shown above, passive social capital explains significant variance in the rest of our anticipated predictors that is not otherwise associated with social capital activation.

In the next sub-section, we will analyze the influence of individual motivation, perceived ability, perceived social influence and trigger on social capital activation controlling for the hierarchical position, scientific domain and orientation, gender and the country of origin of academics.

8.4.3 Positional factors and control variables (Who, Where, When)

We conducted similar inner and outer model assessments for all sub-groups of the sample. No considerable differences were observed between those groups with regard to measurement model assessments. In this section, we examine the correlations between our latent variables when looking at different sub-groups within the sample.

Hierarchical position

Considerable differences can be observed between academics from different hierarchical positions (see Table 8-5). For example, the effect of the individual motivation of academics to engage in interactions with industry on the actual social capital activation markedly increases with their level of hierarchy. The influence of the academics' direct social environment (i.e., the behavior and opinions of their bosses, colleagues and research partners), in turn, proves to affect social capital activation more when academics are at the lower levels of hierarchy than when academics are on the top. Perceived social influence proves to be more important than academics' individual motivation to engage in interaction with industry for PhD candidates, while academics from higher levels of hierarchy seem to be more driven by individual motives. These findings confirm the results of the previous research suggesting that the influence of the chair on the behavior of academics is likely to vary depending on their hierarchical position (Bercovitz et al., 2008).

Table 8-5: Latent variable correlations for different positional factors and control variables

	IM	PA	PSC	PSI	SCA	TR
1. Hierarchical position						
Full professors and Associate professors						
SCA	0.420**	0.454**	0.834**	0.241*	1.000	
TR	0.565**	0.542**	0.403**	0.509**	0.246*	1.000
Assistant professors, Postdocs, Other						
SCA	0.262*	0.122	0.788**	0.176	1.000	
TR	0.592**	0.584**	0.444**	0.683**	0.271	1.000
PhD candidates						
SCA	0.130	0.306**	0.880**	0.356**	1.000	

TR	0.494**	0.531**	0.530**	0.634**	0.402**	1.000
2. Scientific orientation						
Academics whose scientific orientation is more Basic than Applied						
SCA	0.221*	0.310**	0.875**	0.239*	1.000	
TR	0.331**	0.537**	0.370**	0.567**	0.315**	1.000
Academics whose scientific orientation is equally Basic and Applied						
SCA	0.329**	0.457**	0.830**	0.340**	1.000	
TR	0.593**	0.523**	0.618**	0.695**	0.463**	1.000
Academics whose scientific orientation is more Applied than Basic						
SCA	0.106	0.165	0.796**	0.192	1.000	
TR	0.538**	0.585**	0.445**	0.537**	0.224*	1.000
3. Scientific domain						
Academics whose scientific domain is Biotechnology						
SCA	0.181	0.419**	0.892**	0.360**	1.000	
TR	0.541**	0.647**	0.536**	0.612**	0.418**	1.000
Academics whose scientific domain is Nanotechnology						
SCA	0.216*	0.148	0.776**	0.268*	1.000	
TR	0.482**	0.635**	0.522**	0.732**	0.287**	1.000
Academics whose scientific domain is other than Bio- or Nanotechnology						
SCA	0.330**	0.440**	0.813**	0.140	1.000	
TR	0.519**	0.402**	0.469**	0.518**	0.383**	1.000
4. Gender						
Female participants						
SCA	0.168	0.322**	0.837**	0.339**	1.000	
TR	0.415**	0.596**	0.537**	0.630**	0.414**	1.000
Male participants						
SCA	0.269**	0.314**	0.828**	0.248**	1.000	
TR	0.552**	0.545**	0.500**	0.624**	0.333**	1.000
5. Origin						
Dutch participants						
SCA	0.253**	0.360**	0.850**	0.285**	1.000	
TR	0.576**	0.598**	0.502**	0.645**	0.341**	1.000
Non-Dutch participants						
SCA	0.294**	0.214*	0.753**	0.291**	1.000	
TR	0.391**	0.519**	0.570**	0.600**	0.409**	1.000

**. Correlation is significant at the 0.01 level (1-tailed).
*. Correlation is significant at the 0.05 level (1-tailed).

Interestingly, the presence of trigger, i.e., the opportunities for academics to engage in interaction with industry, has a large effect on social capital activation only for PhD candidates, and is less important for academics from higher levels of hierarchy. This result can be explained by the fact that PhD candidates represent newcomers in terms of interaction with industry, and thus are more dependent on chances and opportunities to ‘enter the playing field’ than their senior colleagues.

Scientific orientation

The largest effects of the proposed predictors of behavior on social capital activation can be observed in the group of academics whose scientific orientation is equally Basic and Applied (see Table 8-5). In the other two groups with either Basic or Applied research being dominant, individual motivation, perceived ability, perceived social influence and trigger prove to have a weaker effect on the actual exploitation of social networks with industry. This difference can be explained by the fact that academics mainly engaged in Basic research are per definition less predisposed to interactions with industry, while academics mainly engaged in Applied research are per definition predisposed to actively interact with industry, and thus behavioral predictors such as individual motivation, perceived ability, perceived social influence and trigger play a less significant role in determining the behavior. In case of the academics equally engaged in Basic and Applied research, the academics have more ‘freedom’ to decide whether to engage in interactions with industry or not, and therefore there the traditional predictors of behavior play a greater role.

Scientific domain

For academics working in the field of Biotechnology, perceived ability has a considerably larger effect on social capital activation than for the academics from the Nanotechnology field (see Table 8-5). This difference can be partly explained by the highly sensitive intellectual property domain related to Biotechnology, and the corresponding implications for university-industry projects (Cantor, 2000; Conley & Makowski, 2003; Drahos, 1999). At the same time, Nanotechnology represents an emerging field, and the intellectual property domain there is less defined (Bowman, 2007). Consequently, not all academics from the Biotechnology field may feel confident when interacting with industry because of IP issues they have to deal with.

Furthermore, for academics working in Biotechnology, trigger proves to play a more important role on social capital activation than in case of Nanotechnology. This difference can be partly linked to the previous positional factor, i.e., scientific orientation. While in Biotechnology, the projects are more often equally of Basic and Applied nature, the Nanotechnology field demonstrates more extremes, i.e., the projects that are either highly Basic or highly Applied, with the largest part still being highly Basic and representing longer-term radical applications (Bowman, 2007). This, in turn can be explained by the fact that Nanotechnology is a newer technology when compared to Biotechnology; and the latter has a significantly closer link to the market than the first one (Mehta, 2004).

Gender

Our results thus suggest that gender does not have a substantial effect on the way our predictors influence social capital activation of academics engaged in interaction with industry (see Table 8-5).

Country of origin

This control variable was included in the study as academics working in the Netherlands and being engaged in interaction with industry often have to deal with Netherlands-based firms. This fact does not only imply potential language barriers, but also contextual and cultural differences for academics coming from other countries. Our data, however, does not demonstrate considerable differences between those two groups in terms of the effect of the proposed predictors of behavior and actual social capital activation (see Table 8-5).

8.5 CONCLUSIONS

In this final part of our research, we aimed to develop a comprehensive but parsimonious model of social capital activation by consolidating the findings from the previous chapters and building on both literature review and own empirical analyses. The proposed conceptual model proved to be testable and explained a substantial variance (about 70%) in academics' social capital activation with industry. Our results also confirmed the significant role of trigger in the process of social capital activation.

We modeled social capital activation as behavior resulting from the following factors: the individual motivation of academics (IM), the influence of their direct social environment (PSI), the ability of academics to interact with their industrial acquaintances (PA), the characteristics of their social networks with industry (PSC), and the presence of opportunities to engage in interaction with industry (TR).

The empirical results supported the hypotheses that the abovementioned exogenous constructs have a positive relationship with social capital activation. However, this relationship proved to be significant only when those factors were taken individually. When all taken into account, the effects of those factors neutralized each other, and most of those factors did not show a substantial effect on social capital activation anymore. The structural relationships in the model proved to be dominated by the presence of passive social capital or the results of academics' previous interactions with industry. This conclusion supports the role of prior experience suggesting that decisions an academic faces with regard to interaction with industry are determined by the decisions he or she has made in the past (Audretsch, Bönte, & Krabel, 2010; D'Este & Perkmann, 2010). Our results thus support the suggestion of various scholars that many crucial social phenomena can be adequately explained only in terms of prior experience (Aminzade, 1992; Griffin, 1992, 1993; Isaac, 1997; Mahoney, 2000; McDonald, 1996; Somers, 1998; Tilly, 1988). Our results also confirmed a mediator role of the trigger on the relationship between the four individual factors and social capital activation.

In addition, the results suggest that considerable differences can be observed between academics from different hierarchical positions, scientific orientations and scientific domains. For lower hierarchical levels (i.e., PhD candidates), the influence of the academics' direct social environment proves to be more important for social capital activation than their individual motivation to engage in interaction with industry, while academics from higher levels (Full professors and Associate professors) seem to be more driven by individual motives. In addition, the presence of certain opportunities for academics to engage in interaction with industry has a large effect on social capital activation only for PhD candidates, and is less important for academics from higher levels of hierarchy. This result can be explained by the fact that PhD candidates represent newcomers in terms of interaction with industry, and thus are more dependent on chances and opportunities to 'enter the playing field' than their senior colleagues.

The largest effects of the proposed predictors of behavior on social capital activation can be observed in the group of academics whose scientific orientation is equally Basic and Applied. In this case, the academics have more 'freedom' to decide whether to engage in interactions with industry or not, and therefore there the traditional predictors of behavior play a greater role.

For academics working in the field of Biotechnology, the relevant competences and skills necessary to interact with industry have a considerably larger effect on social capital activation than for the academics from the Nanotechnology field. This difference can be partly explained by the highly sensitive intellectual property domain related to Biotechnology, and the corresponding implications for university-industry projects. Our data however did not indicate considerable differences between female and male respondents, as well as Dutch academics and foreign academics working in the Netherlands.

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9 Conclusions and implications

"A conclusion is the place where you got tired of thinking."

Martin Henry Fischer (1879-1962), German-born American physician and author

In this chapter, we link the research findings back to the problem presented in the introductory section. We therefore begin by briefly recalling the research problem and research questions. We then move on to summarizing the key findings on each research question, and derive the overall conclusions. We elaborate on the implications for research and practice, and outline the limitations of the current study. We conclude by providing suggestions for future research.

9.1 INTRODUCTION

So far, scientific studies have contributed to the debate on university-industry interactions mainly by taking the perspective of firms (Cohen, Nelson, & Walsh, 2002; Fontana, Geuna, & Matt, 2006a) or the viewpoint of the university/department (Friedman & Silberman, 2003; Schartinger, Schibany, & Gassler, 2001; Tornquist & Kallsen, 1994). A few studies have actually taken individual academics as the unit of analysis (Agrawal & Henderson, 2002; Bercovitz & Feldman, 2003; D'Este et al., 2007). The latter group of studies has suggested various and often opposing explanations of what essentially drives academics to interact with industry. Furthermore, high heterogeneity among academics has been identified with regard to the number of industrial partners, the diversity of interactions, the duration and the frequency of interactions (Agrawal et al., 2002; Balconi et al., 2004; Cukierman, Fontana, Sarfatti, & Nuova, 2007; D'Este & Patel, 2007b). The reasons behind this heterogeneity, however, stayed underexplored, both theoretically and empirically (D'Este et al., 2007b). Consequently, there is a clear need for the integration of various research streams and for the development of a comprehensive understanding of the determinants of academics' engagement in interaction with industry. The current research aimed to contribute in this respect.

Given the noncompulsory nature of academics' engagement in interactions with industry, we first analyzed the essence of academics' motivation to engage in the behavior in question. We examined which specific motives comprised of wants and beliefs are the most significant in determining the academics' motivation to interact with industry. We hypothesized that not all motives are equally important for creating a general feeling of motivation to interact with industry, and that some motives play a greater role than others. Understanding the significance of specific motives is crucial for the design of effective public policies, since measures building on different motives imply considerably different approaches (e.g., support and facilitation of the academics' desire to solve practical problems vs. incentive systems designed to reward the attraction of additional funding). Public policies and incentive systems can therefore only be effective if the efforts are focused on the motives that prove to be significant enough to determine the academic's decision to interact with industry.

We then broadened our attention beyond academics' motivation and moved on to examining the role of the three key predictors of academics' engagement in interaction with industry suggested by the literature. We aimed at challenging multiple perspectives by means of their reciprocal confrontation and integration. The three different perspectives were as follows. First, academics are suggested to be driven by a set of specific motives to engage in interaction with industry (Goktepe & Mahagaonkar, 2008; Hull, 1988; Lee, 2000; Mansfield, 1995; Meyer-Krahmer & Schmoch, 1998; Stephan, 1996; Stephan & Levin, 2005; Stern, 2004; Stokes, 1997). Second, academics' behavior is argued to be determined by the norms and culture of the research department in which they are embedded (Bercovitz et al., 2003; Cukierman et al., 2007; D'Este & Patel, 2007a; Kenney & Richard Goe, 2004; Magnusson, McKelvey, & Versiglioni, 2008). Finally, academics' future decisions to interact with industry are suggested to be based on their past experiences (Audretsch et al., 2010; Hite, 2005). We hypothesized that these three groups of factors are not equally important for the behavior in question to occur. We examined the relative weight of these factors on the actual academics' behavior and compared the weights of these factors with each other. Such knowledge is essential for designing effective knowledge transfer policies and measures, as stimulating each of the three factors implies fundamentally different approaches.

