VNIVERSITAT DE VALÈNCIA Facultat d'Economia

Departament de Direcció d'Empreses "Juan José Renau Piqueras"

AN INDIVIDUAL-LEVEL APPROACH TO KNOWLEDGE EXCHANGE: EMPIRICAL STUDIES IN BUSINESS AND PUBLIC RESEARCH ORGANIZATIONS

TESIS DOCTORAL

PRESENTADA POR

Óscar Llopis Córcoles

DIRIGIDA POR

Dr. Pablo D'Este Cukierman

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Abstract

Extant research acknowledges that knowledge creation and knowledge flows play an important role in the process of value creation within knowledge-based societies. One of the conceptual frameworks placing knowledge creation and knowledge flow at the center of value creation is the knowledge-based view of the firm (KBV). The KBV supports the idea that knowledge is the key factor of an organizations' success and, thereby, a continuous exchange of knowledge within organizational members is a primary source of sustainable competitive advantage. This thesis aims to contribute to the analysis of knowledge exchange in two settings where the individuals' decision to exchange their knowledge stock with others is a critical aspect for value creation: business organizations and the interaction between scientific agents and social agents. Although existing literature has identified a number of contextual variables that may explain the exchange of knowledge, comparatively less is known about the individual-level factors that predict why some individuals are more prone than others in engaging in knowledge exchange initiatives.

The first part of this thesis is focused on the exchange of knowledge in a single business organization. We propose a theoretical model to study the interplay between contextual-level and individual-level factors to explain the employees' knowledge sharing behavior. Particularly, we focus on the role of cooperative climate, intrinsic motivation and job autonomy as potential predictors of knowledge sharing behavior between employees working in the same company. As expected, our results indicate that a cooperative climate is positively linked to the employees' knowledge sharing behavior. However, we found that this effect is heterogeneously distributed across employees if intrinsic motivation and job autonomy are taken into account. Specifically, our results indicate that the intrinsic motivation of employees plays a substitution effect on the relationship between cooperative climate and knowledge sharing behavior. Conversely, results also reflect that employees with higher job autonomy are more likely to share

knowledge with their colleagues under a cooperative climate, compared to employees with lower levels of autonomy.

The second part of the thesis moves on the discussion to the relationship between scientific agents and social agents. Existing research recognizes that the majority of knowledge that is exchanged between science and society is concentrated in a small number of scientists. Given the current reward system in science, few scientists engage with the potential beneficiaries of their research and establish knowledge exchange activities with them (Van Looy, Callaert, & Debackere, 2006). In this sense, little is known about the individual-level factors that may facilitate the adoption of such activities by the scientists. Our study aims to fill this gap by focusing on the individual characteristics of the scientists that shape their propensity to engage with non-academic agents. Specifically, we propose the concept of "pro-social research behavior" as a conceptualization of the scientists' awareness of the impact that their research results have over actors outside the scientific boundaries. We also propose that "pro-social research behavior" is shaped by the scientists' prior knowledge transfer experience, research excellence and cognitive diversity.

This thesis aims to offer both theoretical and practical implications. From a theoretical perspective, our focus on the individual converges with recent scholarly calls advocating for more studies on the micro-foundations of knowledge creation. Our findings from the study in the business organization indicate that a cooperative climate is particularly effective in fostering knowledge sharing when employees have little intrinsic motivation to do so, and when they have high job autonomy. This may indicate that too much managerial attention in promoting a cooperative climate may overlook the fact that such cooperative climate is not equally effective over all employees. The results obtained from a sample of scientists from a public research organization (PRO) suggest that previous experience in knowledge transfer facilitates the adoption of a pro-social research behavior. We also found that both research excellence and cognitive diversity play an important role in those scientists with a lack of knowledge transfer experience with social actors. Specifically, our results support a call for policies oriented to change incentives for the participation in knowledge exchange activities. Further, they provide

arguments to support more interdisciplinary research tracks in scientists' academic profiles.

Resumen

Los estudios existentes reconocen que la creación y el flujo de conocimiento juegan un rol importante en el proceso de creación de conocimiento dentro de una sociedad basada en el conocimiento. Uno de los marcos conceptuales que sitúan a la creación y el flujo de conocimiento en el centro de la creación de valor es la perspectiva de la organización basada en el conocimiento (KBV). La KBV apoya la idea de que el conocimiento es el factor clave del éxito de las organizaciones y, por tanto, el intercambio continuo de conocimiento entre los miembros de la organización es una fuente primaria para la obtención de una ventaja competitiva sostenible. Esta tesis pretende contribuir al análisis del intercambio de conocimiento en dos contextos en los que la decisión individual de intercambiar conocimiento con otros individuos es un aspecto crítico para la creación de valor: las empresas y la relación entre agentes científicos y agentes sociales. Aunque la literatura existente ha identificado diversas variables contextuales que pueden explicar el intercambio de conocimiento, existe comparativamente menos información acerca de los factores individuales que predicen por qué algunos individuos están más dispuestos que otros a comprometerse en iniciativas relacionadas con el intercambio de conocimiento.

La primera parte de esta tesis está centrada en el intercambio de conocimiento dentro de una empresa. Proponemos un modelo teórico para analizar la interacción entre variables contextuales e individuales como factores explicativos de la compartición de conocimiento entre empleados. Particularmente, nos centramos en el rol del clima cooperativo, la motivación intrínseca y la autonomía en el trabajo como potenciales antecedentes de la compartición de conocimiento entre empleados en la misma empresa. Como se esperaba, nuestros resultados indican que un clima cooperativo está positivamente ligado a altos niveles de compartición de conocimiento. Sin embargo, encontramos que éste efecto se distribuye de manera heterogénea entre los empleados cuando la motivación intrínseca y la autonomía son considerados en el análisis. Específicamente, nuestros resultados indican que la motivación intrínseca juega un

papel sustitutivo en la relación entre el clima cooperativo y la compartición de conocimiento. Contrariamente, los resultados también reflejan que aquellos empleados con mayor autonomía en el trabajo es más probable que compartan conocimiento con sus colegas bajo un clima cooperativo, en comparación con empleados que cuenten con menores niveles de autonomía.

La segunda parte de la tesis traslada la discusión a un contexto académico. La literatura existente reconoce que la mayoría de conocimiento que se intercambia entre el ámbito científico y la sociedad se concentra en un pequeño número de científicos. Dado el sistema de incentivos existente en el ámbito académico, pocos científicos se relacionan con los potenciales beneficiarios de sus investigaciones y establecen actividades de intercambio de conocimiento con ellos. En este sentido, existe poca información acerca de los factores individuales que pueden facilitar la adopción de estas actividades por parte de los científicos. Nuestro estudio pretende abordar esta cuestión centrándose en las características individuales de los investigadores que determinan su propensión a implicarse con actores no académicos. Específicamente, proponemos el concepto de "comportamiento de investigación pro-social" como una conceptualización de la conciencia del investigador acerca del impacto que sus investigaciones tienen sobre los agentes situados mas allá del ámbito científico. También proponemos que el "comportamiento de investigación pro-social" está influenciado por la experiencia previa del investigador en transferencia de conocimiento, su excelencia investigadora y su diversidad cognitiva.

Esta tesis pretende ofrecer implicaciones teóricas y prácticas. Desde una perspectiva teórica, nuestro énfasis en el individuo converge con una reciente llamada de los investigadores abogando por una mayor cantidad de estudios sobre las micro-fundaciones de la creación de conocimiento. Nuestros resultados del estudio en la empresa indican que un clima cooperativo es particularmente efectivo promoviendo la compartición de conocimiento cuando los empleados poseen poca motivación intrínseca para hacerlo y cuando cuentan con altos niveles de autonomía en el trabajo. Esto puede indicar que demasiada atención por parte de los directivos en promover un clima cooperativo puede ignorar el hecho de que un clima cooperativo no es igualmente efectivo para todos los empleados. Los resultados obtenidos de la muestra de investigadores de una organización pública

de investigación (PRO) sugieren que la experiencia previa en transferencia de conocimiento facilita la adopción de un comportamiento de investigación pro-social. También encontramos que la excelencia investigadora y la diversidad cognitiva juegan un papel importante en aquellos científicos sin experiencia previa en transferencia de conocimiento con agentes sociales. Específicamente, nuestros resultados apoyan una llamada a políticas orientadas a modificar los incentivos para participar en actividades de intercambio de conocimiento. Además, proporcionan argumentos que apoyan perfiles de investigación más interdisciplinares entre los investigadores.

Resum

Els estudis existents reconeixen que la creació i el flux de coneixement juguen un rol important en el procés de creació de coneixement dins d'una societat basada en el coneixement. Un dels marcs conceptuals que situen a la creació i el flux de coneixement en el centre de la creació de valor és la perspectiva de l'organització basada en el coneixement (KBV) . La KBV recolza la idea que el coneixement és el factor clau de l'èxit de les organitzacions i, per tant, l'intercanvi continu de coneixement entre els membres de l'organització és una font primària per a l'obtenció d'un avantatge competitiu sostenible. Esta tesi pretén contribuir a l'anàlisi de l'intercanvi de coneixement en dos contextos en què la decisió individual d'intercanviar el seu coneixement amb altres individus és un aspecte crític per a la creació de valor: les empreses i la relació entre agents científics i agents socials. Encara que la literatura existent ha identificat diverses variables contextuals que poden explicar l'intercanvi de coneixement, existeix comparativament menys informació sobre els factors individuals que prediuen per què alguns individus estan més disposats que altres a comprometre's en iniciatives relacionades amb l'intercanvi de coneixement.

La primera part d'esta tesi està centrada en l'intercanvi de coneixement dins d'una empresa. Proposem un model teòric per a analitzar la interacció entre variables contextuals i individuals com a factors explicatius de la compartició de coneixement entre empleats. Particularment, ens centrem en el rol del clima cooperatiu, la motivació intrínseca i l'autonomia en el treball com a potencials antecedents de la compartició de coneixement entre empleats en la mateixa empresa. Com s'esperava, els nostres resultats indiquen que un clima cooperatiu està positivament lligat a alts nivells de compartició de coneixement. No obstant això, trobem que este efecte es distribueix de manera heterogènia entre els empleats quan la motivació intrínseca i l'autonomia són tinguts en compte. Específicament, els nostres resultats indiquen que la motivació intrínseca juga un paper substitutiu en la relació entre clima cooperatiu i compartició de coneixement. Contràriament, els resultats també reflecteixen que aquells empleats amb més

autonomia en el treball és més probable que compartisquen coneixement amb els seus col·legues davall un clima cooperatiu, en comparació amb empleats amb nivells d'autonomia menors.

La segona part de la tesi trasllada la discussió a un context acadèmic. La literatura existent reconeix que la majoria de coneixement que s'intercanvia entre l'àmbit científic i la societat es concentra en un xicotet nombre de científics. Donat l'existent sistema d'incentius de la ciència, pocs científics es relacionen amb els potencials beneficiaris de les seues investigacions i estableixen activitats d'intercanvi de coneixement amb ells. En este sentit, hi ha poca informació sobre els factors individuals que poden facilitar l'adopció d'estes activitats per part dels científics. El nostre estudi pretén abordar esta qüestió centrant-se en les característiques individuals dels investigadors que determinen la seua propensió a implicar-se amb actors no acadèmics. Específicament, proposem el concepte de "comportament d'investigació pro-social" com una conceptualització de la consciència de l'investigador sobre l'impacte que les seues investigacions tenen sobre els actors situats mes allà de l'àmbit científic. També proposem que el "comportament d'investigació pro-social" està influenciat per l'experiència prèvia de l'investigador en transferència de coneixement, la seua excel·lència investigadora i la seua diversitat cognitiva.

Esta tesi pretén oferir implicacions teòriques i pràctiques. Des d'una perspectiva teòrica, el nostre èmfasi en l'individu convergeix amb una recent crida dels investigadors que advoca per una major quantitat d'estudis sobre de les micro-fundacions de la creació de coneixement. Els nostres resultats de l'estudi en l'empresa indiquen que un clima cooperatiu és particularment efectiu promovent la compartició de coneixement quan els empleats posseeixen poca motivació intrínseca per a fer-ho i quan compten amb alts nivells d'autonomia en el treball. Açò pot indicar que massa atenció per part dels directius a promoure un clima cooperatiu pot ignorar el fet de que un clima cooperatiu no és igualment efectiu per a tots els empleats. Els resultats obtinguts de la mostra d'investigadors d'una organització pública d'investigació (PRO) suggereixen que l'experiència prèvia en transferència de coneixement facilita l'adopció d'un comportament d'investigació pro-social. També trobem que l'excel·lència investigadora i la diversitat cognitiva juguen un paper important en aquells científics sense experiència prèvia en

transferència de coneixement amb agents socials. Específicament, els nostres resultats recolzen una crida a polítiques orientades a modificar els incentius per a participar en activitats d'intercanvi de coneixement. A més, proporcionen arguments que recolzen perfils d'investigació més interdisciplinària entre els investigadors.