Finally, in contrast to the predictive nature of the first two approaches, we turned to developing a mechanistic understanding of the behavior in question. We hypothesized that a certain behavioral mechanism exists that determines when and to what extent academics exploit their existing social networks with industry. By a mechanism here we mean constellations of factors that are organized such that they regularly bring about a particular type of outcome (Hedström & Ylikoski, 2010), i.e., social capital activation. The key benefits of a mechanistic understanding of behavior refer to the ability to explain why it happens and thus to control/shape that behavior, if necessary. Such knowledge could better equip policy makers and university administrators to adjust their current strategies and measures with regard to university-industry interactions. The mechanistic understanding could help scholars and practitioners learn how to influence the development of social capital of academics and how academics can get most out of its potential effects. To achieve this objective, we called upon a broad range of relevant theories that so far have been outside the scope of existing literature on university-industry interactions. We aimed to identify a broader range of factors that are likely to determine academics' engagement in interaction with industry, as well as the relations between those factors. We then examined how these factors change or what new factors can be formulated as a result of their reciprocal confrontation. We also examined previously unexplored moderating effects of the factors included in the model.

Consequently, the current study represents a multi-dimensional analysis of the question of why academics interact with industry. By combining various approaches, we aimed to minimize the inadequacies of individual perspectives and to address the threats to internal validity, thereby achieving a stronger research design and more valid and reliable research findings. The next section summarizes the conclusions on each of the abovementioned research questions.

9.2 CONCLUSIONS ON EACH RESEARCH QUESTION

We begin by summarizing the conclusions on the question of which specific motives are the most significant in determining the academics' motivation to interact with industry. We then move on to the conclusions on the role of the three key predictors, the role of positional and dispositional factors, the role of the trigger, and on the developed model of social capital activation.

9.2.1 Examining the roles of specific motives

In this part of the research, we examined to what extent eight specific motives from the literature are accountable for the academics' general feeling of motivation to interact with industry (research question 1). Key conclusions with regard to this research question are as follows:

- The major part (60%) of the academics' motivation to engage in interaction with industry cannot be explained by those eight specific motives.

- Only two specific motives demonstrated a significant impact on a general feeling of motivation to interact with industry: the motive of solving practical problems and the motive of getting access to industry knowledge. Both of those motives are of intrinsic nature. The results confirm the conclusions of D'Este and Perkmann (2010) who found that most academics engage in interaction with industry to advance their own research through learning rather than to become entrepreneurs.

- None of the extrinsic motives proved to be significant in forming the general feeling of enthusiasm about and openness towards interaction with industry. In addition, the results confirmed that the identified eight motives are not redundant and all carry different meaning. Therefore, their low individual significance is not related to potential overlap in their meaning.

- The other six specific motives did not prove to be significant in creating a general feeling of academics' motivation to interact with industry. These motives include recognition within the scientific community, reputational rewards, supporting teaching duties, getting access to industry facilities, getting promotion on a career ladder and keeping abreast of industry problems.

- The motive of keeping abreast with industry problems proved to be significant only for academics whose scientific orientation is more basic than applied. It can be explained by the fact that academics working on applied research per definition are aware of certain industry problems, and thus may not see it as a strong motivator for them to interact with industry.

- In general, academics engaged in interaction with industry are not primarily driven by the desire to obtain additional funding, which does not confirm the hypothesis that "that scientists are motivated by the same kinds of extrinsic rewards as 'everybody else', namely position and money" (Hangstrom, 1965, p. 52; quoted in Gustin, 1973, p. 1120). For academics higher than PhD candidates, this motive does prove to be significant. It can be explained by the fact that the need to obtain additional funding for a research group, graduate students or laboratory equipment becomes important at later stages of academic career, and is less relevant for PhD candidates.

- The identified eight motives explain the general feeling of academics' motivation to interact with industry much better for academics engaged in a few different types of interactions than for the ones engaged in many different types. These results suggest that academics' motivation to interact with industry depends on the type of interaction, and when different types of interactions and various motives are put together, the impacts of specific motives may neutralize each other.

9.2.2 Comparing the roles of motivation, embeddedness and prior experience

In this part of the research, we examined to what extent motivation, embeddedness and prior experience are able to predict academics' behavior, and identified relative weights of each of those factors (research question 2). In addition, we examined the differences in the role of those factors between academics from different hierarchical positions, scientific orientations and scientific domains, as well as genders and origins. Key conclusions with regard to this research question are as follows:

- When examined individually, the three factors have a significant effect on academics' social capital activation with industry. Prior experience clearly proves to be the strongest predictor, while motivation and embeddedness play a secondary role, though still significant.

- In general, the norms and culture of the research department proved to be slightly more important than academics' own desire to pursue their teaching, research and possibly commercialization interests by actively engaging in university-industry interactions.

- When all taken into account, the effects of the three factors neutralize each other, and factors such as motivation and embeddedness do not show a substantial effect on the actual engagement of academics in interactions with industry anymore.

- The role of embeddedness decreases with higher levels of hierarchy, while the role of own motivation increases as academics move up to higher levels of hierarchy. These findings are hardly surprising since the more senior an academic becomes, the more he or she influences the surrounding environment (e.g., becomes a role model for others, creates norms and shapes culture etc.). These findings are also in line with the results of Bercovitz and Feldman (2008) who suggested that the influence of the chair on the behavior of academics is likely to vary depending on their hierarchical position.

- Although the role of embeddedness and motivation change with the career cycle, it is still prior experience that primarily determines the academics' level of engagement in interactions with industry. Unlike embeddedness and motivation, the role of prior experience is less dependent of the career cycle.

- For the academics whose scientific orientation is more applied than basic, own motivation proves to play a weaker role in determining their actual behavior than for their ‘more basic’ colleagues.

- Our results did not indicate significant differences between academics from different scientific domains (biotechnology vs. nanotechnology). Neither did we find differences between Dutch and foreign-born academics with regard to the role of the three predictors on the actual level of engagement in interactions with industry. The latter is in line with the findings of Lee (2004) who showed that language and culture of foreign-born academics do not influence the number of collaborations when compared with their ‘local’ colleagues.

9.2.3 Examining the moderating effects of positional and dispositional factors

In this part of the research, we analyzed the moderating effects of dispositional and positional factors on the relationship between passive social capital and social capital activation (research question 3). Key conclusions with regard to this research question are as follows:

- Although most of the detected moderating effects are small, they can still be meaningful in explaining the entrepreneurial behavior in question (Chin, Marcolin, & Newsted, 2003).

- No significant differences were found between the moderating effects of positional and dispositional factors. A possible explanation for these results refers to a low significance of all of the examined moderating effects themselves which, in turn, makes the difference between these effects less likely to be significant for the relationship in question. Besides, testing the exploratory hypotheses based on the whole sample does not take into account the issue of high heterogeneity of academics, thereby decreasing the likelihood of detecting significant effects.

- One of the ways to minimize these limitations is to test the moderating effects of dispositional factors through the prism of positional factors, as was presented in the next part of the analysis. Although the effects detected by the second approach are small, they prove to be significant and are worth further examination.

- For academics from higher hierarchical positions, the perceived social influence to interact with industry proved to affect the relationship between passive social capital and social capital activation in a negative way. An explanation for these findings can be as follows. Professors and other senior academics often already have their “own agenda” with regard to their teaching, research and commercialization activities, and a more powerful position in academia and in the network with industry (Van Dierdonck, Debackere, & Engelen, 1990). As a result, they may ‘dare’ to go against the accepted norms of their research group contrary to their less senior colleagues.

- For academics with a more basic scientific orientation, interactions with industry occur without significant influence of their own motivation on it. The moderator role for this group of academics proved to belong to their perceived ability to interact with industry. The perceived ability is associated with the academics’ ability to work according to industry standards, operate with wide bodies of knowledge, balance conflicting interests of incentive systems between academia and industry, and have a good understanding of practical applicability of scientific concepts. These findings are in line with Lockett et al. (2005) who argued that many academics who are willing to commercialize their research do not have the necessary capabilities to do so.

9.2.4 Examining the role of trigger

In this part of the research, we analyzed the role of the trigger in the relationship between passive social capital and social capital activation (research question 4). Key conclusions with regard to this research question are as follows:

- The examination of the moderating effects suggested that the trigger has a trivial influence on the relation between passive social capital and social capital activation. Furthermore, when the trigger is low, passive social capital predicts social capital activation even slightly better than when the trigger is high. However, when passive social capital is not taken into account, the trigger has a significant positive association with social capital activation.

- These findings need to be treated with caution as the reason for this counterintuitive result is likely to be related to other factors not taken into account by this model. For example, it may be not only the quantity of triggers that matters, but also the quality of emerging opportunities (e.g., long-term engagements with industry vs. short informal contacts).

- Another possible explanation for these results can be found in the measurement approach employed in this study. When analyzing moderating effects, we examined how this total pool of opportunities influences the relation between passive social capital and social capital activation for academics' relations with a limited selection of industrial partners. The fact that we looked at a limited selection of industrial partners inevitably creates a certain bias in our approach.

- The total pool of opportunities for academics to interact with industry does not significantly influence the relation between passive social capital and social capital activation, given that the latter two are related to the five industrial partners with whom academics had the strongest connections at the beginning of the year in question. Most of the opportunities from the total pool are thus likely to be irrelevant for those particular connections. Furthermore, some opportunities may even distract academics from interaction with those particular connections, thereby explaining a slight negative effect.

- The mediator role of the trigger in the relationship between passive social capital and social capital activation was confirmed; however a suppressor effect was detected. Further analysis showed that passive social capital represents a negative suppressor variable, and suppresses the irrelevant variance in trigger. This result indicated that the notion of the trigger should not be abandoned.

9.2.5 Developing a parsimonious model of social capital activation

In the final part of the research, we aimed to develop a comprehensive but parsimonious model of social capital activation. We consolidated the findings from the abovementioned research questions into one model of social capital activation. We modeled social capital activation as a result of the interaction of the following factors: academics' individual motivation to interact with industry, the influence of their direct social environment (e.g., head of department, peer colleagues, academic partners), the ability of academics to interact with their industrial acquaintances, the characteristics of their social networks with industry (i.e., passive social capital), and the presence of opportunities to engage in interaction with industry or trigger.

When analyzing the proposed model of social capital activation, the empirical results supported the hypotheses that the abovementioned exogenous factors have a positive relationship with social capital activation. However, this relationship proved to be significant only when those factors were taken individually. When all taken into account, the effects of those factors neutralized each other, and most of those factors did not show a substantial effect on social capital activation anymore.

The structural relationships in the model proved to be dominated by the presence of passive social capital or the results of academics' previous interactions with industry. This conclusion supports the role of prior experience suggesting that decisions an academic faces with regard to interaction with industry are determined by the decisions he or she has made in the past (Audretsch et al., 2010; D'Este et al., 2010).

Additionally, the results suggest that considerable differences can be observed between academics from different hierarchical positions, scientific orientations and scientific domains. For example, the presence of certain opportunities for academics to engage in interaction with industry has a large effect on social capital activation only for PhD candidates, and is less important for academics from higher levels of hierarchy. This result can be explained by the fact that PhD candidates represent newcomers in terms of interaction with industry, and thus are more dependent on chances and opportunities to 'enter the playing field' than their senior colleagues.

The largest effects of the proposed predictors of behavior on social capital activation can be observed in the group of academics whose scientific orientation is equally basic and applied. In this case, the academics have more 'freedom' to decide whether to engage in interactions with industry or not, and therefore there the traditional predictors of behavior play a greater role. For academics working in the field of biotechnology, the relevant competences and skills necessary to interact with industry have a considerably larger effect on social capital activation than for the academics from the nanotechnology field. This difference can be partly explained by the highly sensitive intellectual property domain related to biotechnology, and the corresponding implications for university-industry projects. Our data however did not indicate considerable differences between female and male respondents, as well as Dutch academics and foreign academics working in the Netherlands.

9.3 CONCLUSION ABOUT THE RESEARCH PROBLEM

The key objective of this research was to develop a comprehensive but parsimonious model that provides insight into the key determinants of academics' social capital activation with industry, and to understand and explain the way these determinants lead to actual behavior.

Academics' social capital activation with industry proved to be a complex process of heterogeneous nature resulting from the interaction of multiple factors that enhance or, on the contrary, neutralize each other. The following general mechanism behind academics' social capital activation with industry can be derived based on the study results. Decisions an academic takes with regard to social capital activation with industry are primarily determined by the decisions he or she has made in the past (Audretsch et al., 2010; D'Este et al., 2010). The decisions made in the past result in a certain range of social network characteristics such the number of industrial partners in the network, closeness, multiplexity of roles and history of interactions. These factors represent academic's passive social capital with industry. The past behavior of academics regarding their participation in university-industry interactions transformed into their passive social capital with industry thus generates a strong imprint and leads to an expectation to continue these activities in the future (Bercovitz et al., 2003; D'Este et al., 2007a). With increasing returns, a behavioral pattern of interaction with industry – once adopted – delivers increasing benefits with its continued adoption, and thus over time it becomes more and more difficult for academics to transform this pattern. The nature of academics' engagement in interaction with industry can therefore be thought of as 'inertia', i.e., once a process of interaction with industry is set into motion and begins generating certain outcomes, this process tends to stay in motion and continue to generate those outcomes (Mahoney, 2000). Following the same algorithm, for academics previously not engaged in interactions with industry, the chance of doing so in the future is thus lower than for their colleagues who actively interacted with industry in the past.