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CHAPTER 1: GENERAL INTRODUCTION

1.1 Introduction and objectives

The rise of the *knowledge-based economy* clearly reflects the deep transformation that economics and organizations have suffered during the last decades. From a macroeconomic perspective, economies are increasingly driven by an intensive production and use of knowledge assets, which have led to profound changes for all the agents involved in the economic system. The global economy has become a dense and interconnected web where agents continuously try to capture value from available knowledge (Owen-Smith & Powell, 2004).

Knowledge exchange is a critical aspect of a knowledge-based economy. It is recognized that a primary source of value creation in a knowledge-based society is obtained when knowledge is shared and when it circulates across the diversity of actors in the system. This idea is well established since Schumpeter's (1942) seminal work on the determinants of innovation. According to this view, innovations are formed through new combinations of existing knowledge. This knowledge is dispersed across the social agents and hence, combination and recombination processes are essential in bringing such new combinations and creating value (Cohen & Levinthal, 1990; Kogut & Zander, 1992; Nahapiet & Ghoshal, 1998). This argument has been empirically supported across all levels of analysis: individuals, organizations or even regions or countries, and confirms the importance of knowledge flow as a primary source of value creation. Despite its primary role, existing results have shown that the exchange of knowledge between actors cannot be taken for granted. That means that social actors may individually possess a knowledge stock but decide not to exchange it with others. As it will be discussed throughout this thesis, a number of reasons have been invoked to explain such reluctance to share. A closer look at the individual motives and characteristics help to understand why some individuals are more willing than others in exchanging their knowledge with others.

A relevant stream of research in which the importance of knowledge exchange has been extensively investigated is in the field of management. Aiming to explain how firms obtain and maintain a competitive advantage, extensive literature has been focused on knowledge creation and knowledge sharing (Grant, 1996; Ikujiro Nonaka, 1991; Nonaka & Takeuchi, 1995). Research on knowledge

management and knowledge governance also reflects the close link between the management of knowledge and a number of firm-level outcomes such as innovation or superior economic performance. It is argued, for instance, that the organizations' potential to develop "combinative capabilities" determines the firms' innovation and performance (Kogut & Zander, 1992). That is, the capacity of organizations to assimilate and apply current and acquired knowledge to the organizations' interests has become a central issue for its performance. In this field of research, understanding employees' knowledge sharing behavior has become a critical issue (Cabrera & Cabrera, 2002; Hansen, 1999; Osterloh & Frey, 2000).

A different, yet related group of scholars interested in the process of knowledge exchange between different actors can be found in the literature studying academic entrepreneurship and university-industry linkages (Etzkowitz, 2003; Rothaermel, Agung, & Jiang, 2007; Tartari & Breschi, 2012; Thursby & Thursby, 2002). These scholars are particularly concerned about the mechanisms through which the general society and economy can benefit from the knowledge that is generated at scientific institutions. There is consensus on the key role that universities and scientific research centers play as central institutions in contributing to the pool of knowledge available into the economic system. However, a successful exchange of knowledge between academic and non-academic agents is far from easy. Scholars have identified a number of barriers to university-industry collaboration, such as the different set of incentives governing both fields or the potential conflicts between scientists and institutions with regard to the economic benefits of the commercialization of knowledge (Bruneel, D'Este, & Salter, 2010; Tartari, Salter, & D'Este, 2012). A paradigmatic example of the challenge and difficulties in overcoming these barriers can be found in the biomedical field. Literature on translational research (TR) (Collins, 2011; Contopoulos-Ioannidis, 2003; Douet, Preedy, Thomas, & Cree, 2010; Fontanarosa & DeAngelis, 2002) recognizes that it is very difficult to move research findings from the researchers' bench to the patient's bedside and to the general society. Barriers to translational research include inadequate funding and resources or a lack of training in clinical methods or regulatory requirements (Hobin et al., 2012).

In an effort to understand the factors explaining the exchange of knowledge between academic agents and social agents, many studies have analyzed the

contextual factors and mechanisms that can facilitate knowledge exchange, such as the support of technology transfer offices (TTO) (Thursby & Thursby, 2002). However, some scholars have suggested to turn on to the micro-foundations and the socio-psychological characteristics of scientists involved in different forms of knowledge exchange, such as academic entrepreneurship (Jain, George, & Maltarich, 2009), placing a greater focus on the role of individuals as the primary agents in the knowledge exchange process.

This dissertation aims to contribute to the understanding of the process of knowledge exchange in two different contexts. In both settings (business organizations and scientific institutions), this thesis investigates the exchange of knowledge between agents by focusing on the individuals' decision to disclose and share their own stock of knowledge with others. Also, existing literature has stressed the idea that many factors influence the individual decision to participate in knowledge exchange activities. This thesis follows an emerging call among researchers in organizational theory and strategic management advocating for theoretical approaches based on micro-foundations (Devinney, 2013; Felin & Foss, 2005; Felin & Hesterly, 2007; Foss, 2011) to explore the individual-level factors that may explain the propensity of individuals to put their knowledge available for others. A micro-foundations approach argues that organization-level constructs are based on individual actions and interactions. Thus, this theoretical view suggests that the individual level of analysis might be the starting point of research to understand differences at higher levels of analysis.

1.2 Structure of the dissertation

In response to the appeal for more individual-level research on knowledge creation and knowledge sharing, this thesis is centered on the determinants of knowledge exchange in two different contexts: business organizations and scientific institutions. Given that industry and science are guided by a substantially different set of norms and values (Sauermann & Stephan, 2012; Stephan, 2010), we expect that the study of both contexts may enrich the ongoing discussion. Figure 1 illustrates how this thesis is structured.

After this introductory chapter, Chapter 2 is devoted to review the relevance of knowledge exchange for current organizations and societies. Within this

chapter, a discussion on the emergence and importance of the knowledge-based view of the organization is provided. Further, this chapter introduces the discussion between the "capabilities-first" perspective and "individuals-first" perspective when studying the role of knowledge in organizations, and argues that more research on individual-level actions and interactions is needed. Chapter 3 provides an empirical analysis on the determinants of employees' knowledge sharing behavior within business organizations, providing insights about the interactive effects of motivation, job autonomy and a cooperative climate in the organization over the employees' decision to share knowledge with their colleagues. The context of this study is the Danish subsidiary of a multinational company, where data from a sample of 170 employees was collected and analyzed.

Table 1: Theoretical and methodological approaches of Chapter 3

Topic	Determinants of employees' knowledge sharing behavior in organizations
Dependent variable	Knowledge sharing behavior (acquisition and provision)
Unit of analysis	Employees in a single organizational department
Sample	170 responses
Data source	Survey
Main theoretical approaches and concepts	Knowledge-based view Self-determination theory Organizational climate Pro-social behavior Job design

Chapter 4 and Chapter 5 move the discussion to a different context. Chapter 4 provides a theoretical discussion on the individual-level determinants of the engagement in knowledge exchange between scientists and social agents. The chapter proposes the concept of "pro-social research behavior" as a behavioral antecedent of the scientists' participation in knowledge exchange activities with non-academic agents. The chapter also presents a descriptive analysis on "pro-social research behavior" for a large sample of academic scientists from a public research organization. Chapter 5 examines the role of some individual-level characteristics as predictors of the scientists' engagement in knowledge exchange activities with social agents. Specifically, it is argued that prior knowledge

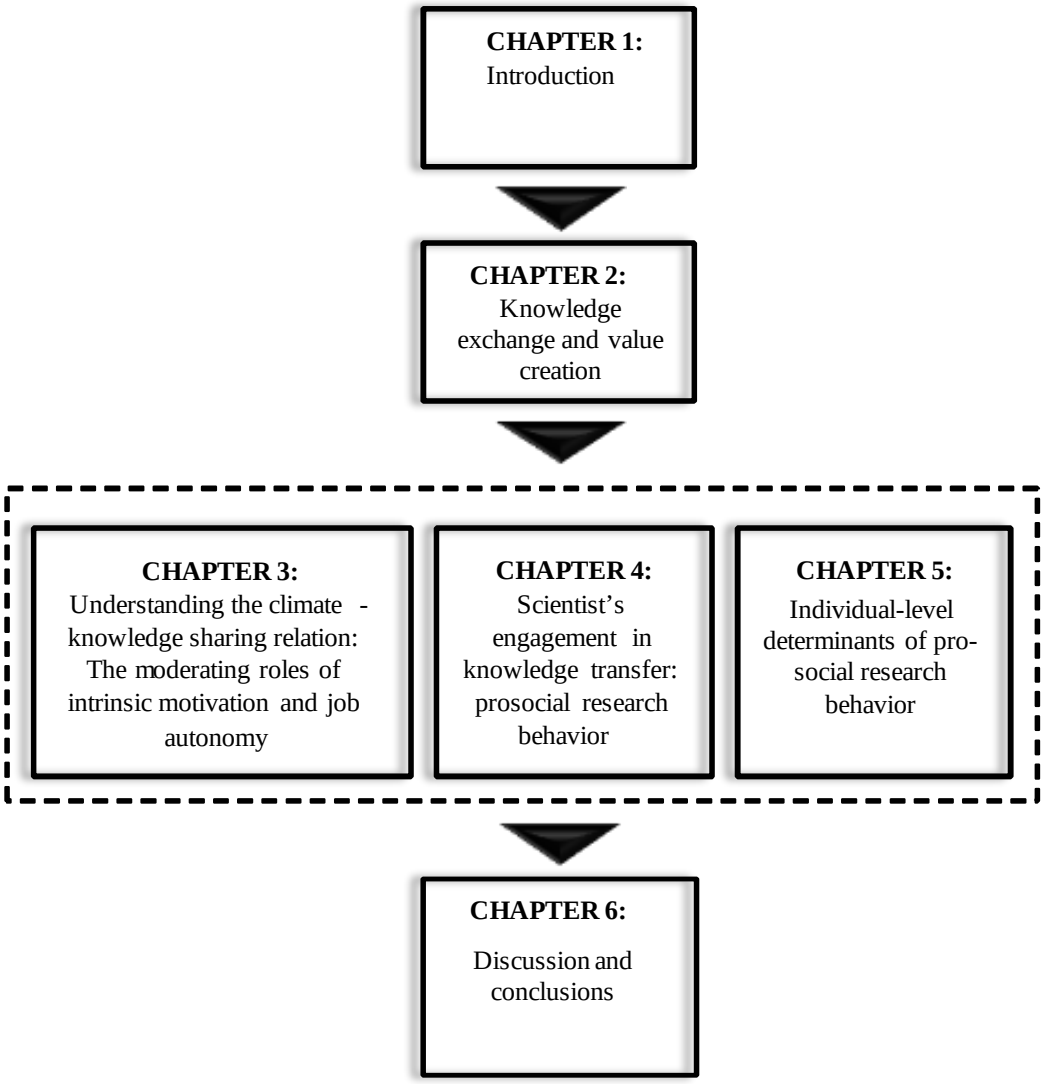
exchange experience, research excellence and cognitive diversity may contribute to explain why some scientists are more prone than others to engage in various forms of knowledge exchange activities. The empirical analyses from Chapters 4 and Chapter 5 are performed on a sample of scientists from the Spanish Council of Scientific Research (CSIC), which is the main public research organization in Spain. To perform the analysis, a database was built by combining data from three different sources: (i) a large-scale survey to all CSIC tenured scientists, (ii) administrative data provided by the CSIC, (iii) data on all publications for each scientist, collected from, the Thomson Reuters' Web of Science.

Table 2: Theoretical and methodological approaches of Chapter 4 and Chapter 5

Topic	Study of the individual-level antecedents of knowledge exchange among scientists
Dependent variable	Pro-social research behavior
Unit of analysis	Scientists from the Spanish Council of Scientific Research (CSIC)
Sample	1295 scientists
Data source	Survey + Administrative data + Bibliometric data
Main theoretical approaches and concepts	Knowledge-based view Pro-social behavior Pro-social motivation University-industry interaction

Chapter 6 provides a general discussion on the findings of the studies presented in this thesis. Theoretical and practical relevance of the research findings are summarized. The chapter ends with the limitations of this thesis as well as with some suggestions for further research.