Besides passive social capital, a set of positional factors also proved to have influence of social capital activation. These factors include academic's individual motivation to interact with industry, perceived social influence and perceived ability to do so. Individual motivation refers to a general feeling of enthusiasm about doing something professionally interesting and enjoyable, interest in and openness towards engaging in interaction with industry. Perceived social influence corresponds to a general feeling of social pressure to engage in interaction with industry, including references to expectations, duty and opinions of important people such as heads of department, peer colleagues and other academic partners. Finally, perceived ability is related to a general feeling of academic's ability to engage in interaction with industry that is, among others, associated with comfort, confidence and easiness. Furthermore, the relationship between the abovementioned factors and social capital activation proved to be mediated by a trigger (event or reason for an interaction to occur).

The strength of the relationship between the abovementioned factors and social capital activation, in turn, proved to depend on a number of moderating factors. These refer to positional characteristics such as hierarchical position, scientific orientation and scientific domain. Although most of the detected effects are small, they are worth further examination.

The proposed conceptual model proved to be testable and explained a substantial variance (about 70%) in academics' social capital activation with industry.

9.4 IMPLICATIONS FOR RESEARCH

Our analysis contributes to the debate on the role of individual academics in the process of university-industry interactions by shedding light on the question of who interacts with industry and why (Audretsch et al., 2010; Bercovitz et al., 2003; D'Este et al., 2007a; D'Este et al., 2010). By this study we aimed to contribute to the 'humanization' of the research on university-industry interactions. Empirical studies in the field mainly looked at the determinants of such interactions from either the perspective of firms (Cohen et al., 2002; Fontana, Geuna, & Matt, 2006b) or the university/department (Geuna, 1999; Tornquist et al., 1994), while the design of effective policy measures requires a good understanding of factors related to the key actors in the knowledge transfer process, i.e., academics themselves (D'Este et al., 2010; Magnusson et al., 2009).

To our knowledge, the study represents the first attempt to measure the relative weight of specific motives on the academics' general motivation to engage in interaction with industry. Furthermore, instead of exclusive focus on the 'wants' (or 'attitudes') component of motives, we pay attention to the interaction of wants and beliefs, thereby covering both the desirability (wants) and feasibility (beliefs) of specific benefits related to interaction with industry. Our results suggest that the major part of the academics' general motivation to engage in interaction with industry cannot be explained by the eight motives included in the study. The motives employed by the study, however, cover the majority of motives presented in the literature on university-industry interactions. These findings thus indicate a need for future studies to look for other potentially significant motives not yet mentioned in the literature. In addition, our results indicate the complex nature of academics motivation to engage in interaction with industry, and this complexity should not be ignored by future studies.

By this study we introduced the notion of passive and active modes of social capital to the university-industry and entrepreneurship literature. The study presents social capital as a dynamic asset that is itself an exogenous force. Rather than focusing on the effects of social capital, in this study, we focused on its nature, which is a promising avenue for entrepreneurship research for years to come (Adler & Kwon, 2002; Glaeser, 2001). In addition, we offered a structured approach towards measuring the level of academics' social capital activation with industry. We suggested treating it as a complex multi-dimensional phenomenon that can hardly be expressed by one single characteristic. Existing literature on university-industry interactions lacks a clear agreement on such characteristics which often leads to fragmented approaches. We derived that the level of academics' engagement in interactions with industry can manifest itself as the following four characteristics: the size of exploited network, as well as the multiplexity, frequency and total duration of interactions during a certain period of time, for instance, one year.

By developing a set of reliable and valid measures for both passive and active modes of social capital we aimed to help social capital scholars to trace its development in time, i.e., to analyze how social capital is accumulated, maintained and changed. The analysis of the effect of passive social capital on social capital activation in the future, in turn, helps predict how social capital will be exploited in the future, and consequently also the corresponding effects of its exploitation in the future. The proposed set of measures thus allows scholars to empirically treat social capital as a dynamic asset and improves our understanding of the essence and causes of social capital. In addition, the notion of social capital activation allows analyzing returns on investment related to social capital formation (i.e., the creation and maintenance of social capital) and thus measuring productivity of social networks, which might be of particular interest for scholars studying formal relations.

Furthermore, in the current study, we broadened our attention beyond academics prominent in university-industry interactions and also examined academics who interact with industry to a lesser extent. The latter represents an advancement of the existing research on university-industry interactions, which has been exclusively focusing on so called "star scientists" (Zucker & Darby, 1996). It is only possible to distill the actual drivers of academics' behavior if we analyze both actively engaged academics and their less actively engaged colleagues. Such approach, however, often requires gathering primary data, as existing databases typically do not record data on "less active" academics. This approach allowed for the statistical analysis of the relative contribution of each of the three factors into the actual behavior.

While existing research emphasizes the role of academics' motivation and the influence of their research group, our results suggest that academics' engagement in interactions with industry is primarily determined by their previous experiences. The notion of prior experience can thus be a promising avenue of research on university-industry interactions for years to come.

In this study, we analyzed a specific manifestation of entrepreneurial behavior, i.e., the exploitation of social capital by entrepreneurial academics in the context of university-industry interactions. This behavior often precedes spin-off creation and various other forms of entrepreneurship, and thus can be helpful in spotting potential entrepreneurs, as well as in explaining why, when and how some academics and not others demonstrate entrepreneurial activity. This type of reasoning is also in line with the key sets of research questions about entrepreneurship proposed by Shane and Venkataraman (2000).

9.5 IMPLICATIONS FOR PRACTICE

First of all, academics engaged in interactions with industry themselves will benefit from a better understanding of the circumstances under which they exploit their social networks with industry. The research may help them to understand why they made certain choices in the past and how their social capital is likely to develop in the future. We showed that these choices can be partly explained by their hierarchical position, scientific orientation and scientific domain. However, the main predictor of their social capital activation in the future refers to the characteristics of their existing social networks with industry, and not their motivation, the influence of their direct social environment or their perceived ability. It may often be challenging for newcomers to ‘enter the playing field’, but once they are in, their future behavior is to a high degree predetermined. The key challenge is therefore not to make sure that academics keep collaborating with industry, but to make sure they ‘enter the playing field’. Consequently, if policy makers and university administrators want to stimulate university-industry interactions, the academics should primarily be supported in their efforts to build and maintain their social networks with industry.

Policies building on the notion of prior experience need to aim at creating opportunities for newcomers to get involved in projects with industry. Such newcomers usually refer to PhD students and postdocs with hardly any connections to industry. The assistance and reputation of their senior colleagues and supervisors is thus crucial for linking them with industrial partners (see also Lazega, Mounier, Jourda, & Stofer, 2006). We expect that the role of prior experience holds also for academics not engaged in interaction with industry. Therefore, the longer the academics stay within the boundaries of the university, the more difficult it becomes for them to change this behavioral pattern in the future. Boosting university-industry interactions is a long-term process, and that it is the younger generation of academics that needs to be targeted by knowledge transfer policies, as those academics are more likely to evolve into prominent collaborations with industry than their more senior colleagues that have not done so yet. At the same time, more senior academics who are currently actively engaged in interactions with industry should be stimulated to support their younger colleagues in bringing them in touch with industry. In addition, our results suggested that the presence of trigger, i.e., opportunities for academics to engage in interaction with industry, has a large effect on social capital activation only for PhD candidates and is less important for academics from higher levels of hierarchy. Therefore, the PhD candidates are more dependent on chances and opportunities to ‘enter the playing field’ than their senior colleagues, and require their support.

When designing specific policies and measures, policy makers and university administrators also should take into account that academics do not represent a homogenous population. Neither do they have homogeneous motives to engage in university-industry interactions. For instance, while academics from lower hierarchical levels prove to be better stimulated by the opportunity of solving practical problems and getting access to industry knowledge, academics from higher hierarchical levels are likely to be more driven by the motive of obtaining additional funding. However, in general, the motives that make interaction with industry enjoyable and interesting for academics refer to the ones related to learning and advancing their own research. Academics’ motivation to interact with industry is primarily driven by the expected benefits from solving practical puzzles, gaining new insights, receiving feedback on their research and accessing new knowledge (see also D’Este et al., 2010; Rosenberg, 1982). Consequently, the promoted benefits of university-industry collaboration should relate to these research-oriented motives.

Finally, by building on the notion of passive and active modes of social capital, we aimed to show that the added value of social networks is derived from their use. If no use will be made of those networks in the future, the investments made by practitioners in those networks are not likely to lead to any results. Consequently, if a practitioner wants to keep a certain contact in his or her passive network, regular follow-ups of communication are required, otherwise that connection is likely to deteriorate with time. By deterioration we mean situations when people do not consider each other as acquaintances anymore. The weaker the connection, the less time is needed for that connection to deteriorate if it does not get used. Consequently, a lifespan of a social connection can vary from several weeks for extremely weak connections to decades for extremely strong connections. At the same time, too much activation of social capital or overinvestment can also create a negative effect by distracting from other interactions, tasks and roles. These implications may be of particular interest to management practitioners.

9.6 LIMITATIONS

The current study has a number of limitations. First, the conceptual model builds on the principle of aggregation and therefore does not allow predicting a specific behavior in a given situation. Nor does the model explain the differences between behaviors across situations. However, since the model aims at deriving general behavioral patterns related to social capital activation, it is crucial to employ the principal of aggregation, and this limitation therefore could not be avoided.

Second, the conceptual model builds on the assumption that the individual is always aware about his or her motivation, ability and social influence around and that individual's behavior can be explained by examining individual's perceptions with regard to the antecedents of his or her behavior. However, it might not always be the case. It might be reasonable to assume that individual's behavior might also be influenced by factors that he or she is not aware of or does not consider important. To address this limitation when collecting the data, we included several additional variables that are not related to the individual's perceptions (e.g., academic's origin (local or foreigner); scientific orientation (basic or applied); scientific domain etc.).

Third, we have not included factors like personality traits in our model. As argued by Ajzen (1991), the low empirical relations between general personality traits and behavior in specific situations have led theorists to claim that the trait concept is unsound (see also Mischel, 1968 quoted in Ajzen, 1991). Therefore, predicting entrepreneurial behavior of academic researchers by modeling their personality traits is likely to result in disappointingly small explanatory power. As a result, these factors do not form a part of this model.

Furthermore, the notion of trust was also not included in the model. Most scholars consider trust a dominant component of social capital and reliable networks (Adler et al., 2002; Bowey & Easton, 2007; Portes, 1998; Portes & Sensenbrenner, 1993), and we agree that trust can be used as a powerful explanation for questions like why individuals engage in interaction with certain actors and not with the others. However, the current study does not aim to examine the role of trust in activation of social capital, considering trust necessary but not sufficient condition for social capital to be activated. Our research was based on the assumption that trust is already present (see, for example, the concept of "enforced trust" implying that obligations are enforced on both parties by broader community by Adler et al., 2002; Portes et al., 1993).

The conceptual model represents a simple causal model that documents a one-way causal chain of independent, intervening and dependent variables. However, actual social processes are usually more complex and involve feedback loops, reciprocal causal effects, lag effects, threshold effects etc. (Turner, 1988). In the context of the current study, it would be reasonable to suggest that there is a feedback loop from social capital activation back to readiness to activate social capital in the future. For example, positive experience from social capital activation is likely to increase passive social capital of an academic by increasing the closeness to a particular interaction partner and/or the number of partners with whom this academic could interact in the future. Similar effects could be observed with regard to individual motivation, perceived social influence, and perceived ability. The mechanism behind social capital activation is thus a complex process of cyclical nature; however, this complexity is not yet reflected in the current model. This approach was chosen by us intentionally in order to be able to focus on the primary causal relations of the model and to keep the model empirically testable. We leave it up to the future research to advance the model by exploring new configurations of causal effects among suggested variables.

In this study, we analyzed the significance of various specific motives relevant to various types of interactions by putting them all into one model. However, as mentioned above, our findings confirmed that academics' motivation to interact with industry depends on the type of interaction, and, when put all together, the impacts of specific motives may neutralize each other. Consequently, low weight of specific motives can also be attributed to a broad orientation of our approach. Future studies should aim to analyze the significance of specific motives per specific type of interaction.

When assessing the adequacy of our formative measures by means of the redundancy analysis (Chin, 2010), we were able to conclude that our formative sets did not demonstrate a sufficient convergence and an adequate coverage of the meaning of our reflective constructs. As a result, formative constructs had to be removed from the analysis at the structural level. Our conclusions are thus exclusively based on the analysis of the model with reflective constructs. This situation can be explained by the fact that the latent variables employed in the study (e.g., academics' motivation to interact with industry) are of highly complex nature and are formed by a wide variety of factors. Obviously, not all of those factors were included in the measurement model. Future studies should therefore broaden a set of employed formative measures and/or reconsider the threshold for sufficient adequacy of those measures (currently, a path of 0.8 or above is considered to be able to secure an adequate, i.e., comprehensive, set of measures; see Chin, 2010).

Finally, as mentioned above, another limitation of the methodology refers to the retrospective nature of the study instead of longitudinal analysis. When measuring passive social capital and social capital activation in a retrospective way, the timeframe the respondents can be asked about is rather limited, i.e., asking the respondents to recall the characteristics of their social capital five years ago is likely to lead to missing or unreliable data since the respondents will most likely have difficulties with remembering what the situation was like five years ago. Therefore, in this study, we asked the respondents to report on their passive social capital with industry one year ago, and on their social capital activation during the last year. Although such approach leads to more precise data on social capital characteristics (than if we were asking the respondents about the timeframe of five years), it also creates a certain bias in the influence of passive social capital at a certain moment of time on social capital activation in the future. Given that academics' collaboration with industry is often of long-term nature, when looking at a shorter timeframe, the role of passive social capital is likely to be exaggerated. The presence of strong connections with industry at a certain moment of time is more likely to lead to social capital activation in the next year than in the next five years. As a result, the role of passive social capital in social capital activation as detected by this study is likely to be inflated. In the next section, we provide some suggestions on how future studies can overcome this limitation.