Figure 1: Structure of the dissertation



CHAPTER 2: KNOWLEDGE EXCHANGE AND VALUE CREATION

2.1 Introduction

The increasing significance of knowledge has yielded a vast amount of scientific approaches and theoretical models to explain its impact in organizations and contemporary societies. The world economy is increasingly driven by an intensive production and use of knowledge (Powell & Snellman, 2004). It is evident that this paradigm has leaded to a deep transformation of society and organizations. Just like land was the key resource for an economic system based on agriculture, knowledge has become the critical production factor in a knowledge-based economy (Houghton & Sheehan, 2000). The pivotal role of knowledge for the functioning of the economic system was already predicted by Marshall (1890) in his "Principles of Economics" when stating that: *"Knowledge is our most powerful engine of production; it enables us to subdue Nature and force her to satisfy our wants."*. Renowned scholars from the management field such as Peter Drucker (1969) also pointed that *"knowledge had become the central capital, the cost centre and the crucial resource of the economy"* (1969:IX). The necessity to understand how knowledge has influenced the way organizations works, as well as how organizations survive in an increasingly competitive market has been a recurrent issue among management scientists. Knowledge creation and knowledge exchange among social agents has become essential components to explain economic growth and industrial dynamics according to economists (Nelson & Winter, 1982; Schumpeter, 1942) and management scientists.

This chapter aims to contribute to the above discussion by focusing on a set of complementary objectives. First, it aims to provide a conceptual discussion about the increasing relevance of knowledge as a resource for society and organizations. Second, it focuses on two particular contexts where knowledge exchange processes are particularly important: intra-organizational knowledge sharing and knowledge exchange activities between academia and society. Third, this chapter will confront two different conceptual approaches to study the determinants and consequences of knowledge exchange. A first perspective, known as the "capabilities-first" approach, is grounded on a methodological collectivist tradition (Durkheim, Catlin, Solovay, & Mueller, 1964) and tends to emphasize the importance of group-level aspects to explain individual-level behaviors. A second perspective, known as the "individuals-first" perspective

(Popper, 1965) derives from the methodological individualism doctrine, and is particularly focused on understanding group-level aspects as an aggregate of individual-level actions and interactions. By way of grounding this dissertation, this chapter builds on recent literature (Felin & Foss, 2005; Felin & Hesterly, 2007) that confronts both perspectives from a knowledge-based approach. Finally, we advocate for a greater emphasis on the "individuals-first" approach on knowledge sharing and knowledge transfer. Most of the existing literature has examined the organizational-level factors that facilitate the creation and sharing of knowledge, but comparatively less has been done to consider the importance of individual-level heterogeneity in the analysis. In other words, it will be argued that an individual-first view of the determinants of knowledge sharing and knowledge transfer is particularly important to provide a more fine-grained understanding of the phenomenon.

2.2 Knowledge and organizations: the knowledge-based view

At the organizational level, the key role of knowledge has been extensively reflected in the way in which organizations are currently managed. Probably as a consequence of the rising of the "knowledge economy" or "knowledge society", organizations have come to realize about the strategic relevance of managing, developing and protecting their intangible assets. Organizational theorists have captured this by developing a wide range of concepts, theories and perspectives giving knowledge a central stage. For instance, research on "knowledge management" (Alavi & Leidner, 2001; Ramesh & Tiwana, 1999) and "knowledge governance" (Fey & Birkinshaw, 2005; Foss & Michailova, 2009) is based on the idea that managing knowledge is a critical issue for firms' survival and competitiveness. Knowledge has currently become a unit of analysis in itself (Hull, 2000), and a number of related constructs and theoretical developments have emerged around this perspective (e.g.: dynamic capabilities, absorptive capacity, learning capacity, combinative capabilities). One of the most influential perspectives which clearly reflects the value of knowledge for the organizational functioning is the "knowledge-based view" (KBV) of the firm.

2.2.1 From a resource-based view to a knowledge-based view

Management scientists have proposed a number of theories and paradigms that have placed knowledge at the forefront of the organizational functioning. At the level of the organization, perhaps the most representative perspective reflecting the preferential role of knowledge is the "knowledge-based view" (henceforth, KBV) of the firm (Blackler, 1995; Grant, 1996; Spender, 1996). The KBV provides an explanation of why firms are superior entities compared to market mechanisms in managing knowledge and applying knowledge to create economic value. The KBV emerged as a natural extension of the resource-based view of the firm (RBV) (Barney, 1991; Peteraf, 1993; Wernerfelt, 1984). The main assumption of the RBV is that resources and capabilities[1] are heterogeneously distributed among firms. Hence, differences between organizations' performance are directly attributed to the possession of resources that are neither imitable nor perfectly mobile (Makadok, 2001). These assumptions lead to the idea that if a company possess and exploits these resources and capabilities it will obtain sustainable competitive advantage. Also, given that these resources cannot be easily imitated by other organizations, the firm will sustain this advantage and improve its economic performance (Barney, 1991; Newbert, 2008).

The RBV proposes that resources should fulfill a series of characteristics in order to constitute a sustainable competitive advantage for the organization (Barney, 1991). The first one is that the resource has to be *valuable* for the organization to employ a value-creating strategy. In other words, the resource or capability should have the potential to reduce costs or respond to environmental opportunities. Second, the resource or capability has to be *rare* by definition. That is, the resource has to be possessed by a number of organizations that is small enough to make perfect competition difficult in the market (Barney, 1991; Newbert, 2008). Third, these resources have to be *difficult to imitate*. If competitors can perfectly imitate the resource, then competitive advantage in the market will be unsustainable. Lastly, the resource or capability has to be *non-*

1 Makadok (2001) provides a distinction between "resources" and "capabilities". The former are "stocks of available factors that are owned or controlled by the organization". The latter are "a special type of resource, specifically an organizationally embedded non-transferable firm-specific resource whose purpose is to improve the productivity of the other resources possessed by the firm" (p389).

substitutable. That is, if competitors are able to find a different resource or capability that can substitute the value of the resource owned by a firm, the competitive advantage for the organization will disappear.

Being established the particularities that resources should fulfill in order to provide a sustainable competitive advantage; some authors suggested that *knowledge* is the resource that better fulfills the characteristics suggested by the RBV. If knowledge is recognized as the most strategically significant resource of the organization, then the capability to create and obtain value from knowledge is the key capability that justifies the existence of business organizations explains its performance differences between them (Conner & Prahalad, 1996; R. Grant, 1996; Kogut & Zander, 1992, 1996). This idea represents a major change compared to the RBV, which treated knowledge as a generic resource that may (or may not) constitute a source of competitive advantage.

Further, KBV suggests the distinction between "information" and "know-how" as the two primary components of knowledge (Kogut & Zander, 1992). While the former refers to the knowledge that can be easily transmitted without any loss, the latter is associated to the accumulated skills and experience that is learned across time. The argument defended by the KBV is that organizations are more advantageous than markets in developing certain "combinative capabilities" that allows knowledge to be shared and replicated inside the organizational boundaries. By generating common languages and shared codes, knowledge can be spread, replicated and transformed into novel knowledge and innovation outputs within the boundaries of the organization. Hence, differences in "combinative capabilities" explain why some firms are better than others in creating knowledge and transforming it into novel knowledge configurations that can lead to innovations and more efficient processes.

2.2.2 Key ideas from the knowledge-based view

The KBV contains some important ideas which are directly related to the critical role of knowledge for organizations and the economic system. The first one is that the fundamental reason why a firm exists –in contrast to the market mechanism- is to efficiently integrate and transform the knowledge possessed by

the organizational members (Grant, 1996, Kogut and Zander, 1992). Although some scholars have argued that this perspective does not provide sufficient arguments for the existence of firms (Foss, 1996a, 1996b), it seems clear that coordinating knowledge is conceived as a fundamental issue for the organization. This idea contrasts with previous theories of the firm, which were focused on other aspects of the organization, such as the minimization of opportunistic behavior by contracting mechanisms (Williamson, 1981).

The second building block of the KBV is that knowledge management is a critical factor for organization survival – which builds on the explicit recognition of knowledge as the most valuable asset for the organization (Grant, 1996). If the key capability of the organization is the coordination or knowledge, it seems reasonable to argue that greater managerial attention should be placed in creating the optimal conditions for knowledge to be shared, deployed and protected. According to the KBV, successful organizations are those than can create, disseminate and replicate knowledge within their boundaries and transform it into new products or services (Krogh, Nonaka, & Nishiguchi, 2000). Therefore, it is particularly important for organizations to carefully manage this process. The managerial relevance of this process is reflected in the large set of academic literature dealing with "knowledge management" issues (e.g.: Alavi & Leidner, 2001; Hedlund, 1994).

The third aspect that is critical in the KBV is the idea that the exchange of knowledge at the individual level is the basis for the construction of collective knowledge, as it has been reflected in some of the most well-known theories of new knowledge creation (Nonaka, 1991; Nonaka & Takeuchi, 1995). Extensive research under the KBV has argued that sustainable competitive advantage is more likely to arise when knowledge from different agents is combined (Argote & Ingram, 2000; Kogut & Zander, 1992). When individuals are exposed to knowledge from others, they are more likely to come up with novel combinations, leading to the generation of new knowledge (Reagans & McEvily, 2003). Also, individuals providing knowledge to others may obtain feedback from them, which contributes to the refinement of their own stock of knowledge (Haas & Hansen, 2007).

2.3 Knowledge exchange in a knowledge-based economy

It has been previously argued that knowledge as a resource has a critical impact in the way organizations are managed as well as in the functioning of the current economic system. A fundamental characteristic of knowledge compared to physical goods and services is that knowledge is not destroyed when it is consumed (Podolny, 2001). Rather, its value is likely to be multiplied when it is shared across different actors. Further, research suggests that new knowledge is created from the novel combination of previously existing knowledge (Fleming, Mingo, & Chen, 2007). In order to facilitate such novel combinations, knowledge is continuously exchanged across the different agents. Hence, an understanding of the determinants of knowledge exchange is crucial to know how new knowledge is created and how organizations and societies obtain value from it.

The importance of knowledge exchange for value creation has been pointed out by a range of diverse perspectives. For instance, social network theorists stress that actors are connected through "pipes" where knowledge continuously flows across the economic system (Phelps, Heidl, & Wadhwa, 2012). This view has been particularly fruitful for understanding how knowledge flows and it is transformed. Also, this stream of research studies how actors can appropriate the value from their structural position in the knowledge network. Although a vigorous debate is emerging around the question of which position is more effective in this endeavor, there is consensus on the idea that actors may obtain "information benefits" and "control benefits" depending on the particular position they occupy in the network (Burt, 1995). A second perspective that emphasizes the importance of knowledge exchange comes from creativity research (Amabile, Barsade, Mueller, & Staw, 2005; Amabile, Conti, Coon, Lazenby, & Herron, 1996). This body of work acknowledges that idea generation and creativity largely depends on having access to a diversity of different knowledge from others. This knowledge is normally acquired through establishing relations with others and mutually exchanging knowledge with them. A third stream of literature builds on the process of knowledge creation in organizations (Nonaka, 1991; Nonaka & Takeuchi, 1995). This literature builds on the argument that organizational knowledge is created

when individuals engage in processes of knowledge exchange in organizations. Although this literature recognizes the existence of knowledge at the organizational level, it also emphasizes that the creation and development of knowledge at the organizational level would not be possible without an individual-level exchange of knowledge.

2.4 Knowledge exchange in two different contexts

According to the discussion previously shown, it seems particularly relevant to study the factors explaining the individual decision to participate in knowledge exchange activities. Knowledge exchange can take place in multiple contexts and can be viewed from a range of perspectives. This dissertation is focused on two particular cases where this process is essential. The following two sub-sections are devoted to justify why knowledge exchange processes are particularly important within business organizations and between scientists and social agents.

2.4.1 Importance of knowledge exchange within business organizations

Knowledge sharing is beneficial for organizations because it fosters the continuous creation of new knowledge. The creation of new knowledge is a cumulative process, and new knowledge is, to a large extent, based on knowledge already developed by others. Thus, from the perspective of knowledge creation, a continuous circulation and exchange of knowledge becomes an essential process. Specifically, and following Schumpeter (1942) and Nelson & Winter (1982), the creation of new knowledge is explained by two related processes: 1) the combination of previously unconnected pieces of existing knowledge, and 2) the development of novel ways of combining elements previously associated (T. M Amabile et al., 2005; Hargadon & Sutton, 1997; Kogut & Zander, 1992; Nahapiet & Ghoshal, 1998; Nonaka & Takeuchi, 1995). In both processes, knowledge sharing is liable to have a strong impact.

Being aware of the key role of knowledge sharing, scholars from the management field have carried out significant research to investigate the factors explaining knowledge sharing inside organizational boundaries (e.g.: Bartol &

Srivastava, 2002; Bock et al., 2005; Davenport & Prusak, 1998; Husted & Michailova, 2002). A fast-growing body of research approaches this issue through the idea of the development and maintenance of "communities of practice" inside organizations as a mechanism to facilitate the employees' willingness to acquire and provide knowledge (Brown & Duguid, 1991). Communities of practice are useful because they provide an adequate environment for fostering informal knowledge sharing among employees working in related fields. However, research has revealed that sharing knowledge within organizations is a problematic and complex issue because it involves individual-level decisions and interactions (Cabrera & Cabrera, 2002). For instance, Szulanski (1996) studied 122 best-practice transfers in eight companies. He found that transferring knowledge across departments was subject to a large number of barriers which are often difficult to overcome. Some of this barriers stem from the difficulties in articulating and sharing tacit knowledge (Polanyi & Sen, 1966); others refer to motivations and attitudes of employees. For instance, employees may lack the motivation to share their knowledge with co-workers (Gagné, 2009; Osterloh & Frey, 2000) because an adequate incentive system for knowledge sharing is lacking in the organization (Davenport & Prusak, 1998). Due to the complexity of this process, a large discussion in the literature analyzes the importance of a diversity of factors for the engagement in knowledge sharing, such as the organizational climate and culture, the employees' motivation or the expected gains and losses associated to knowledge sharing (for a review, see Foss, Husted, & Michailova, 2010).

The argument of knowledge exchange as an essential dimension for the creation of novel knowledge is also supported by scholars from different fields. Research on creativity and social capital, for instance, suggest that individuals with more connections to others are particularly creative, compared to individuals with less access to different pools of knowledge (Amabile et al., 2005; Baer, 2010). The underlying mechanism is that social connections provide opportunities for knowledge exchange. It is also recognized that those employees engaging in knowledge sharing initiatives with their colleagues tend to generate new knowledge in the form of creativity and innovation outputs.

2.4.2 Importance of knowledge exchange between scientists and social agents

The second context in which knowledge exchange is critical is on the transformation of scientific knowledge into societal and economic value. To investigate the exchange of knowledge between scientists and social agents is particularly relevant for at least two reasons. The first reason refers to the importance of scientific knowledge as a source of wealth creation for societies and the economic system. In this sense, scholars have pointed out to numerous benefits from the production of scientific knowledge for the generation of innovations and social welfare (Salter & Martin, 2001).

Given that the production of scientific knowledge is mainly concentrated at scientific institutions such as universities, government institutes or research labs (Etkowitz, 2000; Powell & Snellman, 2004); mobilizing knowledge out of the "ivory tower" into commercial practice is one of the greatest challenges in a knowledge-based economy. Policymakers have taken numerous initiatives to promote the flow and diffusion of knowledge from scientific institutions to the society through the support of the "third mission" of universities (Etkowitz, 2000; Etzkowitz, 1998). The "third mission" refers to the stimulation and promotion of the application and exploitation of the scientific knowledge generated at universities to the benefit of the social, cultural and economic development of societies. Scientific institutions are increasingly active in commercializing and disseminating the scientific knowledge they produce, and scientists have currently a higher pressure towards transferring their knowledge with individuals and institutions outside the academic boundaries. As it will be developed later, understanding the factors underlying a successful flow of knowledge between both realms deserves greater attention.

A second reason why knowledge exchange with social agents is important in the academic context comes from the process of scientific knowledge creation itself. Knowledge exchange is not only beneficial for societies, but also for the individual performance of scientists. The accumulated stock of scientific knowledge is fundamental for a successful generation of novel knowledge (Cohen & Levinthal, 1990). Social interaction, information exchange and discussion are among the fundamental cornerstones over which new scientific knowledge

emerges and develops (Seufert, Krogh, & Bach, 1999). Interactions between scientists and social agents constitute an opportunity to come up with new knowledge and original ideas. Actually, some scholars have suggested that knowledge is produced at the interface between scientific institutions and social agents such as technologists (Brooks, 1994; Rosenberg, 1991). In this sense, Cohen, Nelson, & Walsh (2002) emphasize that there is a two-way flow of knowledge between public research entities and industry, arguing that industrial partners are potential sources of new ideas and research projects for scientists working on public research institutions.

The importance of exchanging knowledge with social agents can also be viewed from an organizational psychology perspective. Research in this field points out that those individuals that have direct contact with the potential beneficiaries of their work are particularly motivated to make a difference with their work and to put more effort in their tasks (Grant, 2007; Grant & Berry, 2011). Thus, a similar logic may be applied for scientists. Scholars having more ties with social agents may be more able to obtain original insights from such contacts, and will be particularly motivated to detect and fulfill the societal needs of these agents through their research. Taken together, the above arguments support the idea that scientists can get important insights for their research from their connections with social agents.

The benefits of establishing knowledge linkages with social agents can be explained through a social capital lens. Bridging ties are defined as those that link a focal actor to contacts in economic, professional and social circles not otherwise accessible (Zaheer & McEvily, 1999). Social capital research has theorized that bridging ties are the most valuable sources for obtaining novel information (Granovetter, 1973) because the information acquired though these linkages is more likely to be nonredundant. Applying this argument for the case of scientists, it is arguable that those scientists having bridging ties with social agents may be more likely to benefit from more novel knowledge from their contacts. This information advantage may be translated into a subsequent creation of new knowledge (McFadyen & Cannella, 2004).

2.5 Explaining knowledge exchange and knowledge creation: two conceptual approaches

Having justified the importance of knowledge exchange in two different contexts, and given that knowledge exchange is a key process for creating value according to the KBV, a natural question arises: *What are the factors explaining knowledge exchange in each context?* The literature from the KBV offers an adequate frame to discuss the variety of approaches that researchers have taken in trying to answer this question. This section builds on this literature to confront two research traditions in the field: the "capabilities-first" and the "individuals-first".

2.5.1. "Capabilities-first" vs. "individuals-first": an open discussion

A critical aspect to justify the approach of this dissertation deals with the subject of the "locus of knowledge". There is an open debate in the literature which discusses at which level of the organization new knowledge is created and therefore, where is located the creation of value (Felin & Hesterly, 2007). While some authors support the organization as the locus of knowledge creation, others claim that the adequate level is the individual (Felin & Foss, 2005). The adoption of one or another perspective necessarily means making assumptions that are worth to be aware of.

As explained by Felin & Hesterly (2007), the KBV mainly draws on theoretical constructs that focus on the organizational level. That is, organizational routines and capabilities are the fundamental unit of analysis, and the organizations' competitive advantage emanates from the heterogeneity in such capabilities (Felin & Foss, 2005). In this line, Felin and Hesterly (2007) offer a theoretical comparison between the individual level of analysis (or "individual locus of knowledge") and the collective level of analysis (or "collective locus of knowledge") and analyze the implications of treating the KBV under either one or the other approach. The particular aim of this section is to analyze the potential limitations of adopting a collective locus to analyze the process of knowledge creation.

The discussion between the individual locus and the collective locus has been coined as the "capabilities-first" and the "individuals-first" approaches (Foss, 2009; Minbaeva, 2007). Scholars adopting a "capabilities-first" approach have tended to emphasize the importance of group-level aspects and processes of the organization to explain why some organizations are better than others in generating novel knowledge and create superior economic value from knowledge. Indicative of the focus on collective variables is the development of a number of group-level concepts such as "combinative capabilities", "organizing principles" (Kogut & Zander, 1992), "dynamic capabilities" (Teece, Pisano, & Shuen, 1997), "routines" (Nelson & Winter, 1982) or a "collective mind" (Weick & Roberts, 1993). According to this view, it is the existence of such supra-individual mechanisms that determines to what extent organizations are superior in generating collective knowledge.

It should be noted that research under this perspective views organizational knowledge as something that cannot be reducible to the knowledge possessed by individuals. Underlying this idea is the assumption that organizational constructs exist prior to individual action. In order to avoid the role of individual agency, employees' heterogeneity in terms of motivation or values is masked by the set of routines, capabilities or other group-level variables possessed by the organization as a whole (Coleman, 1994; Felin & Hesterly, 2007). In other words, collective constructs are considered as realities that must be placed at the forefront of the analysis. This line of thought is reflected, for instance, in one of the most popular definitions of the concept of "dynamic capabilities", provided by Leonard-Barton (1992) and adopted by Teece et al., (1997):

> *"We define dynamic capabilities as the firm's ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments. Dynamic capabilities thus reflect an organization's ability to achieve new and innovative forms of competitive advantage, given path dependencies and market positions" (1997,p. 516).*

The explicit use of the expression "firm's ability" and "organization's ability" reflects that the organizations' level constructs are the main pillar over

which competitive advantage is sustained. A similar underlying idea can be observed in Kogut & Zander's model (1992) when they argue about:

> *"…understanding the capabilities of the firm as a set of "inert" resources that are difficult to imitate and redeploy" (p. 385).*

Again, this perspective reflects a conceptualization of the organization as a source of differential characteristics which determine its capacity to create new knowledge and generate value out of it. Value creation is conceived as an organizational capability. However, an issue that remains poorly understood refers to the underlying source of such collective ability for value creation. The next section is aimed to point out potential problems derived from allocating little attention to the "individuals first" approach.

Table 3: "Capabilities-first" vs. "Individuals-first" approaches in the knowledge-based perspective

	Capabilities-first	**Individuals-first**
Methodological tradition	Methodological collectivism	Methodological individualism
Intellectual roots	Evolutionary economics, innovation studies	Methodological individualism, behavioral economics, organizational psychology
Units of analysis	Social facts: routines, organizing principles, capabilities, culture.	Individuals, knowledge exchanges between individuals.
Causal directionality	Links between macro-levels of the organization (e.g: organizational capabilities -> organizational performance)	- Links from macro-variables to micro – outcomes (e.g.: organizational climate ->individual performance) - Links from micro-variables to micro-outcomes (e.g.: individual motivation -> individual behavior) -Links from micro-variables to macro-outcomes (e.g.: individual creativity – organizational innovation)
Collective ontology	Not reducible to individuals	Reducible to individuals
Conceptualization of the organization	Bundle of routines and capabilities	Organizations serve individual ends and joint production
Conceptualization of the individual	Nurture, homo "sociologicus"	Nature
Representative contributions	(Cohen & Levinthal, 1990; Kogut & Zander, 1992; Nelson & Winter, 1982; Teece et al., 1997)	Felin & Foss, 2005; Felin & Hesterly, 2007; Nonaka & Takeuchi, 1995; Osterloh & Frey, 2000; Rothaermel & Hess, 2007
Representative quote	*"…the possession of technical knowledge is an attribute of the firm as a whole, as an organized entity, and it is not reducible to what any single individual knows, or even to any simple aggregation of competencies and capabilities of all the various individuals, equipments and installations of the firm"*(Nelson & Winter, 1982: 63)	*"The firm is in no sense a "natural unit". Only the individual members of the economy can lay claim to that distinction. All are potential entrepreneurs…The ultimate repositories of technological knowledge in any society are the men comprising it…in itself the firm possesses no knowledge"*(De Graaf, 1957:16)

Source: adapted from Felin & Hesterly (2007) and Foss (2009)

2.5.2 Need for an "individuals-first" approach

Whereas the "capabilities-first" perspective of the organization has been useful in offering many insights to advance the understanding of the firm as an entity to create and manage knowledge, recent theoretical contributions from organizational theory have pointed that this perspective can be problematic. (Felin & Foss, 2005; Felin & Hesterly, 2007; Klein, Dansereau, & Hall, 1994; Rothaermel & Hess, 2007). Scientists defending an "individuals-first" perspective argue that individual actors should be the indispensable starting point before theorizing about organizational constructs. They argue that causality always goes from individual actions and interactions to collective issues (Balashov & Rosenberg, 2002). The theoretical roots of the "individuals-first" approach can be found on the "methodological individualism" school of thought (henceforth MI). This perspective defends the general argument that social collectivities and social entities cannot be explained without analyzing the role of individuals as active creators of such collective phenomena. To put it differently, MI conceive individuals in society as the atom in chemistry. That is, whatever happens can ultimately be described exhaustively in terms of the individuals involved in the process (Arrow, 1994). The idea of MI was firstly introduced by Schumpeter (1909) to advocate for a need to start from the individual in order to describe certain economic relationships. Since then, the concept has been extended and used in a large range of scientific disciplines. The antagonistic perspective of MI is the "social holism" or "methodological collectivism" (henceforth, MC) approach (Durkheim et al., 1964). To put it succinctly, the MC perspective argues -contrary to the MI- that there are some social facts that cannot be reduced to the individual level. Capabilities, routines and other "social forces" are here viewed as the primary causal power over individuals.