9.7 SUGGESTIONS FOR FUTURE RESEARCH

In this study, we examined specific expression of entrepreneurship – entrepreneurial academics in a broader sense, or academics seeking to advance their teaching, research or commercialization activities by means of interactions with industry. Given the central role of these academics and their social networks in university spin-off creation and other forms of entrepreneurship (Meyer, 2003), it is crucial to keep advancing our knowledge on the key drivers of their behavior.

Future studies should aim at studying the dynamics of social capital by means of a longitudinal research (Mosey & Wright, 2007) in which individual's passive and activated social capitals are assessed at various points in time. As mentioned above, we recommend the distance between these points in time to be five years. Such approach is likely to minimize the bias related to the role of passive social capital at a certain moment of time in social capital activation in the future. Additionally, more detailed group analysis is needed (e.g., specific hierarchical positions), and additional variables should be introduced (e.g., scientific reputation, scientific domain, country of origin).

Furthermore, in this study, we exclusively focused on the intrinsic motivation of academics associated with their genuine interest, enthusiasm and excitement with regard to interactions with industry. However, academics' motives may also be of extrinsic nature, e.g., obtaining additional funding for a research group, graduate students or laboratory equipment. Future studies should test the influence of the latter type of motivation on the relationship in question. This is likely to be especially important for PhD candidates as those usually do not decide themselves whether or not they engage in collaboration with private firms, but rather follow the decision of their supervisor.

We modeled specific motives as having a direct influence on the academics' willingness to engage in interaction with industry. However, not all specific motives may be directly relevant for creating a general willingness, and some of them may be mediated by others. Future studies should aim at examining the causal relations between the specific motives and their potential mediator role between other specific motives and the general feeling of motivation.

Future studies, should also, when possible, introduce valid and reliable formative measures to the model thus allowing for analysis of the sources of each of the factors. For example, individual motivation could be modeled as a set of specific motives; perceived ability could be presented as a set of specific skills and competences, and perceived social influence could be operationalized into a set of opinions and behaviors of actors from the direct social environment of academics. Furthermore, additional control variables may be included corresponding to both individual (e.g., scientific excellence) and institutional (e.g., university reputation) characteristics. Future research efforts should also be devoted to identifying the critical minimums of individual motivation, perceived social influence, perceived ability, passive social capital and trigger for social capital of entrepreneurial academics to be activated. Finally, other causal relationships between the factors from the model should be explored, both theoretically and empirically.

The future studies should also try to ensure a better consistency in measuring trigger, passive and activated social capitals. When feasible, the future studies should aim at capturing the whole network and the whole pool of triggering opportunities. In most cases, however, such approach will represent a challenge, and instead, more specific measures of a trigger will need to be employed. These measures should refer to the reasons and opportunities related to a limited selection of industrial partners included in the analysis. Future studies thus should aim at developing a more detailed typology of triggering events and examine the moderating and mediating role of specific types of triggers instead of treating it as one general pool.

Finally, our findings do not imply that motivation and embeddedness have a marginal role in shaping academics' behavior. Although when compared to the role of prior experience, these factors prove to be of secondary importance, they are also significant. Academics' own motivation, as well as the norms and culture of their research department are likely to be more crucial for the initiation of the process of interaction with industry, while experience is more important for its continuation. While such interdependencies are beyond the scope of this research, they may represent another fruitful area for future research.

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Summary in English

The design of effective knowledge transfer policies and incentive systems requires a good understanding of why academics activate their social capital with industry at all. The current research showed that academics' social capital activation with industry is a complex process of heterogeneous nature resulting from the interaction of multiple factors that enhance or, on the contrary, neutralize each other. Decisions an academic faces with regard to social capital activation with industry proved to be primarily determined by their experience in the past. Policies building on the notion of prior experience need to aim at creating opportunities for newcomers to get involved in projects with industry.

Research problem

The evidence that economic growth is dependent on university-industry interactions has boosted the number of national and international policies and programs oriented towards promoting such interactions. Given a central role of universities in this process, a growing number of initiatives specifically targets academic institutions. However, policies that are primarily targeted at institutions are likely to have a limited impact unless those take a better account of individual academics engaged in interactions with industry. As interaction with industry is not a compulsory task contrary to teaching, new incentive mechanisms are needed to specifically encourage academics to activate their social capital with industry. The design of effective knowledge transfer policies and incentive systems, in turn, requires a good understanding of why academics activate their social capital with industry at all.

Existing research on this issue is, however, fragmented and scarce. Scientific studies that so far have contributed to the debate on university-industry interactions have mainly analyzed the determinants of those interactions either from the perspective of firms or from the viewpoint of the university/department. A few studies have examined the issue taking individual academics as the unit of analysis. The studies that do look at individual academics, in turn, follow heterogeneous and often non-converging approaches and typically exclusively focus on basic demographic variables (e.g., age, hierarchical position and gender).

Although such approach enriches our knowledge on university-industry interactions, it also has a limitation. Such approach does not provide us with knowledge on factors that can be influenced, and how exactly the desired behavior can be stimulated, i.e., knowledge essential to the development of effective policies and measures. The current study aims to contribute in this respect.

Research objective and research questions

The overall objective of this research can be formulated as follows: to develop a comprehensive but parsimonious model that provides insight into the key determinants of academics' social capital activation with industry, and to understand and explain the way these factors lead to actual behavior.

In order to achieve this objective, we analyze the question of why academics activate their social capital with industry from the following perspectives:

- by examining the role of specific motives in forming the general motivation of academics to activate their social capital with industry (research question 1);
- by examining the role of three key predictors of academics' engagement in interaction with industry suggested by the literature on university-industry interactions (research question 2);
- by examining the moderating effects of dispositional factors (perceived social influence, motivation and perceived ability) on social capital activation, and the influence of positional factors (hierarchical position, scientific orientation, scientific domain) on this relationship, as well as by comparing these effects with each other (research question 3);
- by examining the moderating and mediating roles of trigger in the relationship between passive social capital and social capital activation (research question 4); resulting in
- consolidating findings into a parsimonious model of social capital activation.

When working with different perspectives, we called upon a broad range of relevant theories some of which had been outside the scope of existing literature on university-industry interactions. For example, we consulted existing behavioral theories, including entrepreneurship theories such as Ajzen's Theory of Planned Behavior and Shapero's Model of Entrepreneurial Event, and more general models of behavior such as the MOA framework, Goldman's theory of human action and other models. Our task was to identify the key factors that are likely to lead to social capital activation, as well as the most important relations between those factors.

The current research thus focuses on theory building (i.e., constructing and modeling a theory) rather than theory testing. The research implies inductive reasoning. The inductive reasoning refers to the process of developing a model based on a broad literature base and on various empirical analyses conducted in the course of the current study. The inductive logic of the research is combined with the definition of research questions, and even a priori constructs.

Proposed model

According to the proposed conceptual model, social capital activation represents the result of a two-stage process that starts with the readiness of an individual to activate social capital. This readiness leads to the actual activation only in the presence of a trigger. The latter implies the presence of opportunities or reasons to engage in interaction with industry. The readiness to activate social capital represents a joint effect of four factors: academics' individual motivation to interact with industry, the influence of their direct social environment (e.g., head of department, peer colleagues, academic partners), the ability of academics to interact with their industrial acquaintances, and the characteristics of their social networks with industry (i.e., passive social capital). As a general rule, the greater the readiness of an individual to activate it, the higher the chance of a trigger to occur, the higher should be the level of social capital activation.

Each specific research question implied own conceptual model. By developing and integrating multiple perspectives, we aimed to acquire a comprehensive understanding of the phenomenon in question. Such approach is likely to result in a stronger research design and more valid and reliable research findings. It minimizes the inadequacies of individual perspectives and addresses the threats to internal validity.

Research methods

The current research studies theoretical constructs of latent nature. For the purpose of the empirical analysis, we operationalized them into a set of measurable items (both reflective and formative) and postulated relations between the proposed observed measures and the underlying latent variables. The operationalization of constructs was situated in the context of university-industry interactions, and only the measures relevant to this particular setting were taken on board.

When drawing the sample, we aimed to broaden our attention beyond the groups of academics that are actively engaged in university-industry interactions to thoughtfully consider less active publics. We targeted academics from bio- and nanotechnology fields from twelve Dutch universities and research centres. The data was collected by means of an online survey.

For the empirical analysis, we employed PLS techniques as we (1) wanted to avoid negative impact due to errors in modeling or item usage; (2) valued soft distributional assumptions; (3) had formative measurement items; (4) wanted to shift the perspective of a "true" model towards a predictive focus; and (5) valued the ease of model specification and interpretation.

Results

In the first part of the research, we examined to what extent eight specific motives from the literature are accountable for the academics' general feeling of motivation to interact with industry (research question 1). The results indicated that the major part of the academics' motivation cannot be explained by those eight specific motives. Only two specific motives demonstrated a significant impact: the motive of solving practical problems and the motive of getting access to industry knowledge. Both of those motives are of intrinsic nature. None of the extrinsic motives proved to be significant. The motives that proved to play a trivial role include recognition within the scientific community, reputational rewards, supporting teaching duties, getting access to industry facilities, getting promotion on a career ladder and keeping abreast of industry problems. The results also suggested that academics' motivation to interact with industry depends on the type of interaction.

In the second part of the research, we examined to what extent motivation, embeddedness and prior experience are able to predict academics' behavior, and identified relative weights of each of those factors (research question 2). The results suggested that three factors have a significant effect on academics' social capital activation with industry. Prior experience clearly proves to be the strongest predictor, while motivation and embeddedness play a secondary role, though still significant. The role of embeddedness decreases with higher levels of hierarchy, while the role of own motivation increases as academics move up to higher levels of hierarchy. For the academics whose scientific orientation is more applied than basic, own motivation proves to play a weaker role in determining their actual behavior than for their 'more basic' colleagues.

In the third part of the research, we analyzed the moderating effects of dispositional and positional factors on the relationship between passive social capital and social capital activation (research question 3). No significant differences were found between the moderating effects of positional and dispositional factors. We also tested the moderating effects of dispositional factors through the prism of positional factors. Although the detected effects are small, they proved to be significant and are worth further examination. Furthermore, for academics from higher hierarchical positions, the perceived social influence to interact with industry proved to affect the relationship between passive social capital and social capital activation in a negative way. For academics with a more basic scientific orientation, interactions with industry proved to occur without significant influence of their own motivation on it. The moderator role for this group of academics proved to belong to their perceived ability to interact with industry.

In the fourth part of the research, we analyzed the role of the trigger in the relationship between passive social capital and social capital activation (research question 4). The examination of the moderating effects suggested that the trigger has a trivial influence on the relation between passive social capital and social capital activation. The mediator role of the trigger in the relationship between passive social capital and social capital activation was confirmed; however a suppressor effect was detected. Further analysis showed that passive social capital represents a negative suppressor variable, and suppresses the irrelevant variance in trigger. Nevertheless, this result indicated that the notion of the trigger should not be abandoned.

In the final part of the research, we consolidated the findings from the abovementioned research questions into one model of social capital activation. The empirical results supported the hypotheses that the abovementioned exogenous factors have a positive relationship with social capital activation. However, this relationship proved to be significant only when those factors were taken individually. When all taken into account, the effects of those factors neutralized each other, and most of those factors did not show a substantial effect on social capital activation anymore. The structural relationships in the model proved to be dominated by the presence of passive social capital or the results of academics' previous interactions with industry.

Conclusion

Academics' social capital activation with industry proved to be a complex process of heterogeneous nature resulting from the interaction of multiple factors that enhance or, on the contrary, neutralize each other. Decisions an academic faces with regard to social capital activation with industry proved to be primarily determined by the decisions he or she has made in the past. The past behavior of academics transformed into their passive social capital with industry generates a strong imprint and leads to an expectation to continue these activities in the future.

Besides passive social capital, a set of dispositional factors also proved to have influence of social capital activation. These factors include academics' individual motivation to interact with industry, perceived social influence and perceived ability to do so. Furthermore, the relationship between the abovementioned factors and social capital activation proved to be mediated by a trigger (event or reason for an interaction to occur). The strength of the relationship between the abovementioned factors and social capital activation, in turn, proved to depend on a number of moderating factors. These refer to positional characteristics such as hierarchical position, scientific orientation and scientific domain. Although most of the detected effects are small, they are worth further examination.

Policies building on the notion of prior experience need to aim at creating opportunities for newcomers to get involved in projects with industry. Such newcomers usually refer to PhD students and postdocs with hardly any connections to industry. The assistance and reputation of their senior colleagues and supervisors is thus crucial for linking them with industrial partners. One can expect that the role of prior experience holds also for academics not engaged in interaction with industry. Therefore, the longer the academics stay within the boundaries of the university, the more difficult it becomes for them to change this behavioral pattern in the future. Boosting university-industry interactions is a long-term process, and that it is the younger generation of academics that needs to be targeted by knowledge transfer policies, as those academics are more likely to evolve into prominent collaborations with industry than their more senior colleagues that have not done so yet. At the same time, senior academics who are currently actively engaged in interactions with industry should be more stimulated to support their younger colleagues in bringing them in touch with industry.

Summary in Dutch / Nederlandse samenvatting

Het vormgeven van effectief beleid gericht op het stimuleren van kennisoverdracht vereist een goed inzicht in de redenen die academici hebben om hun sociaal kapitaal te activeren bij interactie met het bedrijfsleven. Dit onderzoek laat zien dat voor academici het activeren van sociaal kapitaal bij interactie met het bedrijfsleven een complex proces is van heterogene aard, dat voortkomt uit samenspel tussen meerdere factoren die elkaar versterken dan wel neutraliseren. Het besluit van academici om sociaal kapitaal te activeren bij interactie met het bedrijfsleven, blijkt voornamelijk gebaseerd te zijn op eerdere ervaringen van deze academici. Beleid dat gebaseerd is op deze notie van eerdere ervaringen, moet zich richten op het creëren van mogelijkheden voor jonge onderzoekers om betrokken te raken bij projecten waarin wordt samengewerkt met het bedrijfsleven.

Probleemstelling

Het bewijs dat economische groei afhankelijk is van de interactie tussen universiteiten en bedrijven, heeft geleid tot een toename in het aantal nationale en internationale beleidsprogramma's dat zich richt op het stimuleren van deze interactie. Met oog op de centrale rol die universiteiten in dit proces spelen, zijn er steeds meer initatieven opgezet die zich specifiek richten op academische instellingen. Echter, beleid dat voornamelijk gericht is op instellingen heeft waarschijnlijk een beperkte impact, tenzij het beleid meer rekening houdt met de individuele wetenschapper die interactie aan gaat met het bedrijfsleven. Deze interactie is voor academici, in tegenstelling tot lesgeven, geen verplichting, waardoor nieuwe prikkelmechanismen nodig zijn om hen aan te moedigen hun sociaal kapitaal te activeren. Het vormgeven van effectief beleid en prikkelsystemen voor kennisdeling tussen universiteiten en bedrijven vereist op haar beurt een goed begrip van waarom academici hun sociaal kapitaal zouden willen activeren.

Bestaande literatuur over deze probleemstelling is echter schaars en gefragmenteerd. De wetenschappelijke studies die tot op heden hebben bijgedragen aan de discussie over interactie tussen bedrijven en universiteiten, hebben vooral de determinanten van deze interactie onderzocht, ofwel vanuit het perspectief van bedrijven, ofwel vanuit het perspectief van universiteiten of departementen. Enkele studies hebben de interactie geanalyseerd op het niveau van individuele academici. De studies die naar individuele academici kijken, volgen echter een heterogene en veelal niet-convergerende aanpak, en richten zich vaak uitsluitend op basale demografische variabelen (zoals bijvoorbeeld leeftijd, hiërarchische positie en geslacht).

Hoewel een dergelijke aanpak onze kennis over de interactie tussen universiteiten en bedrijven verrijkt, kent het ook haar beperkingen. Een dergelijke methode geeft geen inzicht in de factoren die kunnen worden beïnvloed, en laat ook niet zien hoe precies het gewenste gedrag gestimuleerd kan worden. Met andere woorden, deze studies genereren niet de kennis die juist essentieel is voor het ontwikkelen van effectief beleid en effectieve maatregelen. Deze huidige studie heeft als doel bij te dragen op deze punten van het thema.

Onderzoeksdoel en onderzoekvragen

Het doel van het onderzoek kan als volgt worden omschreven: het ontwikkelen van een uitgebreid maar efficiënt model dat inzicht biedt in de belangrijkste determinanten van het activeren door academici van hun sociaal kapitaal richting het bedrijfsleven, en te begrijpen en te verklaren hoe deze factoren leiden tot feitelijke gedragingen.

Om dit doel te bereiken, analyseren wij het vraagstuk van waarom academici hun sociaal kapitaal activeren richting het bedrijfsleven vanuit de volgende perspectieven:

- door de rol te onderzoeken van specifieke motieven voor het vormen van de algemene motivatie van academici om hun sociaal kapitaal te activeren richting het bedrijfsleven (onderzoeksvraag 1);
- door de rol te onderzoeken van de drie belangrijkste voorspellende factoren voor het aangaan door academici van interactie met het bedrijfsleven, voorgesteld in de literatuur die betrekking heeft op interactie tussen universiteiten en het bedrijfsleven (onderzoeksvraag 2);
- door de modererende effecten te onderzoeken van dispositionele factoren (gepercipieerde sociale invloed, motivatie en gepercipieerd vermogen om met het bedrijfsleven te werken) op het activeren van sociaal kapitaal, en de invloed daarop te onderzoeken van positionele factoren (hiërarchische positie, wetenschappelijke oriëntatie, wetenschappelijk domein), en door deze effecten met elkaar te vergelijken (onderzoeksvraag 3)
- door de modererende en bemiddelende rol te onderzoeken van een ‘trigger’, in de relatie tussen passief sociaal kapitaal en het activeren van sociaal kapitaal (onderzoeksvraag 4); hetgeen resulteert in
- het consolideren van bevindingen in een uitgebreid maar efficiënt model voor het activeren van sociaal kapitaal.

Bij het werken vanuit deze verschillende perspectieven hebben wij een beroep gedaan op een breed aanbod aan relevante theorieën, waarvan sommigen geen deel uitmaken van de bestaande literatuur aangaande de interactie tussen universiteiten en het bedrijfsleven. Zo hebben wij bijvoorbeeld gekeken naar bestaande gedragstheorieën, waaronder ondernemerschaptheorieën zoals Ajzen's Theory of Planned Behavior en Shapero's Model of Entrepreneurial Event, en meer algemene gedragsmodellen, zoals het MOA framework, Goldman's theory of human action en andere theoretische modellen. Ons doel was zowel om factoren te identificeren die waarschijnlijk leiden tot het activeren van sociaal kapitaal, als om de belangrijkste relaties tussen deze factoren te identificeren.

Dit onderzoek richt zich dan ook op het ontwikkelen en modelleren van een theorie, in plaats van op het valideren van een bestaande theorie. Het onderzoek is uitgevoerd op basis van inductief redeneren. Inductief redeneren beschrijft het proces waarin het model ontwikkeld is, namelijk op basis van een brede literatuurverzameling en diverse empirische analyses die tijdens deze studie zijn uitgevoerd. De inductieve logica van het onderzoek is gecombineerd met het definiëren van onderzoeksvragen, en met a priori gedefinieerde concepten.

Voorgestelde model

Volgens het voorgestelde conceptuele model is het activeren van sociaal kapitaal het resultaat van een proces van twee fasen dat begint met de bereidheid van een individu om het sociaal kapitaal te activeren. Deze bereidheid leidt alleen tot het daadwerkelijk activeren van het sociaal kapitaal wanneer er een trigger aanwezig is. Dit impliceert de aanwezigheid van kansen of redenen om de interactie met het bedrijfsleven aan te gaan. De bereidheid om het sociaal kapitaal te activeren vertegenwoordigd een gezamenlijk effect van vier factoren: de individuele motivatie van academici om om te interacteren met bedrijven, de invloed van hun directe sociale omgeving (bijvoorbeeld het hoofd van de afdeling, directe collega's, academische partners), het vermogen van academici om samen te werken met hun contacten in het bedrijfsleven, en de kenmerken van hun sociale netwerk bij het bedrijfsleven (i.e. passief sociaal kapitaal). Over het algemeen geldt dat naar mate de bereidheid groter is van een individu om zijn of haar sociaal kapitaal te activeren, de kans dat een trigger zich voordoet groter is, en het niveau van activering van sociaal kapitaal groter zal zijn.

Elke specifieke onderzoeksvraag impliceert een eigen conceptueel model. Door meerdere perspectieven te ontwikkelen en te integreren, hebben wij getracht een uitgebreider begrip te ontwikkelen van het fenomeen in kwestie. Onze verwachting was dat een dergelijke aanpak zou resulteren in een beter onderzoekskader en zou leiden tot meer valide en betrouwbaardere onderzoeksresultaten. De aanpak minimaliseert de tekortkomingen van de afzonderlijke perspectieven en ondervangt de risico's op het gebied van interne validiteit.

Onderzoeksmethoden

Deze studie onderzoekt theoretische constructen van latente aard. In het belang van de empirische analyse hebben wij deze geoperationaliseerd tot een set meetbare items (zowel reflectieve als vormende) en hebben wij relaties verondersteld tussen de voorgestelde, waargenomen indicatoren en de onderliggende, latente variabelen. Het operationaliseren van de constructen vond plaats binnen de context van interactie tussen universiteiten en bedrijven, en alleen de indicatoren die binnen deze specifieke context relevant waren, zijn meegenomen in de operationalisatie.

Bij het selecteren van de steekproef hebben wij getracht verder te kijken dan de groep academici die al actief deelnemen aan interactie tussen universiteiten en bedrijven, om zodoende de minder actieve groepen zorgvuldig te overwegen. Wij hebben ons gericht op academici uit de bio- en nanotechnologische werkvelden van twaalf Nederlandse universiteiten en onderzoekscentra. De data is verzameld door middel van een online enquête.

Voor de empirische analyse hebben wij PLS technieken gebruikt omdat wij (1) negatieve effecten wilden voorkomen die veroorzaakt worden door onvolkomenheden in het modelleren of het gebruik van variabelen; (2) waarde hechten aan het werken met passende *distributional assumptions* van de analyse techniek bij het niet normale karakter van onze data; (4) het perspectief van een "waar" model wilden verschuiven naar een voorspellende focus; en (5) het gemak van de modelspecificatie en de interpretatie ervan verwelkomden.

Resultaten

In het eerste gedeelte van het onderzoek hebben wij onderzocht in hoeverre acht specifieke motieven uit de literatuur verantwoordelijk zijn voor het algehele gevoel van motivatie van de academici om samen te werken met bedrijven (onderzoeksvraag 1). De resultaten geven weer dat het grootste gedeelte van de motivatie van academici niet verklaard kan worden door deze acht specifieke motieven. Slechts twee specifieke motieven bleken van significante invloed: het motief om problemen uit de praktijk op te lossen en het motief om toegang te krijgen tot kennis uit het bedrijfsleven. Beide motieven zijn intrinsiek van aard. Geen van de extrinsieke motieven bleek significant te zijn. Motieven die een triviale rol bleken te spelen zijn ondermeer de erkenning binnen de wetenschappelijke gemeenschap, reputatiebeloningen, het ondersteunen van de onderwijstaken, het verkrijgen van toegang tot bedrijfsfaciliteiten, het stijgen op de carrièreladder en het op de op de hoogte blijven van de vraagstukken in het bedrijfsleven. De resultaten suggereerden ook dat de motivatie van academici om te interacteren met bedrijven afhangt van de soort interactie.

In het tweede gedeelte van het onderzoek hebben wij uitgezocht in hoeverre motivatie, integratie in de omgeving en eerdere ervaringen in staat zijn om het gedrag van academici te voorspellen, en hebben wij het relatieve gewicht van deze factoren geïdentificeerd. De resultaten suggereerden dat drie factoren een significante invloed hebben op het activeren van sociaal kapitaal door academici. De beste voorspeller was duidelijk te vinden in eerdere ervaringen van academici, terwijl motivatie en integratie in de omgeving een tweede, maar nog steeds significante, rol spelen. De rol van integratie in de omgeving neemt af bij hogere niveaus van hiërarchie, terwijl de rol van eigen motivatie juist toeneemt naarmate academici hogere niveaus van hiërarchie bereiken. Bij academici wiens wetenschappelijke orientatie meer toegepast is dan fundamenteel, bleek de eigen motivatie een zwakkere rol te spelen in het voorspellen van hun feitelijke gedrag dan voor hun collega's die zich richten op meer fundamenteel onderzoek.

In het derde gedeelte van het onderzoek hebben wij de modererende effecten geanalyseerd van dispositionele en positionele factoren op de relatie tussen passief sociaal kapitaal en het activeren van sociaal kapitaal (onderzoeksvraag 3). Er zijn geen significante verschillen gevonden tussen de modererende effecten van positionele en dispositionele factoren. Wij hebben de modererende effecten van dispositionele factoren ook onderzocht door het prisma van positionele factoren. Hoewel de waargenomen effecten klein zijn, bleken ze significant te zijn en zijn zij nader onderzoek waard. Bovendien bleek voor academici die een hogere hiërarchische positie innemen, dat de waargenomen sociale invloed van samenwerken met bedrijven de relatie tussen passief sociaal kapitaal en het activeren van sociaal kapitaal negatief beïnvloedt. Bij academici met een meer fundamenteel wetenschappelijke oriëntatie bleken interacties met het bedrijfsleven plaats te vinden zonder significante invloed daarop van hun eigen motivatie. De modererende rol voor deze groep van academici behoort tot het gepercipieerde vermogen om met het bedrijfsleven te interacteren.

In het vierde gedeelte van het onderzoek hebben wij de rol van de trigger onderzocht in de relatie tussen passief sociaal kapitaal en het activeren van sociaal kapitaal (onderzoeksvraag 4). Het onderzoek naar de modererende effecten suggereerde dat de trigger een triviale invloed heeft op de relatie tussen passief sociaal kapitaal en het activeren van sociaal kapitaal. De bemiddelende rol van de trigger in deze relatie werd bevestigd; echter werd er ook een suppressor effect vastgesteld. Nadere analyse toonde aan dat passief sociaal kapitaal een negatieve suppressor variabele is, en dat deze de irrelevante variatie in de trigger onderdrukt. Desalniettemin wijzen de resultaten erop dat de notie van de trigger niet zou moeten worden verlaten.

In het laatste gedeelte van het onderzoek hebben wij de bevindingen met betrekking tot de bovenstaande onderzoeksvragen samengevoegd in één model voor het activeren van sociaal kapitaal. De empirische resultaten ondersteunden de hypotheses dat de hierboven genoemde exogene factoren positief gerelateerd zijn aan het activeren van sociaal kapitaal. Deze relatie bleek echter alleen significant te zijn wanneer wij deze factoren afzonderlijk gebruikten. Wanneer wij alle factoren tegelijkertijd in acht namen, bleken de effecten van deze variabelen elkaar te neutraliseren en hadden de meeste factoren geen substantieel effect meer op het activeren van sociaal kapitaal. De structurele verbanden in het model bleken gedomineerd te worden door de aanwezigheid van sociaal kapitaal of door de resultaten van eerdere interacties van academici met bedrijven.