As mentioned above, the KBV has been traditionally biased towards the adoption of a MC perspective. Organizational-level phenomena have been supposed to exercise homogeneous influences over individuals, giving less importance to the psychological states or traits of such individuals. This bias has been present since the

very beginning of the foundations of the KBV. Grant (1996) already noted this point in his classic paper "Toward a knowledge-based theory of the firm":

> *"The danger inherent in the concept of organizational knowledge is that, by viewing the organization as the entity which creates, stores and deploys knowledge, the organizational processes through which individuals engage in these activities may be obscured." (p. 113).*
>
> *"Taking the organization as the unit of analysis […] fails to direct attention to the mechanisms through which this 'organizational knowledge' is created through the interactions of individuals" (p. 113).*

The MC approach to the organization is based on a series of conceptual abstractions that are made up as a result of individual actions. MI, however, defends that an "organizational capabilities" approach may not be sufficient to obtain a deep understanding of complex phenomena such as the process of knowledge creation. Specifically, MI claim that a MC approach is built over a series of theoretical assumptions which may obscure the processes and interactions taking place at lower levels of analysis (e.g.: individuals). The purpose of the following section is to identify these assumptions and discuss their potential limitations.

2.5.3 Main assumptions from the "capabilities-first" approach

The first assumption made by approaches based on MC is related to the homogeneity of subunits within higher level units (Klein et al., 1994). If any sort of collective process of the organization is taken as the main unit of analysis, this means that the non-focal levels of analysis are considered as homogeneous (Felin & Hesterly, 2007). To examine a particular phenomenon or process, scholars need to make an initial selection about the ontological level of analysis (e.g.: individual, group, team, organization). When invoking organizational-level constructs such as capabilities or routines as the main unit of analysis, differences between organizations' performance are ascribed to collective-level constructs and not to individual heterogeneity. Thus, it is automatically assumed that individuals are

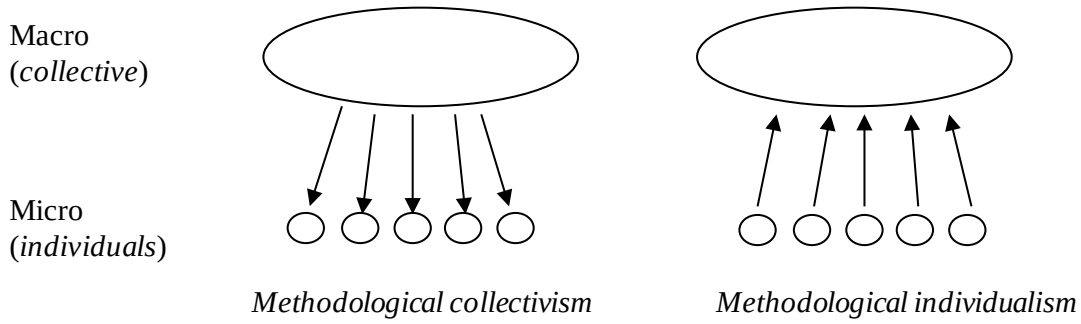
homogeneous or randomly distributed across the collectivity (Rothaermel & Hess, 2007). That implies that individuals are viewed as essentially malleable by the collective-level phenomena, rounding out potential individual-level deviations (Felin & Foss, 2005). "Capabilities-first" scholars justify this approach by explicitly argue that organizational-level constructs or capabilities are independent of individuals (Nelson & Winter, 1982) and its origins can be traced back to previous routines or capabilities. That is, there is no reference to potential individual-level origins of the collective phenomena.

To clarify some of the implications of this assumption, a particular example can be outlined. For instance, Alegre & Chiva (2008) proposed and tested the relationship between the firm's organizational learning capability (OLC) and the firm's product innovation performance. By focusing their analysis on an organizational-level construct (OLC), homogeneity in levels below the organization was assumed (here, employees). Hence, it was assumed that employees of the organization are sufficiently similar with respect to the construct in question (here, OLC), or at least, that the potential heterogeneity was randomly distributed across the organization. Here, the statistical focus is on the variation between organizations but not between individuals. In this case, the starting point of the causality relation is a firm-level capability which influences a firm-level outcome. Heterogeneity is assumed between firms, but not within them (that is, between individuals). However, MI would argue that such approach does not consider any range of employee conformity or deviance from the construct at the organization level (Coleman, 1994). Therefore, from a MI it could be argued that the collective-level construct under study is an aggregation of unobserved individual-level characteristics rather than a capability attributable to the entire organization. The main interest, therefore, would be in exploring which are the individual-level origins that may explain why some firms have higher levels of OLC than others.

From the perspective of MI, a fundamental problem of MC approaches is that they do not provide a clear answer about the *who* question. That is, who are the origins of such routines or capabilities, or who are the key individuals over whom the

organizational-level capabilities emerge (Felin & Foss, 2005). Further, they argue that assuming *a priori* that individuals are homogeneous is in conflict with existing research from psychological and cognitive sciences, which provides numerous insights to argue that individuals are significantly different with respect to their motives for action (e.g.: Deci & Ryan, 1985) or personality traits (e.g.: Goldberg et al., 2006).

Figure 2: Causal directionality between Individual and Collective levels



Source: Felin & Hesterly (2007)

A second assumption made by MC approaches is related to the issue of independence of lower-level observations. When focusing on a collective-level phenomenon, scholars assume that this level of analysis is independent from interactions with other lower or higher levels of analysis. For instance, if heterogeneity on a particular organizational capability is taken as the unit of analysis, it is assumed that such heterogeneity is independent from interactions with other lower-levels (such as employees) but also from higher-levels of analysis (such as the network or the industry where each organization belongs) (Rothaermel & Hess, 2007).

2.6 An "individual-first" approach to knowledge exchange in business organizations

In the previous section it has been argued that collective-based approaches are rooted over a series of assumptions that may not fully consider the individual-level origins of collective constructs. Although most of the literature on strategic

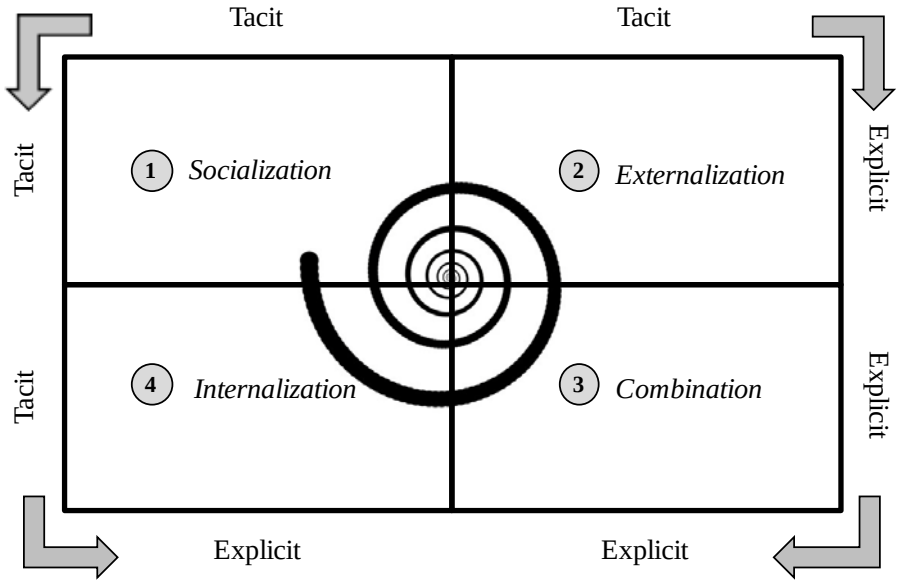
management and knowledge management has adopted a "capabilities-first" approach, some theoretical models have paid explicit attention to the importance of the individual as the starting point of collective-level constructs. Specifically, the Nonaka & Takeuchi model of knowledge creation (Nonaka, 1991; Nonaka & Takeuchi, 1995) provides a paradigmatic example on how an "individuals-first approach" is useful in understanding how individual knowledge is transformed into collective value. Differences between organizations' performance –according to Nonaka & Takeuchi's model – have their roots in individual-level knowledge sharing.

2.6.1 The Nonaka & Takeuchi Knowledge Spiral

Perhaps one of the most influential models of knowledge creation in the organizational literature has been developed by Nonaka & Takeuchi (1995). In the book "The Knowledge-Creating Company", they proposed a model to explain how organizations were able to create new knowledge. In the context of this thesis, the Nonaka & Takeuchi model is particularly pertinent for two reasons. First, and drawing from the above developed discussion, the model persuasively argues for the idea that individual-level knowledge is the source and the main origin of value creation at the organizational level. Second, the starting point of such transition from the individual to the collectivity is *knowledge sharing behavior* between individuals. Organizational capabilities and organizational knowledge are viewed here as outcomes of a particular micro-level behavior, named knowledge sharing.

To explain the transit from individual knowledge to organizational knowledge, the model indicates that the process of transforming individual knowledge into organizational knowledge is comprised by a series of recombination mechanisms. Hence, creating collective value from individual knowledge only takes place if employees engage in knowledge sharing and externalize their knowledge to other members. Specifically, the "spiral of knowledge creation" (Nonaka & Takeuchi, 1995, p. 57) enumerates four mechanisms through which tacit knowledge is converted into explicit knowledge and becomes integrated into the organizations' knowledge pool (Figure 3).

Figure 3: The Nonaka and Takeuchi Knowledge Spiral



Source: Adapted from Nonaka & Takeuchi (1992)

Nonaka & Takeuchi's model give primacy to the role of individual interaction by arguing that *socialization* is the first step of the knowledge spiral, rooted on the sharing of tacit knowledge between individuals. Without social interaction, tacit knowledge could not be externalized and transferred to other members of the organization. The second step, *externalization*, converts the tacit knowledge into explicit knowledge. By using language metaphors, analogies or models, individuals can make explicit their knowledge. *Combination* means putting together different types of explicit knowledge to form new knowledge. The last step, *internalization*, occurs when explicit knowledge becomes part of an individuals' knowledge background. This process means that the individual learns from the explicit knowledge, and the spiral of knowledge creation can be triggered again. The bottomline of this model is that it places individual interaction at the center of the knowledge creation process. Therefore, if organizations aim to put individual knowledge into organizational practice, they need to seek for ways to stimulate knowledge sharing among members.

2.6.2 An individual-based approach to knowledge sharing

The Nonaka & Takeuchi's model is a notable example of an individual-based approach to explain why organizations are superior to markets in creating new knowledge and developing the combinative capabilities required to successfully compete in the market (Kogut & Zander, 1992). Individual-level knowledge sharing is postulated as the key behavior to understand how such capabilities emerge and develop.

Some scholars have called for the adoption of an individual-level approach to understand knowledge sharing in organizations. As observed by Foss et al. (2010) in a review of the current research in knowledge sharing, scholars have tended to center their analysis in constructs defined at the macro level, paying comparatively less attention to the individual-level mechanisms that may also explain the circulation of knowledge between individuals and across the organization. Specifically, the authors analyzed 100 management research papers containing the expressions "knowledge sharing", "knowledge exchange" and "knowledge transfer" from a list of top management journals. After reviewing the conceptual models of each paper, they found that seventy-one of the one-hundred studies were centered on macro-macro links. Only ten of the studies analyzed the causal link from macro-micro links (macro→ micro), sixteen were focused on the causal link from micro-macro link (micro → macro), and twenty analyzed the micro-micro link (micro → micro). Thus, their results confirmed a preponderance of collective-level explanations over individual-level explanations in analyzing knowledge sharing in organizations.

A number of reasons may be argued to justify the need for a deeper consideration of the individual-level antecedents of knowledge sharing (Reinholt & Clausen, 2008). First, Coleman (1990) argues that interventions aimed to change a particular outcome of a given system should be implemented at lower levels of analysis. For the case of knowledge sharing in organization, this argument implies that, if the aim of the organization is to develop a sustainable competitive advantage based on their knowledge assets, managerial interventions should be aimed to facilitate and encourage knowledge sharing behavior between employees. It is the

aggregation of the individual behavior that, subsequently, will impact the organizations' capabilities to be in a better position to successfully compete in a knowledge-based economy.

Second, existing research on topics highly related to knowledge sharing suggests that motivational factors play a preponderant role in explaining why individuals decide to help others. For instance, psychological studies on pro-social behavior highlight the key role of motivations to explain differences in the degree of adoption of pro-social behaviors (POB) (Grant, 2008; Grant & Mayer, 2009). POB are defined as are actions that are intended to help or benefit the individual, group, or organization toward which they are directed (Brief & Montowidlo, 1986). Similarly, studies on organizational citizenship behaviors (OCB) (e.g.: Bolino, Turnley, & Bloodgood, 2002; Grant & Mayer, 2009) have emphasized that individual motivations help to explain why some employees are more willing to engage in OCB than others. For instance, organizational behavior research indicates that autonomously motivated employees are particularly willing to help others in organizations (Podsakoff, MacKenzie, Paine, & Bachrach, 2000) even if helping is costly for themselves. Given that knowledge sharing has been conceptualized as a particular type of pro-social behavior in organizations, motivation is likely to play an important role as well. Actually, an increasing number of studies (e.g.: Foss, Minbaeva, Pedersen, & Reinholt, 2009; Gagné, 2009; Osterloh & Frey, 2000; Reinholt, Pedersen, & Foss, 2011) have confirmed the explanatory power of the motivational approach for knowledge sharing.

And third, scholarly contributions indicate that individuals may differ in their ability to provide knowledge to others as well as to acquire knowledge from others. For instance, it is important to consider the absorptive capacity of the knowledge receiver (Cohen & Levinthal, 1990; Zahra & George, 2002). The ability to recognize, assimilate and apply new knowledge available from other individuals may explain why some individuals engage more in knowledge sharing than others. Similarly, individuals may differ in their ability to provide knowledge to others. Those

individuals more able to articulate their knowledge stock into understandable pieces of knowledge will be more likely to engage in knowledge sharing activities.

Table 4: Some empirical studies including an individual motivation approach to explain knowledge sharing behavior

Research paper	Motivational variable(s) in the model	Research sample and context	Key findings
(Reinholt et al., 2011)	Autonomous motivation to share knowledge	705 employees from a knowledge-intensive company	Autonomous motivation moderates the positive relation between network size and knowledge-sharing behavior
(Lin, 2007)	Extrinsic motivation / Intrinsic motivation to share knowledge	172 organizations from multiple sectors in Taiwan	Intrinsic motivation to share has a stronger impact than extrinsic motivation on attitudes and intention to share knowledge
(Foss et al., 2009)	Intrinsic motivation/introjected motivation/extrinsic motivation	186 employee responses from a single organization	Intrinsic motivation predicts both knowledge sending and knowledge reception. Autonomy, task identity and feedback impact the employees' motivation towards knowledge sharing.
(Bock et al., 2005)	Anticipated extrinsic rewards (extrinsic motivation)	154 organizations across 16 industries in Korea	Evidence of crowding-out effects: the greater the anticipated extrinsic rewards are, the less favorable the attitude towards knowledge sharing is.
(Cabrera, Collins, & Salgado, 2006)	Intrinsic rewards / extrinsic rewards associated with knowledge sharing	372 employees from a multinational company	Positive effect of intrinsic and intrinsic rewards on knowledge sharing behavior
(Kankanhalli, Tan, & Wei, 2005)	Extrinsic benefits / Intrinsic benefits to share	150 employees from 10 organizations in Singapore	Intrinsic benefits have stronger effects than extrinsic benefits in predicting knowledge sharing

Taken together, the above mentioned insights as well as the empirical evidence suggest that assuming individual-level homogeneity when studying knowledge sharing may lead to a potential mistake. Concentrating only in organizational-level characteristics to explain knowledge sharing does not take into consideration the above cited potential sources of individual heterogeneity. Analyzing the interaction effects between different levels of analysis (e.g.: Lacetera, Cockburn, & Henderson, 2004; Rothaermel & Hess, 2007) may provide a clearer perspective about the drivers of knowledge sharing. For instance, it may be that a particular personality trait or a specific type of motivation may substitute or complement the effect of a given organizational-level characteristic in explaining knowledge sharing.

This fundamental idea justifies the first empirical study of this thesis. Specifically, three predictors of individual knowledge sharing are considered in the model. As a baseline hypothesis, and building over previous research on knowledge sharing, it is argued that a cooperative climate in the organization is likely to have a positive impact on the individual decision to share knowledge with their colleagues (Collins & Smith, 2006; Quigley et al., 2007; Wasko & Faraj, 2005). Then, the study takes a MI approach to argue that this impact is likely to be heterogeneously distributed across employees, depending on two particular individual-level characteristics: intrinsic motivation (Deci & Ryan, 1985) and job autonomy (Hackman & Oldham, 1976). Results from our study confirm that, while high intrinsic motivation *substitute* for a cooperative climate, high job autonomy is *complementary* to the positive influence of a cooperative climate on knowledge sharing behavior.

2.7 An “individual-first” approach to knowledge exchange between scientists and social agents

The main premise of this dissertation is the need for an individual-level approach to study the determinants of knowledge transfer. Previously it has been stressed the role of knowledge sharing at the individual level in organizations. This section follows a similar logic to argue that more research is needed onto the

individual-level factors explaining knowledge exchange between scientists and social agents.

2.7.1 Approaches to knowledge exchange between scientists and social agents

A large body of work is based on the premise that knowledge exchange between public founded science and society is a central process for capitalizing the benefits of knowledge as well as to generate new scientific knowledge (e.g.: Etkowitz, 2000; Salter & Martin, 2001). The process of transferring knowledge from the academic environment to the overall society has been extensively explored in a set of related topics such as academic engagement (Perkmann et al., 2012), academic entrepreneurship (D'Este, Mahdi, Neely, & Rentocchini, 2012) or research commercialization (Lam, 2011). This literature highlights that knowledge generated in academic institutions can reach society through multiple channels. Some of these channels are related to the commercialization of knowledge, such as patenting or licensing; while others rely on more informal mechanisms, such as the establishment of informal links with social agents, the mobility of personnel as well as the participation in consulting activities with business organizations (D'Este & Patel, 2007; Perkmann et al., 2012). What is common across most of these mechanisms is that there is a two-way flow of knowledge between both domains: scientific institutions and social agents. Scholars have devoted significant attention to the changing relation between academic institutions and the socioeconomic system. In the last decades there has been a growing interest in promoting initiatives aimed to transfer the pool of knowledge generated in the academic domain into the broader society (Markman, Gianiodis, Phan, & Balkin, 2004; Thursby & Thursby, 2002). This focus has been reflected in the development of an "entrepreneurial university" model (Etkowitz, 2000; Slaughter & Leslie, 1997) as well as in a clear political discourse fueling knowledge transfer activities among academic scientists. Currently, a well performing research center or department is not successful when generating academic outputs only, but also when having a proactive role in transferring and commercializing such knowledge out of the academic context. The constitution of technology transfer offices (TTO) in virtually every university or the promotion of

science/research parks are clear examples of the interest from policymakers in promoting knowledge transfer activities (Link, Siegel, & Bozeman, 2007; Thursby & Thursby, 2002).

2.7.2 Individual-level heterogeneity among scientists

The creation of organizational structures to encourage the engagement of scientists into knowledge exchange activities does not ensure a successful adoption of such practices among the scientists (Jain et al., 2009). As previously mentioned, it is evidenced that only a small number of individuals accrue for the majority of knowledge exchange activities (Balconi, Breschi, & Lissoni, 2004), while many are more reluctant to do so. Research suggests that some scientists may not be equipped with the needed "commercial" mindset to engage in such knowledge transfer activities (Owen-Smith & Powell, 2001). As noted by Bercovitz & Feldman (2008), in a process of a structural change – such as the one considered here in terms a of new political landscape oriented to foster a more entrepreneurial behavior among scientists-, individuals may find themselves in a situation of cognitive dissonance (Festinger, 1958). This may be a result of the discomfort experienced as a consequence of holding a position where scientists are exposed to the pressures of two different logics: the academic logic and the business logic (Bercovitz & Feldman, 2011; Sauermann & Stephan, 2012). While the former is grounded on aspects such as peer recognition and open disclosure of research results (Merton, 1973), the latter is grounded on concepts such as the appropriation of returns from R&D expenditures, bureaucratic control and limited disclosure of results.

In line with the discussion put forward in this thesis, the objective is to adopt a micro-level approach to provide a clearer understanding of the individual determinants to the scientists' participation in knowledge exchange activities with social agents. Recent research has extended the call for micro-foundations to the study of the scientists' engagement in knowledge exchange activities with agents outside the scientific field (Jain et al., 2009; Shane, 2004). Existing research on the topic offers a set of individual-level factors that are related to a greater tendency to

participate in such activities. Table 5 offers a sample of studies with an individual-level focus on the determinants to various forms of knowledge exchange activities with social agents.

Table 5: Studies on the individual-level determinants of knowledge exchange

Research paper	Individual-level variable(s) considered	Conceptualization of the knowledge transfer mechanism(s)	Key findings
(Jain et al., 2009)	Four set of motivators: learning, access to in-kind resources, accessing funding, commercialization	Joint research, contract research, consulting, spin-offs, patents	Most academics engage with industry to further their own research, either through learning or through access to funds and other resources
(Lam, 2011)	Three motivations: gold, ribbon (peer recognition), puzzle (intrinsic interest)	Commercialization activities	"Puzzle" (intrinsic motivation) exerts a significant impact in the scientists' decision to engage in commercial activities
(Tartari & Breschi, 2012)	Perceived benefits / perceived costs of collaborating with industry	Collaboration with private companies	Collaboration is a form of increasing the available financial resources for performing research
(Fitzsimmons & Douglas, 2011)	Perceived feasibility/ perceived desirability	Academic entrepreneurship	Negative interaction effect between perceptions of feasibility and perceptions of desirability in the formation of entrepreneurial intentions
(Goethner, Obschonka, Silbereisen, & Cantner, 2012)	Attitudes, perceived behavioral control	Academic entrepreneurship	Positive attitudes towards entrepreneurship and PBC exert a positive impact in the formation of entrepreneurial intentions

As it is shown on Table 5, existing research has proposed a series of individual-level factors that partly explain the observed heterogeneity in the scientists' participation in knowledge exchange initiatives. Although these studies certainly provide useful insights, comparatively less is known about the sociological and psychological processes explaining the decision to engage in knowledge exchange with social actors. Given that the key actor of the process is the individual scientist, a deeper understanding about the socio-psychological features of individuals seems essential. It is also worth to note that scientists still hold autonomy in deciding the extent to which they want to engage in such knowledge exchange activities. That gives room to think that factors such as the type and strength of individual motivation may play a role (Lam, 2011). Existing research adopting a motivational perspective, however, is primarily concentrated on the role of monetary rewards and financial incentives (extrinsic motivation, in the language of the self-determination theory) (e.g.: Lach & Schankerman, 2008). Other types of motivations, such as the intrinsic motivation (Deci & Ryan, 1985) or the pro-social motivation (Grant, 2008) have received much less attention. Further, as previously argued , if the ultimate goal is to propose strategic interventions to promote knowledge exchange between scientists and social agents, it is important to consider in the analysis the individual-level factors governing such decision (Coleman, 1994; Felin & Foss, 2005).

The above discussion drives the empirical analyses presented on Chapter 4 and Chapter 5. Specifically, Chapter 4 proposes a potential predictor of scientists' subsequent engagement in various forms of knowledge exchange activities with social agents. This concept, named pro-social research behavior, aims to conceptualize the scientists' awareness about the positive impact they exert on social agents through their work. Chapter 5 explores the influence of previous knowledge transfer experience, research excellence and cognitive diversity on the formation of a pro-social research behavior. As a baseline hypothesis, it is argued that prior experience in knowledge transfer is likely to have a positive influence over scientists' pro-social research behavior. Then, the model proposes that research excellence and cognitive diversity are two predictors of pro-social research behaviors that are particularly important for those scientists with little or no previous experience in knowledge

transfer with social actors. Results confirm that previous experience is a strong predictor of pro-social research behavior, but cognitive diversity act as a substitute for experience. We also found that scientists seem to be comparatively reluctant to embrace a pro-social research behavior at intermediate levels of research excellence.