Conclusie

Het activeren van sociaal kapitaal door academici richting het bedrijfsleven bleek een complex proces waarin veel variabelen en relaties daartussen een rol spelen. Dit resulteert in interactie van meerdere factoren die elkaar versterken en soms ook elkaar neutraliseren. Het besluit van academici om hun sociaal kapitaal te activeren richting het bedrijfsleven, bleek voornamelijk gebaseerd te zijn op keuzes die deze academici in het verleden hebben gemaakt. Hun eerdere gedrag, vertaald in hun passief sociaal kapitaal richting het bedrijfsleven, laat bij hen een sterke indruk achter en leidt tot de verwachting om deze activiteiten voort te zetten in de toekomst.

Naast het passief sociaal kapitaal bleken ook een aantal dispositionele factoren invloed te hebben op het activeren van sociaal kapitaal. Deze factoren omvatten de individuele motivatie van academici om te interacteren met bedrijven, de gepercipieerde sociale invloed en het gepercipieerde vermogen om dit te doen. Daarnaast bleek een trigger (een gebeurtenis of reden waardoor een samenwerking tot stand komt) een bemiddelende rol te hebben voor de relatie tussen de hier bovengenoemde factoren en het activeren van sociaal kapitaal. De sterkte van het verband tussen de bovengenoemde factoren en het activeren van sociaal kapitaal bleek af te hangen van een aantal modererende factoren. Deze modererende factoren omvatten positionele kenmerken zoals hiërarchische positie, wetenschappelijke oriëntatie en wetenschappelijk domein. Hoewel de meeste effecten die wij hebben vastgesteld klein zijn, zijn zij nader onderzoek waard.

Beleid dat gebaseerd is op de notie van eerdere ervaringen moet zich richten op het creëren van mogelijkheden voor nieuwelingen om betrokken te raken bij projecten waarin wordt samengewerkt met het bedrijfsleven. Dergelijke nieuwelingen zijn vaak PhD-studenten en nieuwkomers op de arbeidsmarkt met een postdoctorale opleiding, die nauwelijks connecties hebben met het bedrijfsleven. De ondersteuning en de reputatie van hun meer senior collega's en begeleiders is dan ook van cruciaal belang voor het koppelen van nieuwelingen aan industriële partners. Men kan bovendien verwachten dat het ontbreken van eerdere ervaringen ook opgaat voor academici die niet betrokken zijn bij interactie met bedrijven. Hoe langer de academici dus binnen de grenzen van hun eigen universiteit blijven, des te moeilijker wordt het voor hen om in de toekomst dit gedragspatroon aan te passen. Het stimuleren van de interactie tussen universiteiten en het bedrijfsleven is een langetermijnproces, en het is de jongere generatie van academici waar beleid voor kennisdeling zich op moet richten, omdat het waarschijnlijker is dat deze academici deel zullen nemen aan prominente samenwerkingsverbanden met het bedrijfsleven dan hun meer senior collega's die dat nog niet gedaan hebben. Tegelijkertijd zouden meer senior academici die op dit moment wel samenwerken met het bedrijfsleven meer gestimuleerd moeten worden om hun jongere collega's te helpen in contact te komen met bedrijven.

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"Gratitude is the memory of the heart."
French proverb

A PhD research is a challenging, demanding and hard exercise on its own, let alone when it has to be conducted in addition to a full-time job at a consultancy firm. Under these tough circumstances, it took me several years to complete this research, and these were years full of commitment, devotion, self-discipline and determination. When the pressure of limited time and ambitious deadlines was testing my mental and physical limits, my scientific curiosity and practitioner's adrenalin still kept me afloat. In addition, a significant part of my personal life during this period had to be brought as a sacrifice. As a result, what seemed to be impossible in the beginning proved to be possible in the end - my dissertation was ready on time. However, I could never have done this on my own. This dissertation is a fruit of sustained collaborative efforts together with many great people. Therefore, in this final section, I would like to express my deepest gratitude to those who supported me all the way through the research process.

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Kristina Dervojeda, The Hague, 2012

Appendices

ANNEX A: LIST OF EMPLOYED MEASURES

Observable Variable	Question	Options	Additional Operations
Positional factors and control variables			
POS1	Hierarchical position	Full professor (Hoogleraar) Associate professor (Universitair Hoofddocent) Assistant professor (Universitair Docent) Postdoc (Onderzoeker) PhD candidate (Promovendus) Other	n.a.
POS2	Scientific orientation	Pure Basic More Basic than Applied Equally Basic and Applied More Applied than Basic Pure Applied	n.a.
POS3	Scientific domain	Biotechnology Nanotechnology Other (please specify)	n.a.
CONV1	Affiliated institution	List of twelve Dutch universities and knowledge institutions	n.a.
CONV2	Gender	Female Male	n.a.
CONV3	Country of origin	Netherlands Other (please specify)	n.a.
Individual Motivation (IM) Reflective			
IMR1	"In general, I am <u>not</u> interested in collaborating with industry."	1 – 7 scale ("1"= Strongly disagree; "7" = Strongly agree)	Reverse coding
IMR2	"Overall, I am open to interaction with industrial partners."	1 – 7 scale ("1"= Strongly disagree; "7" = Strongly agree)	n.a.
IMR3	"I am enthusiastic about working together with industry."	1 – 7 scale ("1"= Strongly disagree; "7" = Strongly agree)	n.a.
IMR4	"Interaction with industry brings me satisfaction."	1 – 7 scale ("1"= Strongly disagree; "7" = Strongly agree)	n.a.

Observable Variable	Question	Options	Additional Operations
IMR5	"All things considered, collaboration with industry is not important to me."	1 – 7 scale ("1"= Strongly disagree; "7" = Strongly agree)	Reverse coding
Individual Motivation (IM) Formative			
IM1a	Interaction with industry leads to solutions to practical problems.	1 – 7 ("Strongly disagree" to "Strongly agree")	x IM1b
IM2a	Interaction with industry brings more recognition within the scientific community.	1 – 7 ("Strongly disagree" to "Strongly agree")	x IM2b
IM3a	Interaction with industry supports teaching duties [pop up tip text: e.g., allows preparing student assignments based on cases from industry, going on field trips to the premises of industrial partners, getting access to practical problems that are suitable for student work].	1 – 7 ("Strongly disagree" to "Strongly agree")	x IM3b
IM4a	Interaction with industry provides access to industry facilities.	1 – 7 ("Strongly disagree" to "Strongly agree")	x IM4b
IM5a	Interaction with industry provides access to industry knowledge.	1 – 7 ("Strongly disagree" to "Strongly agree")	x IM5b
IM6a	Interaction with industry allows keeping abreast of industry problems.	1 – 7 ("Strongly disagree" to "Strongly agree")	x IM6b
IM7a	Interaction with industry is necessary for the promotion on a career ladder.	1 – 7 ("Strongly disagree" to "Strongly agree")	x IM7b
IM8a	Interaction with industry leads to additional funding for research group [pop up tip text: including funding for graduate students or laboratory equipment].	1 – 7 ("Strongly disagree" to "Strongly agree")	x IM8b
IM1b	I … to work on solutions to practical problems.	-3 - +3 ("do not want at all" to "very much want")	n.a.
IM2b	I … to get more recognition within the scientific community.	-3 - +3 ("do not want at all" to "very much want")	n.a.
IM3b	I … to support my teaching duties by complementary information from industry	-3 - +3 ("do not want at all" to "very much want")	n.a.

Observable Variable	Question	Options	Additional Operations
	[pop up tip text: e.g., allows preparing student assignments based on cases from industry, going on field trips to the premises of industrial partners, getting access to practical problems that are suitable for student work].		
IM4b	I … to get access to industry facilities.	-3 - +3 (“do not want at all” to “very much want”)	n.a.
IM5b	I … to get access to industry knowledge.	-3 - +3 (“do not want at all” to “very much want”)	n.a.
IM6b	I … to keep abreast of industry problems.	-3 - +3 (“do not want at all” to “very much want”)	n.a.
IM7b	I … to get promoted on a career ladder.	-3 - +3 (“do not want at all” to “very much want”)	n.a.
IM8b	I … to obtain additional funding for my research group [pop up tip text: including funding for graduate students or laboratory equipment].	-3 - +3 (“do not want at all” to “very much want”)	n.a.
Perceived Ability (PA) Reflective			
PAR1	“In general, I do <u>not</u> know how to interact with industry.”	1 – 7 scale (“1”= Strongly disagree; “7” = Strongly agree)	Reverse coding
PAR2	“I am comfortable when collaborating with industry.”	1 – 7 scale (“1”= Strongly disagree; “7” = Strongly agree)	n.a.
PAR3	“I am confident to work together with industry.”	1 – 7 scale (“1”= Strongly disagree; “7” = Strongly agree)	n.a.
PAR4	“In general, I am capable of interacting with industry.”	1 – 7 scale (“1”= Strongly disagree; “7” = Strongly agree)	n.a.
PAR5	“Collaboration with industry is difficult for me.”	1 – 7 scale (“1”= Strongly disagree; “7” = Strongly agree)	Reverse coding
Perceived Ability (PA) Formative			
PA1a	“Interaction with industry requires to balance conflicting interests of incentive systems between academia and industry.”	1 – 7 scale (“1”= Strongly disagree; “7” = Strongly agree)	x PA1b

Observable Variable	Question	Options	Additional Operations
PA2a	"Interaction with industry requires to operate with a wide range of bodies of knowledge [pop up tip text: e.g. basic science vs. applied research; multiple disciplines]."	1 – 7 scale ("1"= Strongly disagree; "7" = Strongly agree)	x PA2b
PA3a	"Interaction with industry requires to have a good understanding of practical applicability of scientific concepts."	1 – 7 scale ("1"= Strongly disagree; "7" = Strongly agree)	x PA3b
PA4a	"Interaction with industry requires to work according to the industry standards [pop up tip text: e.g. quick delivery of results]."	1 – 7 scale ("1"= Strongly disagree; "7" = Strongly agree)	x PA4b
PA1b	"Balancing conflicting interests of incentive systems between academia and industry is …"	-3 - +3 ("very difficult for me" to "very easy for me")	n.a.
PA2b	"Operating with a wide range of bodies of knowledge [pop up tip text: e.g. basic science vs. applied research; multiple disciplines] is …"	-3 - +3 ("very difficult for me" to "very easy for me")	n.a.
PA3b	"Understanding practical applicability of scientific concepts is …"	-3 - +3 ("very difficult for me" to "very easy for me")	n.a.
PA4b	"Working according to the industry standards (e.g., quick delivery of results) is …"	-3 - +3 ("very difficult for me" to "very easy for me")	n.a.
Passive Social Capital (PSC)			
PSCR1 (Actual network size (*N*))	How many industrial acquaintances did you have in your social network by September 2009?	0 1 – 10 11 – 20 21 – 30 31 – 40 41 – 50 More than 50	1 point 2 points 3 points 4 points 5 points 6 points 7 points
PSCR2 (Closeness)	I feel a close affinity with this person. [Affinity here refers to a high level of trust, sharing and interpersonal commonalities.] *Partner-specific*	1 – 7 scale ("1"= Strongly disagree; "7" = Strongly agree)	Total closeness: PSCR2 = $\sum_{i=1}^{n} PSCR2_i$ Correction for total result (x $\frac{\sqrt{N}}{n}$)
PSCR3 (Multiplexity	Please check all the roles of this acquaintance in which	Friend Research partner	Each role = 1 point

Observable Variable	Question	Options	Additional Operations
of roles)	you know this person in relation to yourself. *Partner-specific*	Expert/Advisor Business partner Coach Coachee Other (please specify)	PSCR3 = $\sum_{i=1}^{n} PSCR3_i$ Correction total result (x $\frac{\sqrt{N}}{n}$)
PSCR4 (History)	How many years have you known this person? *Partner-specific*	Less than a year 1 year 2 years 3 years 4 years 5 years More than 5 years	1 point 2 points 3 points 4 points 5 points 6 points 7 points PSCR4 = $\sum_{i=1}^{n} PSCR4_i$ Correction total result (x $\frac{\sqrt{N}}{n}$)
Perceived Social Influence (PSI) Reflective			
PSIR1	"It is <u>not</u> expected of me that I interact with industry."	1 – 7 scale ("1"= Strongly disagree; "7" = Strongly agree)	Reverse coding
PSIR2	"I am under social pressure to collaborate with industry."	1 – 7 scale ("1"= Strongly disagree; "7" = Strongly agree)	n.a.
PSIR3	"I have to interact with industry."	1 – 7 scale ("1"= Strongly disagree; "7" = Strongly agree)	n.a.
PSIR4	"People whose opinion is important to me think that I should work together with industry."	1 – 7 scale ("1"= Strongly disagree; "7" = Strongly agree)	n.a.
PSIR5	"Interaction with industry is <u>not</u> part of my duty."	1 – 7 scale ("1"= Strongly disagree; "7" = Strongly agree)	Reverse coding
Perceived Social Influence (PSI) Formative			
PSI1a	"My boss [pop up tip text: head of research group/laboratory/department/ university] thinks … interact with industry."	-3 - +3 ("I should not" to "I should")	x PSI1b
PSI2a	"My peer colleagues think … interact with industry."	-3 - +3 ("I should not" to "I should")	x PSI2b
PSI3a	"My academic research partners think I … interact with industry."	-3 - +3 ("I should not" to "I should")	x PSI3b
PSI4a	"My boss … interact with industry."	-3 - +3 ("does not at all" to "does very much")	x PSI4b
PSI5a	"My peer colleagues …	-3 - +3 ("do not at all" to	x PSI5b

Observable Variable	Question	Options	Additional Operations
	interact with industry."	"do very much")	
PSI6a	"My academic research partners … interact with industry."	-3 - +3 ("do not at all" to "do very much")	x PSI6b
PSI1b	"My boss's approval of my behavior is important to me."	1 – 7 scale ("1"= Not at all; "7" = Very much)	n.a.
PSI2b	"What my peer colleagues think I should do matters to me."	1 – 7 scale ("1"= Not at all; "7" = Very much)	n.a.
PSI3b	"What my academic research partners think I should do matters to me."	1 – 7 scale ("1"= Not at all; "7" = Very much)	n.a.
PSI4b	"Doing what my boss does is important to me."	1 – 7 scale ("1"= Not at all; "7" = Very much)	n.a.
PSI5b	"Doing what my peer colleagues do is important to me."	1 – 7 scale ("1"= Not at all; "7" = Very much)	n.a.
PSI6b	"Doing what my academic research partners do is important to me."	1 – 7 scale ("1"= Not at all; "7" = Very much)	n.a.
Trigger (TR) Reflective			
TRR1	"During the last year, there was hardly any opportunity for me to collaborate with industry."	1 – 7 scale ("1"= Strongly disagree; "7" = Strongly agree)	Reverse coding
TRR2	"In the course of the last year, I had many chances to communicate with industry."	1 – 7 scale ("1"= Strongly disagree; "7" = Strongly agree)	n.a.
TRR3	"Last year, there were many reasons for me to seek or receive information from my industrial partners."	1 – 7 scale ("1"= Strongly disagree; "7" = Strongly agree)	n.a.
TRR4	"During the last year, there were hardly any occasions where I met industry representatives."	1 – 7 scale ("1"= Strongly disagree; "7" = Strongly agree)	Reverse coding
Trigger (TR) Formative			
TR1	"I approach industry myself with ideas that might be potentially interesting for them."	1 – 7 scale ("1"= Never; "7" = Very often)	n.a.
TR2	"My interactions with industry are initiated by my boss [pop up tip text: the head of research group / laboratory / department / university] and/or my academic peer colleagues."	1 – 7 scale ("1"= Never; "7" = Very often)	n.a.

Observable Variable	Question	Options	Additional Operations
TR3	"Industry representatives approach me directly."	1 – 7 scale ("1"= Never; "7" = Very often)	n.a.
TR4	"I get connected to industry by third parties [pop up tip text: e.g., university-industry match-making services by governmental agencies]."	1 – 7 scale ("1"= Never; "7" = Very often)	n.a.
Social Capital Activation (SCA)			
SCAR1 (Actual size of exploited network (*n*))	Please provide the names of up to five industrial acquaintances of yours with whom you have interacted most in the course of the last year.	Open question	Each name = 1 point
SCAR2 (Frequency)	During the last year, how often have you sought or received information from this person? *Partner-specific*	Twice a week or more Once a week Twice a month Once a month Six times a year Three times a year Once a year	1 point 2 points 3 points 4 points 5 points 6 points 7 points SCAR2 = $\sum_{i=1}^{n} SCAR2_i$ Correction total result (x $\frac{\sqrt{N}}{n}$)
SCAR3 (Multiplexity of interactions)	Please check all the types of interactions that you were involved in with this person in the course of the last year. *Partner-specific*	Informal communication Consultancy work Contract research agreements Setting-up spin-off companies Creation of physical facilities with industry funding Postgraduate training in company Training company employees Joint research agreements Other (please specify)	Each type of interactions = 1 point SCAR3 = $\sum_{i=1}^{n} SCAR3_i$ Correction total result (x $\frac{\sqrt{N}}{n}$)
SCAR4 (Total duration)	How much time did you spend on interactions with this person last year, in hours? *Partner-specific*	Less than 10h 10 – 20h 20 – 30h 30 – 40h 40 – 50h 50 – 60h	1 point 2 points 3 points 4 points 5 points 6 points

Observable Variable	Question	Options	Additional Operations
		More than 60h	7 points SCAR4 = $\sum_{i=1}^{n} SCAR4_i$ Correction total result (x $\frac{\sqrt{N}}{n}$)

ANNEX B: MISSING DATA ANALYSIS

The current annex contains an extensive description of the missing data analysis conducted in the course of this study.

Univariate statistics

The univariate statistics provide an overview of the extent of missing data per variable. The analysis of all employed measures in SPSS showed that the variables that have the greatest number of cases with missing values can be clustered into four main groups:

Group 1:

IM1a	2.6 Interaction with industry leads to solutions to practical problems.
IM2a	2.7 Interaction with industry brings more recognition within the scientific community.
IM3a	2.8 Interaction with industry supports teaching duties.
IM4a	2.9 Interaction with industry provides access to industry facilities.
IM5a	2.10 Interaction with industry provides access to industry knowledge.
IM6a	2.11 Interaction with industry allows to keep abreast of industry problems.
IM7a	2.12 Interaction with industry is necessary for the promotion on a career ladder.
IM8a	2.13 Interaction with industry leads to additional funding for research group.

Group 2:

PA1a	4.6 Interaction with industry requires to balance conflicting interests of incentive systems between academia and industry.
PA2a	4.7 Interaction with industry requires to operate with a wide range of bodies of knowledge.
PA3a	4.8 Interaction with industry requires to have a good understanding of practical applicability of scientific concepts.
PA4a	4.9 Interaction with industry requires to work according to industry standards.

Group 3:

TR1	5.5 I approach industry myself with ideas that might be potentially interesting for them.

TR2	5.6 My interactions with industry are initiated by my boss and/or my academic peer colleagues.
TR3	5.7 Industry representatives approach me directly.
TR4	5.8 I get connected to industry by third parties.

Group 4:

PSCR2	Closeness SUM (6.3; 6.10; 6.17; 6.24; 6.31) I feel a close affinity with this person.
PSCR3	Multiplexity of roles SUM (6.4; 6.11; 6.18; 6.25; 6.32) Please check all the roles of this acquaintance in which you know this person in relation to yourself.
PSCR4	History SUM (6.5; 6.12; 6.19; 6.26; 6.33) How many years have you known this person?

A high number of missing values for the first three groups of variables can be partly explained by the fact that all three groups of questions linked to those variables were located at the bottom of a page, and scrolling down was required before these questions became visible. Therefore, the respondents could simply have overlooked these questions. We carried out an additional analysis to find out whether these data are missing completely at random or not.

The values from group 4 were not considered missing in case PSCR1 (6.1 Network size) is 0, which means that the closeness, multiplexity and history of interactions are equal to 0 too. In all other cases (i.e., when PSCR1 > 0 or is missing), the absent values of PSCR2, PSCR3 and PSCR4 were considered missing. The questions linked to these variables were not located at the bottom of a page (as was the case for the first three groups); consequently, the absence of data should not be related to any technical reasons. We carried out an additional analysis to find out whether these data are missing completely at random or not.

Separate-variance t tests

The separate-variance *t* tests table allowed for identifying the variables which have a pattern of missing values that may be influencing the quantitative variables. The *t* test was calculated using an indicator variable that specifies whether a variable is present or missing for an individual case. The subgroup means for the indicator variable were also tabulated (SPSS, 2007). No considerable influences, however, could be observed on the particular quantitative variables by the absence of values on other quantitative variables (Mean Present and Mean Missing for each variable do not demonstrate considerable differences). The results of this exercise showed that, for example, if IM1a is missing, the mean IMR1 is 6.00, compared to 6.08 when IM1a is present. Some more considerable differences can be observed for example, for IM5a. In this case, if IM1a is missing, the mean IM5a is 3.00 compared to 4.79 when IM1a is present. This difference can be explained by the fact that there are only 2 cases (out of 184) when IM1a is missing and IM5a is present. This small number creates biased estimates.

The separate-variance *t* tests exercise thus did not signal that our data is not MCAR (Missing Completely at Random). However, we needed to look at more output before deciding what type of data (MCAR, MAR or MNAR) we were dealing with, as the type of data will define the type of estimation that we can use for imputing missing values.

Crosstabulations

Above we concluded that the absence of values for particular quantitative variables seems not to have any considerable influence on other quantitative variables. The crosstabulations of categorical variables (in our case, positional factors and control variables) versus indicator variables (Groups 1-4) show whether there are differences in missing values *among categories* of *categorical variables*. In SPSS 16.0, we computed crosstabulations for the following original categorical variables:

POS1	Hierarchical position
POS2	Scientific orientation
POS3	Scientific domain
CONV1	Affiliated institution
CONV2	Gender
CONV3	Country

POS1: Hierarchical position
The crosstabulation for the hierarchical position shows that the number of missing values in the quantitative variables appears to considerably vary between different levels of the hierarchy. Thus the place in the hierarchy seems to affect whether data are missing for all quantitative variables. For example, for IM1a, full professors provided data in 61.3% of all cases; assistant professors reported on this variable in 58.8% of all cases, and postdocs in 79.2% of all cases. At this point, it is difficult to identify a clear trend. This difficulty can be explained by the low number of respondents in some categories (except PhD students, which account for 83 out of 184 cases; just to compare, there are 31 full professors, 16 associate professors, 17 assistant professors and 24 postdocs).

To obtain a more obvious picture, we reduced the number of hierarchical positions by creating three larger categories (POS1a):

Category 1 (High):	Full professor (Hoogleraar) and Associate professor (Universitair Hoofddocent)
Category 2 (Medium):	Assistant professor (Universitair Docent), Postdoc (Onderzoeker), Other
Category 3 (Low):	PhD candidate (Promovendus)

After these adjustments, the trend has become more obvious. The higher the respondent is in the hierarchy, the higher is the chance that the data is missing, for all quantitative variables. For example, for IM1a, the respondents having a high position in the hierarchy reported in 66% of all cases, the respondents with a medium position reported in 69.8% of all cases, and the respondents having a low position responded in 75.9% of cases. Consequently, our data are not MCAR (Missing Completely at Random). Although this condition is already sufficient to conclude that our data is not MCAR, we took a look at the rest of the control variables and checked whether any clear trends can be detected there as well.

POS2: Scientific orientation
The crosstabulation for the scientific orientation shows that the number of the missing values in the quantitative variables appears to considerably vary between different levels of the scientific orientation. The scientific orientation seems to affect whether data are missing for all quantitative variables. For example, for IM1a, respondents with the pure basic scientific orientation provided data in 40% of all cases; the respondents with a scientific orientation that is equally basic and applied reported on this variable in 72.1% of all cases, and the respondents whose scientific orientation was purely applied reported in 77.8% of all cases. Consequently, we can observe a clear trend that in case of IM1a, the more basic the scientific orientation of a respondent is, the higher is the chance that the data will be missing. However, this trend is not always that obvious for other quantitative variables (e.g., PA1a).

To obtain a more obvious picture, we reduced the number of scientific orientations by creating three larger categories (POS2a):

Category 1 (More Basic than Applied):	Pure Basic, More Basic than Applied
Category 2 (Equally Basic and Applied):	Equally Basic and Applied
Category 3 (More Applied than Basic):	More Applied than Basic, Pure Applied

After these adjustments, the trend for PA-variables has become more obvious, but it differs from the trend for IM-variables. The respondents with equally basic and applied research orientation tend to have less missing values than the first and the third groups. Consequently, the analysis of the crosstabulation for POS2 confirmed that the data are not MCAR.

POS3: Scientific domain
The crosstabulation for the scientific domain showed that the number of the missing values in the quantitative variables does not appear to vary much between the scientific domain categories (if compared between bio- and nanotechnology). However, the respondents from the category "Other" systematically tend to have more missing values for all quantitative variables than the first two groups. For example, for IM1a, the respondents from the biotechnology field reported in 73.2% of all cases, the respondents from nanotechnology reported in 73.8% of all cases, and the respondents from other fields reported in 66% of all cases.

CONV1: Affiliated institution
Analyzing the variance of the number of missing values in the quantitative variables between different affiliated institutions is likely to produce biased results, as the current sample is too small for the number of categories within this control variable (12) and for the distribution of answers (70 out of 184 respondents come from UT, and the second largest group accounts for 28 responses from TU/e). As we have already concluded that the data is not MCAR, the analysis of the crosstabulation for this and other variables will not change the next steps of the missing value analysis (i.e., checking whether the data are MAR or MNAR).

CONV2: Gender
The crosstabulation for gender shows that the number of the missing values in the quantitative variables does vary by gender. Male respondents tend to have less missing values than female respondents for most quantitative variables. Consequently, the analysis of the crosstabulation for CONV2 once again confirmed that the data are not MCAR.

CONV3: Country of origin
The crosstabulation for the country of origin showed that the number of missing values in the indicator variables varies depending on the country of origin (Netherlands or Other). For Group 1 (IM1a - IM8a), Group 2 (PA1a – PA4a), and Group 3 (TR1 – TR4) of missing variables, foreign respondents tend to have less missing values than their Dutch colleagues. In case of Group 4 (PSCR2 – PSCR4), the situation is the other way around. Consequently, the country of origin seems to affect whether data are missing for the quantitative variables, which is one more confirmation that the data are not MCAR.