CHAPTER 3: UNDERSTANDING THE CLIMATE-KNOWLEDGE SHARING RELATION: THE MODERATING ROLES OF INTRINSIC MOTIVATION AND JOB AUTONOMY[2]

[2] Developed with Nicolai J. Foss, Copenhagen Business School and Norwegian School of Economics and Business Administration

3.1 Introduction

An important objective for many managers is to promote knowledge sharing among employees. Evidence shows that knowledge-sharing behaviors are positively linked to the creation of new products and services (Hansen, 1999; Smith et al., 2005) and to the transfer of best organizational practices (Szulanski, 1996). As such knowledge sharing can serve as a source of competitive advantage (Kogut and Zander, 1992; Reagans and McEvily, 2003). Much interest has been dedicated to the antecedents of knowledge-sharing behavior, often in the form of some combination of environmental factors and individual characteristics (e.g., Bartol and Srivastava, 2002; Cabrera and Cabrera, 2005; Quigley et al., 2007). In particular, the *organizational climate* of the workplace has been found to influence the extent to which employees will share knowledge (Bock et al., 2005). As knowledge sharing is interpersonal and cooperative (Michailova and Hutchings, 2006), the social climate for cooperation is likely to be a particularly important predictor of employees' knowledge-sharing behavior. In this research, we advance the understanding of this important predictor.

Extant research refers to the social climate for cooperation (henceforth, a "cooperative climate") as the "*organizational norms that emphasize personal effort toward group outcomes or tasks as opposed to individual outcomes*" (Collins and Smith, 2006, p. 547). Much research identifies a cooperative climate as a source of cooperative behaviors among employees (e.g., Leana and Buren, 1999; Nahapiet and Ghoshal, 1998; Schepers and Berg, 2006; Smith et al., 2005; Szulanski et al., 2004). However, less is known about how characteristics of individual employees and jobs features may moderate this influence. This is particularly interesting given that shaping or changing the cooperative climate of a particular organization often requires significant investments by management and employees in the form of time and effort (Collins and Smith, 2006; Ruggles, 1998), as the "climate of the organization is very difficult to change" (Schneider et al., 1996, p.4) (see also Schein, 1990; Ogbonna, 2007). For example, it may be that (some) individuals have specific characteristics that make a cooperative climate less needed for them to share knowledge. Or, jobs can be designed so as to exert the same influence on knowledge sharing as a cooperative climate. This is a relevant issue because employees working in the same organization oftenexhibit considerable

heterogeneity with respect to their values and motives toward work (e.g., Fay and Frese, 2000). Relatedly, most organizations are characterized by considerable task heterogeneity (Langfred and Moye, 2004).

We argue that understanding the relation between a cooperative climate and knowledge sharing is furthered by taking into account such heterogeneity. Indeed, scholars have recently suggested that future avenues on knowledge-sharing research should consider the moderating influences of employee-level characteristics (Felin and Hesterly, 2007; Foss et al., 2010; Wang and Noe, 2010). In this study we propose a contingent model built on two factors that have been extensively used as direct predictors of knowledge sharing, namely intrinsic motivation and job autonomy (e.g., Osterloh and Frey, 2000; Foss, Minbaeva, Reinholdt and Petersen, 2009; Gagnè, 2009; Reinholt, Pedersen and Foss, 2009), though not as moderators.

First, we draw on self-determination theory (SDT) (Deci and Ryan, 1985, 2000) to define intrinsic motivation as the motivation that obtains when individuals desire to expend effort on a task based on their interest in and enjoyment of the task itself (Gagné and Deci, 2005; Ryan and Deci, 2000). This conceptualization implies that intrinsic motivation is not fully determined by the social context; hence, employees exposed to a similar social climate may differ in their intrinsic motivation. This means that intrinsic motivation can substitute for a cooperative climate with respect to impact on knowledge sharing. This is good news for organizations with many intrinsically motivated employees, as it means that it may not be necessary to incur the costs of building a cooperative climate.

We also discuss whether management can enhance the positive effects of a cooperative climate by providing more autonomy to employees. Job autonomy (Hackman and Oldham, 1976) has been found to be an important predictor of extra-role behaviors among employees (e.g., Fried et al., 1999). Knowledge sharing is often an extra-role behavior. Similarly, cooperative behaviors are more likely to emerge between those employees working with a context that is supportive of autonomy (Gagné, 2003). Finally, many knowledge-intensive firms, that is, the empirical setting of this study, are characterized by considerable job autonomy. We build on these insights to argue that employees who have more job

autonomy will also face more opportunities to engage in knowledge-sharing activities because employees with fuzzy guidelines about how to perform their jobs will have a greater need for others' input (Cabrera et al., 2006). For these employees, a cooperative climate will be the ideal framework to engage in knowledge-sharing behaviors. Organizations that already have a cooperative climate can further increase the positive effects of this on knowledge sharing by providing more autonomy to employees.

In sum, prior research suggests that a cooperative climate is positively related to knowledge sharing through a number of mechanisms (e.g., Bock et al., 2005; Hooff and Ridder, 2004; Smith et al., 2005; Wasko and Faraj, 2005). However, the potential moderators of this relation have been given little attention. Accordingly, we examine two moderators—namely, intrinsic motivation and job autonomy—which have been treated in extant research mainly as direct predictors of knowledge sharing. We begin by introducing the theoretical mechanisms through which a cooperative climate is likely to influence knowledge-sharing behavior. We then argue that the understanding of this relationship may be enhanced by considering the moderating effects of intrinsic motivation and job autonomy. We test our hypotheses on a sample of 170 employees from a knowledge-intensive firm, and we discuss directions for future research and managerial implications.

3.2 Theoretical background

3.2.1 Organizational Climate and Employee Behavior

Although many definitions of organizational climate have been offered in the literature (e.g., Dennison, 1996; Glick, 1985; Kuenzi and Schminke, 2009; Schneider, 1990), there is considerable agreement that organizational climate refers to those social features of the workplace that facilitate or inhibit certain behaviors (Schneider, 1975; Schneider et al., 2000). According to Schneider et al. (2000), organizational climate is viewed by employees as a source of embedded knowledge about how things are to be done and prioritized. Thus, this climate provides situational cues about embedded organizational policies, practices and

procedures. Employees can use these contextual cues as guidelines to how organizations work and how they are expected to behave (Ashkanasy et al., 2000).

The focus of climate research has shifted in recent decades from a focus on organizational climate as a unitary construct (e.g., Kozlowski and Klein, 2000; Litwin and Stringer, 1968) to a deconstruction of the concept into multiple facets of organizational reality (beginning with Schneider, 1975). This new approach to organizational climate has been used by organizational behavior scholars as a cornerstone for the development and testing of a wide number of specific climate constructs. Thus, the climate literature offers constructs for climates for justice (Naumann and Bennett, 2000), creativity (Gilson and Shalley, 2004), innovation (Anderson and West, 1998; Pirola-Merlo and Mann, 2004), diversity (McKay et al., 2008), and ethics (Ambrose et al., 2007). As they represent different facets of a given context, many of these specific climates can be found simultaneously in the organization (Kuenzi and Schminke, 2009).

Much research examines the facet-specific climates with regard to a diverse range of individual outcomes (e.g., Bacharach et al., 2005; Tesluk et al., 1999). For example, Ehrhart (2004) describes how a climate of procedural justice affects the employees' organizational citizenship behaviors (OCBs). Note that knowledge sharing has often been linked to OCBs (e.g., Yu and Chu, 2007); indeed, knowledge sharing may itself be seen as an OCB. Employees in organizational units characterized by a climate of fairness are more willing to engage in helping behaviors. The causal mechanism is that if employees perceive that they are treated fairly, they assign meaning to that treatment as representative of a social exchange relationship (Blau, 1964). Therefore, employees will tend to assign the same meaning when interacting with other members. This may result in employees engaging in more OCBs (Mossholder et al., 2011). Gilson and Shalley (2004) also describe how a climate that is supportive of creativity has a positive impact on employees' creative behaviors. When employees feel comfortable in taking risks and openly exchange information, they are more likely to engage in creative behaviors. Chen et al. (2007) show that an empowering climate in a team is positively linked to the individual team members' sense of empowerment. They define the empowering climate as the group's use of structures, policies and practices to support employees' access to power. In a highly empowering climate,

employees have more feelings of self-control, and are more likely to seek feedback, set work goals and solve problems on their own than with the help of their supervisors. Other authors have linked climate aspects to knowledge-related variables, such as knowledge exchange (Collins and Smith, 2006; Smith et al., 2005; Wasko and Faraj, 2005).

3.2.2 Cooperative Climate and Knowledge-Sharing Behavior

Consistent with the focus on facet-specific climates and specific behaviors, we focus on the link between a cooperative climate and knowledge-sharing behaviors. Collins and Smith (2006, p. 547) define a cooperative climate as the "organizational norms that emphasize personal effort toward group outcomes or tasks as opposed to individual outcomes". Employees working under a cooperative climate are likely to view other employees as cooperators rather than competitors. A cooperative climate signals reciprocity and the trustworthiness of colleagues (Bogaert et al., 2012). For example, Bacharach et al. (2005) show that employees that work in a climate of mutual peer support climate tend to establish supportive relations with dissimilar peers. Relatedly, Tse, Dasborough and Ashkanasy (2008) suggest that a group's affective climate increases relationships of friendship among employees.

The relationship between the climate of the organization and the knowledge-sharing behaviors of employees has recently been explored (Collins and Smith, 2006; Levin and Cross, 2004; Quigley et al., 2007; Wasko and Faraj, 2005). Knowledge-sharing behavior is typically conceptualized as the provision or acquisition of task information, know-how and feedback on a product or a procedure (Hansen, 1999). Knowledge sharing usually involves establishing informal links with colleagues. Some studies highlight the discretionary nature of knowledge sharing (Cabrera and Cabrera, 2005) and how socially developed norms within groups are critical for the decision to share among peers (Argote et al., 2003). In contrast, the encouragement of knowledge sharing through formal incentives tends to fail because of the difficulties associated with monitoring employees' knowledge-sharing behaviors (Osterloh and Frey, 2000) and because

formal rewards may have a negative effect on the employees' intrinsic motivations to share (Foss et al., 2009; Reinholt, et al., 2011).

Given that the effectiveness of formal mechanisms to encourage knowledge sharing has been called into question, researchers have turned to the informal processes that may influence the willingness of employees to share knowledge. For instance, Collins and Smith (2006) develop and test a model that relates a social climate of trust, cooperation, and shared codes and language with higher levels of knowledge exchange and knowledge combination in the organization. They argue that a climate of high cooperation can encourage employees to focus on the wider community of the organization rather than on their own interests. As a result, knowledge acquisition and provision can be facilitated among them. In line with this reasoning, Smith et al. (2005) find that when the climate of the organization is characterized by higher levels of risk taking and teamwork, employees are more able to create novel knowledge. Similarly, Bock et al. (2005) show that an organizational climate characterized by fairness, affiliation and innovativeness is positively related to employees' intention to share knowledge. Specifically, by being exposed to such a climate, employees develop subjective norms that are positively related to the intention to share implicit and explicit knowledge among colleagues.

In sum, scholars recognize that employee decisions to share knowledge are influenced by the cooperative climate of the group in which they work. Indeed, several theoretical mechanisms may be invoked to explain this causal link. According to a social psychological view, interactions among employees are likely to create descriptive norms of behavior (Cialdini and Trost, 1998; Ehrhart and Naumann, 2004). Consequently, a cooperative climate can be conceived of as a source of descriptive norms to behave in a cooperative manner. Cooperative behaviors are generally supported in the group and engaging in knowledge sharing is viewed as a way to align one's behavior with the cooperative social norms that are predominant in the group. Furthermore, a cooperative climate implies social exchanges among organizational members. In the language of social exchange theory (Blau, 1964; Deutsch and Gerard, 1955), employees may show a tendency to "pay back" their colleagues' cooperative behavior. In this sense, engaging in knowledge-sharing behavior is likely to be an avenue for reciprocation. Evidence

grounded on social comparison theory (Festinger, 1954; Suls and Wheeler, 2000) suggests that when employees are part of a cooperative climate, their comparisons of themselves with other members will result in a greater tendency to behave in a cooperative manner (Buunk et al., 2005; Kelley and Thibaut, 1978). A cooperative climate is likely to be associated with a higher level of trust among employees, which in turn has been found to be a strong predictor of knowledge sharing (Leana and Buren, 1999; Szulanski et al., 2004; Zaheer et al., 1998).