Missingness of data (MAR or MNAR)

The crosstabulation analysis allowed identifying the following control variables that seem to affect whether data are missing for the quantitative variables:

		Nr of categories
POS1	Hierarchical position	3
POS2	Scientific orientation	3
CONV2	Gender	2
CONV3	Country of origin	2

In other words, for our data, the probability that the quantitative variables (Groups 1-4) are recorded depends on the respondent's hierarchical position, scientific orientation, gender and country of origin. For our data to be MAR (and not MNAR), this probability may vary by each of the abovementioned control variables, but not by their responses within the categories of these control variables (SPSS, 2007). In the remainder of this sub-section, we examine if this condition holds for our data.

Given that the analyzed control variables contain in total 10 categories, and there are in total 19 quantitative variables that require our additional attention, the total number of checks that we would need to carry out is 10 x 19 = 190. However, the descriptive statistics in the previous section showed that the quantitative variables from each group have similar missingness patterns. Therefore, for the current analysis, when analyzing probabilities of missing data within each control variable, we randomly picked one quantitative variable from each group (Group 1-4). We applied a systematic sampling starting with the first, second, third and fourth quantitative variable in each group, and then moving to the next position for the next control variable:

		Assigned quantitative variables
POS1	Hierarchical position	IM1a, PA2a, TR3, PSCR2*
POS2	Scientific orientation	IM2a, PA3a, TR4, PSCR3
CONV2	Gender	IM3a, PA4a, TR1, PSCR4
CONV3	Country of origin	IM4a, PA1a, TR2, PSCR2

* as there are only three variables in the fourth group, following the logic of a cycle, the fourth variable corresponds to the first one

The following variables will be used as predictors of probabilities of missing data for each of the groups:

Group	Variables	Predictor of probabilities
Group 1	IM1a-IM8a	AVE IMR1-IMR5
Group 2	PA1a-PA4a	AVE PAR1-PAR5
Group 3	TR1-TR4	AVE TRR1-TRR4

Group 4 PSCR2-PSCR4 PSCR1

As our sample is relatively small, we should not expect equal probabilities of missing values within each control variable category. Nevertheless, we should check the data for the presence of clear trends within those categories (e.g., if the respondents tend to report less on lower levels of motivation, perceived ability, trigger and/or passive social capital). Our data would be considered MNAR in case if, for example, we would discover that *within each* hierarchical position, the probability of missing data for IM1a grows/decreases depending on the level of motivation (1-7).

POS1: Hierarchical position

As can be seen from Tables B-1 – B-2, no clear trends can be observed with regard to the probability of missing data for the selected quantitative variables within *each* of the hierarchical positions. Consequently, we can conclude that at this point our data can still be considered MAR.

Table B-0-1: Probabilities of missing data for IM1a and PA2a variables within POS1a categories

POS1a categories	IM/PA categories	Nr present IM (AVE IMR1-IMR5)	Missing IM1a	Probability missing IM1a	Nr present PA (AVE PAR1-PAR5)	Missing PA2a	Probability missing PA2a
High: Full professor (Hoogleraar) and Associate professor (Universitair Hoofddocent) (1)	1	0	0	-	0	0	-
	2	1	0	0%	1	0	0%
	3	1	1	100%	4	2	50%
	4	5	2	40%	8	4	50%
	5	9	3	33%	11	5	45%
	6	21	7	33%	11	4	36%
	7	10	3	30%	9	3	33%
Medium: Assistant professor (Universitair Docent), Postdoc (Onderzoeker), Other (2)	1	0	0	-	0	0	-
	2	0	0	-	0	0	-
	3	2	2	100%	4	2	50%
	4	8	2	25%	11	3	27%
	5	10	4	40%	14	3	21%
	6	25	6	24%	17	3	18%
	7	7	2	29%	6	2	33%
Low: PhD candidate (Promovendus) (3)	1	1	0	0	0	0	-
	2	0	0	-	3	1	33%
	3	2	1	50%	11	3	27%
	4	14	2	14%	19	6	32%
	5	19	4	21%	27	11	41%
	6	24	10	42%	19	2	11%

POS1a categories	IM/PA categories	Nr present IM (AVE IMR1-IMR5)	Missing IM1a	Probability missing IM1a	Nr present PA (AVE PAR1-PAR5)	Missing PA2a	Probability missing PA2a
	7	19	2	11%	4	1	25%

Table B-0-2: Probabilities of missing data for TR3 and PSCR2 variables within POS1a categories

POS1a categories	TR/PSCR categories	Nr present TR (AVE TRR1 - TRR4)	Missing TR3	Probability missing TR3	Nr present PSCR1	Missing PSCR2	Probability missing PSCR2
High: Full professor (Hoogleraar) and Associate professor (Universitair Hoofddocent) (1)	1	0	0	-	2	0	0%
	2	3	3	100%	15	0	0%
	3	4	1	25%	10	1	10%
	4	8	0	0%	9	2	22%
	5	7	2	29%	0	0	-
	6	11	7	64%	0	0	-
	7	11	4	36%	8	1	13%
Medium: Assistant professor (Universitair Docent), Postdoc (Onderzoeker), Other (2)	1	2	0	0%	3	0	0%
	2	2	0	0%	26	4	15%
	3	7	3	43%	5	1	20%
	4	6	0	0%	10	1	10%
	5	11	4	36%	2	0	0%
	6	11	0	0%	0	0	-
	7	11	4	36%	4	0	0%
Low: PhD candidate (Promovendus) (3)	1	9	2	22%	17	0	0%
	2	8	2	25%	45	9	20%
	3	12	5	42%	7	0	0%
	4	22	5	23%	1	1	100%
	5	9	3	33%	1	0	0%
	6	10	1	10%	1	0	0%
	7	8	3	38%	1	0	0%

POS2: Scientific orientation

As can be seen from Tables B-3 – B-4, no clear trends can be observed with regard to the probability of missing data for the selected quantitative variables within *each* of the scientific orientations. Consequently, we can conclude that at this point our data can still be considered MAR.

Table B-0-3: Probabilities of missing data for IM2a and PA3a variables within CONV2a categories

POS2a categories	IM/PA categories	Nr present IM (AVE IMR1-IMR5)	Missing IM2a	Probability missing IM2a	Nr present PA (AVE PAR1-PAR5)	Missing PA3a	Probability missing PA3a
More Basic than Applied (1)	1	0	0	-	0	0	-
	2	1	0	0%	2	1	50%
	3	1	0	0%	9	2	22%
	4	5	5	100%	17	8	47%
	5	17	7	41%	22	9	41%
	6	25	10	40%	13	4	31%
	7	7	0	0%	2	1	50%
Equally Basic and Applied (2)	1	1	0	0%	0	0	-
	2	0	0	-	1	0	0%
	3	2	2	100%	3	2	67%
	4	5	0	0%	10	4	40%
	5	14	5	36%	18	5	28%
	6	29	7	24%	18	2	11%
	7	10	3	30%	7	2	29%
More Applied than Basic (3)	1	0	0	-	0	0	-
	2	0	0	-	0	0	-
	3	2	2	100%	3	3	100%
	4	7	1	14%	11	2	18%
	5	9	0	0%	11	5	45%
	6	19	6	32%	14	2	14%
	7	19	4	21%	8	3	38%

Table B-0-4: Probabilities of missing data for TR4 and PSCR3 variables within POS2a categories

POS2a categories	TR/PSCR categories	Nr present TR (AVE TRR1 - TRR4)	Missing TR4	Probability missing TR4	Nr present PSCR1	Missing PSCR3	Probability missing PSCR3
More Basic than Applied (1)	1	5	1	20%	12	0	0%
	2	7	4	57%	36	10	28%
	3	15	7	47%	6	0	0%
	4	12	2	17%	5	2	40%
	5	8	3	38%	0	0	-
	6	5	4	80%	0	0	-
	7	6	2	33%	2	0	0%
Equally Basic and Applied	1	4	1	25%	4	0	0%
	2	2	0	0%	22	8	36%
	3	7	2	29%	16	2	13%

POS2a categories	TR/PSCR categories	Nr present TR (AVE TRR1 - TRR4)	Missing TR4	Probability missing TR4	Nr present PSCR1	Missing PSCR3	Probability missing PSCR3
(2)	4	10	0	0%	11	2	18%
	5	10	4	40%	1	0	0%
	6	15	2	13%	0	0	-
	7	10	3	30%	4	0	0%
More Applied than Basic (3)	1	1	0	0%	6	0	0%
	2	4	1	25%	28	4	14%
	3	0	0	-	2	0	0%
	4	14	3	21%	7	1	14%
	5	9	2	22%	3	0	0%
	6	12	2	17%	1	0	0%
	7	14	6	43%	7	1	14%

CONV2: Gender

As can be seen from Tables B-5 – B-6, no clear trends can be observed with regard to the probability of missing data for the selected quantitative variables within each of genders. Consequently, we can conclude that at this point our data can still be considered MAR.

Table B-0-5: Probabilities of missing data for IM3a and PA4a variables within CONV2 categories

CONV2 categories	IM/PA categories	Nr present IM (AVE IMR1-IMR5)	Missing IM3a	Probability missing IM3a	Nr present PA (AVE PAR1-PAR5)	Missing PA4a	Probability missing PA4a
Male (2)	1	0	0	-	0	0	-
	2	1	0	0%	1	0	0%
	3	4	3	75%	14	1	7%
	4	17	4	24%	25	5	20%
	5	30	9	30%	34	10	29%
	6	52	15	29%	26	3	12%
	7	12	5	42%	12	4	33%
Female (1)	1	1	0	0%	0	0	-
	2	0	0	-	3	1	33%
	3	0	0	-	5	2	40%
	4	10	2	20%	13	6	46%
	5	9	3	33%	17	5	29%
	6	21	7	33%	11	4	36%
	7	11	2	18%	3	1	33%

Table B-0-6: Probabilities of missing data for TR1 and PSCR4 variables within CONV2 categories

CONV2 categories	TR/PSCR categories	Nr present TR (AVE TRR1 - TRR4)	Missing TR1	Probability missing TR1	Nr present PSCR1	Missing PSCR4	Probability missing PSCR4
Male (2)	1	6	2	33%	12	0	0%
	2	11	4	36%	63	24	38%
	3	14	3	21%	16	2	13%
	4	22	2	9%	17	6	35%
	5	24	7	29%	4	0	0%
	6	24	7	29%	1	1	100%
	7	23	6	26%	11	4	36%
Female (1)	1	5	0	0%	10	0	0%
	2	2	1	50%	22	10	45%
	3	9	5	56%	8	1	13%
	4	13	2	15%	5	3	60%
	5	3	2	67%	0	0	-
	6	8	1	13%	0	0	-
	7	7	5	71%	2	2	100%

CONV3: Origin

As can be seen from Tables B-7 – B-8, no clear trends can be observed with regard to the probability of missing data for the selected quantitative variables within each of the categories for the country of origin. As it was the last control variable that we were analyzing, we can now conclude that *our data is MAR*.

Table B-0-7: Probabilities of missing data for IM4a and PA1a variables within CONV3 categories

CONV3 categories	IM/PA categories	Nr present IM (AVE IMR1-IMR5)	Missing IM4a	Probability missing IM4a	Nr present PA (AVE PAR1-PAR5)	Missing PA1a	Probability missing PA1a
Netherlands (1)	1	0	0	-	0	0	-
	2	1	0	0%	2	0	0%
	3	4	3	75%	10	4	40%
	4	22	5	23%	20	7	35%
	5	24	7	29%	39	14	36%
	6	50	15	30%	23	6	26%
	7	9	4	44%	12	5	42%
Other (2)	1	1	0	0%	0	0	-
	2	0	0	-	2	1	50%
	3	1	1	100%	9	3	33%

CONV3 categories	IM/PA categories	Nr present IM (AVE IMR1-IMR5)	Missing IM4a	Probability missing IM4a	Nr present PA (AVE PAR1-PAR5)	Missing PA1a	Probability missing PA1a
	4	5	1	20%	17	5	29%
	5	15	3	20%	14	4	29%
	6	23	7	30%	16	3	19%
	7	17	3	18%	3	1	33%

Table B-0-8: Probabilities of missing data for TR2 and PSCR2 variables within CONV3 categories

CONV3 categories	TR/PSCR categories	Nr present TR (AVE TRR1 - TRR4)	Missing TR2	Probability missing TR2	Nr present PSCR1	Missing PSCR2	Probability missing PSCR2
Netherlands (1)	1	6	2	33%	15	0	0%
	2	8	4	50%	48	10	21%
	3	16	6	38%	10	2	20%
	4	24	3	13%	10	4	40%
	5	17	5	29%	2	0	0%
	6	22	6	27%	0	0	-
	7	22	9	41%	5	1	20%
Other (2)	1	5	0	0%	7	0	0%
	2	5	1	20%	38	10	26%
	3	7	3	43%	4	0	0%
	4	13	1	8%	4	1	25%
	5	10	4	40%	1	0	0%
	6	10	2	20%	1	0	0%
	7	8	2	25%	3	0	0%

Kristina Dervojeda

Dissidents of the Ivory Tower

The evidence that economic growth is dependent on university-industry interactions has boosted the number of national and international policies oriented towards promoting such interactions. The design of effective policies and incentive systems, in turn, requires a good understanding of why academics activate their social capital with industry at all.

The objective of this research was to develop a comprehensive but parsimonious model that would provide insight into the key determinants of academics' social capital activation with industry, and to understand and explain the way these factors lead to the actual behavior. The results show that decisions academics face with regard to interaction with industry are primarily determined by their experience in the past. Other influencing factors include academics' individual motivation to interact with industry, perceived social influence and perceived ability to do so.

Policies building on the notion of prior experience need to aim at creating opportunities for newcomers to get involved in projects with industry at early stages of their academic career.

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