Although the above-mentioned mechanisms can arguably justify the positive influence of a cooperative climate on the employees' knowledge sharing behavior, little is known about whether this positive effect is equally distributed among all employees (Bogaert et al., 2012; Wang and Noe, 2010). When researchers primarily explain employees' knowledge-sharing behavior as a consequence of the social climate of the organization, they implicitly assume employee homogeneity with respect to how employees respond to contextual variations. Rather, and according to Felin and Hesterly (2007), the characteristics of individuals (e.g., heterogeneity in terms of values or traits) have fundamental implications for their response to contextual features. Research suggests that employees within organizations are heterogeneous with respect to their work-related attitudes, motives, behaviors and values (Bogaert et al., 2012; Grant and Rothbard, forthcoming), as well as in how they interpret the organizations' context and actions (Schneider and Smith, 2004).. Managerial interventions to shape the organizational climate towards a cooperative one should take such complexity into account, as heterogeneous employees manifest different reactions to such interventions. Research on the moderating role of individual-level variables is needed to better assess the consequences of interventions aimed at influence the cooperative climate. In the following section, we introduce two variables that represent sources of heterogeneity in the way that employees respond to a cooperative climate.

3.3 Hypothesis development

3.3.1 The Moderating Role of Intrinsic Motivation

Research on motivation shows that the desire to "make an effort" can derive from various sources (Deci and Ryan, 1985; Herzberg, 1966; Reiss, 2004). Self-determination theory (Deci and Ryan, 1985, 2000) offers a theoretical framework that allows for the differentiation of behaviors with respect to how self-motivated and volitional they are. Intrinsic motivation is defined as the desire to expend effort on a certain task based on an interest in and enjoyment of the task itself (Gagné and Deci, 2005; Ryan and Deci, 2000). When they are intrinsically motivated, employees decide to expend effort based on personal enjoyment rather than based on external forces, such as being told what to do or because of the promise of a reward (Kehr, 2004). Thus, intrinsically motivated employees value the content of the work itself as a source of motivation (Gagné and Deci, 2005). Research has also shown that intrinsically motivated individuals tend to put more effort and persistence into tasks (Amabile et al., 1994). Recent research has recognized intrinsic motivation as an important driver to share knowledge with colleagues (e.g., Bock et al., 2005; Cabrera and Cabrera, 2002; Lin, 2007; Wasko and Faraj, 2005).

Although SDT scholars note that the emergence of intrinsic motivation may be facilitated under certain contextual characteristics, they emphasize that it is the nature of the activity *per se* what determines the emergence of intrinsically motivated behaviors. In fact, when individuals feel that contextual factors are pushing them towards certain behaviors, their intrinsic motivation towards that specific behavior tends to decrease (Deci and Ryan, 1985; Gagné and Deci, 2005). Employees that are intrinsically motivated are process-focused and see the work as an end in and of itself (Grant, 2008). For this reason, when intrinsic motivation is high, employees will enjoy the process of performing the task and their behavior will be less determined by the contextual characteristics and more by the nature of the activity to be performed. We extend this rationale to argue that employees differ in their natural tendency to share knowledge with others, that is, in their intrinsic motivation to engage in knowledge sharing. Hence, we propose that

employees with higher levels of intrinsic motivation towards knowledge sharing will be less influenced by a cooperative climate on their decision to share knowledge because their behavior is mainly process-focused and less contingent on external factors. Thus, even if contextual factors do not explicitly support cooperation, some employees may show high levels of intrinsic motivation to share knowledge. That means that they may participate in knowledge sharing for reasons not directly related to the cooperative climate of the organization. In other words, intrinsic motives to share knowledge may be viewed as a reflection of internal dispositions towards the activity itself rather than a response to a given set of contextual factors such the existence of a cooperative climate. Two theoretical, yet complementary perspectives may be used to support this idea.

First, research on SDT proposes that intrinsically motivated efforts enable individuals to fulfill their basic psychological needs for autonomy, competence and relatedness, which are essential nutriments for optimal human development and integrity (Gagné, 2009; Ryan et al., 1996). Recent studies suggest that the participation in activities that benefit others may serve as a way to partially fulfill those three primary needs (Grant, 2008; Sheldon, Arndt, and Houser Marko, 2003; Weinstein and Ryan, 2010). As such, the participation in knowledge sharing may be viewed as a potential activity through which individuals may show a natural interest. Knowledge sharing is an extra-role behavior (Sparrowe et al., 2001), given that it is not fully specified in advance by role prescriptions, not recognized by formal reward systems (Cabrera and Cabrera, 2002; Osterloh and Frey, 2000) and not a source of punitive consequences when not performed by job incumbents (Van Dyne and LePine, 1998). As suggested by Weinstein and Ryan (2010), employees may experience autonomy need satisfaction when deciding to engage in extra-role behaviors such as sharing knowledge with their colleagues. Similarly, knowledge sharing may be closely connected to the fulfillment of the need for relatedness. Because knowledge sharing may lead to building, developing and maintaining social ties with colleagues (Reinholt et al., 2011), some employees may tend to naturally engage in knowledge sharing with others. In addition, research indicates that successfully helping others as well as learning from others' knowledge may elicit feelings of competence (Caprara and Steca, 2005; Weinstein and Ryan, 2010).

Second, organizational behavior scholars note that some individuals are naturally inclined to engage in prosocial behaviors (Bogaert et al., 2008; De Cremer and Van Vugt, 1999). Employees may vary in their tendency towards collaborative action, meaning that their collaborative behavior will be less influenced by contextual factors and more based on internal values and convictions. For example, Grant and Rothbard (forthcoming) show that the employees that score higher in prosocial values tend to be more proactive in ambiguous situations compared with those with lower prosocial values. Given the strong connection between prosocial values and knowledge sharing behaviors (Brief and Motowidlo, 1986; Gagné, 2009) we find it reasonable to predict that inherent employee characteristics can drive the decision to engage in knowledge sharing. A similar argument is provided by a series of motivational studies (Sheldon & Elliot, 1998, 1999) that propose that intrinsic motivation towards a certain activity exists because the activity is consistent with personal convictions, core values and enduring interests of the self.

Taken together, the above arguments support the idea that a cooperative climate is not strictly necessary for all employees to engage in knowledge sharing. As explained above, a cooperative climate may become the contextual support towards knowledge sharing for those employees showing low levels of intrinsic motivation to do so. In contrast, those employees with a natural interest towards knowledge sharing (reflected in higher intrinsic motivation towards knowledge sharing) will engage in knowledge sharing behaviors even in absence of a cooperative climate. On the other hand, for those employees with a lower baseline level of intrinsic motivation towards knowledge sharing, the influence of the cooperative triggers arising from a cooperative climate may be critical to explain their knowledge sharing behavior. Therefore, we offer the following hypothesis:

> **Hypothesis 1***: An employee's intrinsic motivation to share knowledge moderates the relationship between the cooperative climate of the organization and the employee's knowledge-sharing behavior. Specifically, increased intrinsic motivation weakens the positive effect of a cooperative climate on knowledge-sharing behavior.*

3.3.2 The Moderating Role of Job Autonomy

Research on job design focuses on the structure of the employees' work and its relevant tasks and characteristics (Morgeson and Humphrey, 2006). An important job dimension is job autonomy, which refers to the level of discretion that each employee is given with respect to how to perform her tasks (Hackman and Oldham, 1976; Turner and Lawrence, 1965). Employees with more job autonomy have greater freedom to decide which tasks to perform, how the work will be done and how work contingencies are to be handled (Langfred and Moye, 2004). Management scholars have linked job autonomy with a range of employee-level outcomes such as job performance (Morgeson et al., 2005) and creativity (Spreitzer, 1995), among others. A positive association between job autonomy and knowledge sharing is well established in the literature (Cabrera et al., 2006; Gagné, 2009; Janz et al., 1997). The prevailing theoretical mechanism is that job autonomy positively influences employees' motivation towards knowledge sharing (Foss et al., 2009; Fuller et al., 2006).

While in keeping with prior literature, we expect that job autonomy will provide employees with higher ability and greater opportunities to benefit from a cooperative climate. Specifically, job design research shows that job autonomy is correlated with task variety (Whittington et al., 2004), as employees whose jobs entail more variety are likely to be given more autonomy by the manager and less-specific guidelines about how to perform their tasks. Task variety involves the use of diverse knowledge and skills, which may be acquired through the exchange of knowledge with colleagues (Coelho and Augusto, 2010; Hackman and Oldham, 1976). A similar idea is proposed by Cabrera et al. (2006), who argue that job autonomy is normally correlated with creative tasks. Given that creative tasks often drive employees to search for novel knowledge and ideas (Amabile et al., (1996), and this is may be provided by discussion and knowledge exchange with colleagues (Utterback, 1971), it is expected that grating employees more autonomy will lead them to participate in knowledge sharing. Thus, these employees will be better able to absorb the incoming knowledge from their colleagues (Cohen & Levinthal, 1990; Reinholt et al., 2010) as well as to provide knowledge valuable to others (Reagans & McEvily, 2003). From an organizational behavior lens, it is argued that granting employees more job autonomy provides them opportunities to

engage them in extra-role behaviors. That is, in these activities not explicitly specified in their job duties but on which many organizations may depend, such as the participation in knowledge sharing (Morgeson et al., 2005; Smith et al., 1983).

On the basis of the above mentioned arguments, we propose that job autonomy reinforces the relationship between cooperative climate and knowledge sharing behavior. When employees are granted with greater job autonomy, they will be in a better position to benefit from a cooperative climate compared to employees with lower levels of job autonomy. Given that not all employees are granted with the same job autonomy, those with the greater autonomy will be more likely to to free up time to engage in learning activities such as knowledge sharing (Latham and Pinder, 2005; Narayanan et al., 2009). That will allow them to be in a better position to take advantage of a cooperative climate. Also, because employees with higher levels of autonomy in their jobs will be more proactive towards searching for more effective ways to perform their tasks (Fuller et al., 2006) and novel ideas (Oldham, 2003), they will be more positively influenced by the positive effect of the cooperative climate on knowledge sharing. On the contrary, low levels of job autonomy indicate that employees have little choice in terms of how to perform their tasks. Under this condition, employees are restricted in terms of operation and method choice. Hence, they will be less able and willing to exploit the potential benefits (e.g., knowledge sharing) of a cooperative climate.

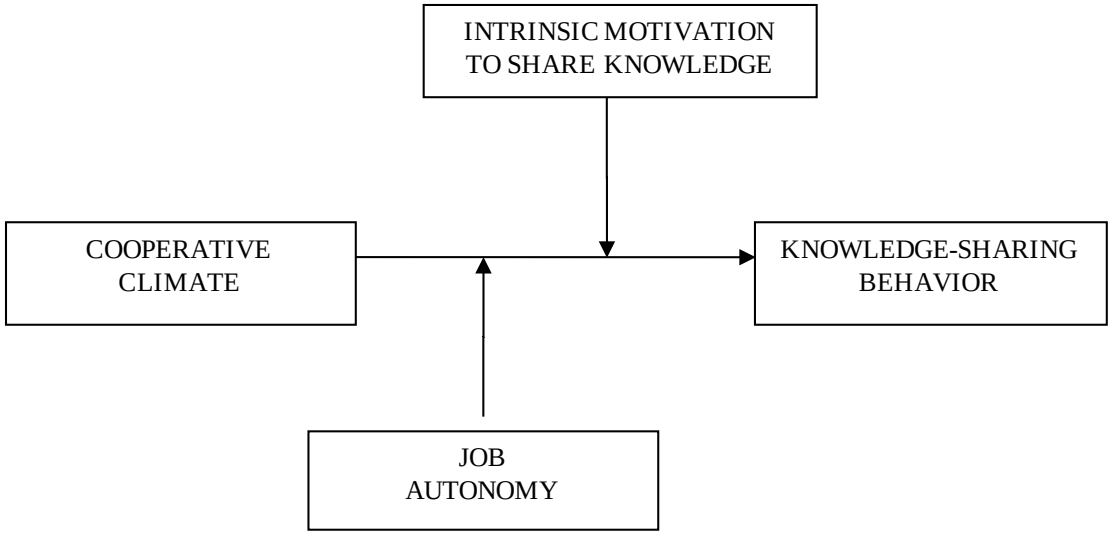
Consequently, we expect that the freedom and latitude available to employees to make decisions in their jobs presents opportunities for them to engage in knowledge-sharing activities, thereby reinforcing the positive influence of a cooperative climate in knowledge sharing.

This motivates the following hypothesis:

***Hypothesis 2**: Job autonomy moderates the relationship between an organizational cooperative climate and an employee's knowledge-sharing behavior, such that increased job autonomy enhances the positive effect of a cooperative climate on the employee's knowledge-sharing behavior.*

Our hypotheses are summarized in Figure 4.

Figure 4: Conceptual model:



3.4 Research Methods

3.4.1 Data Collection and Research Site

The data was collected from the multinational company MAN Diesel in February 2007. MAN Diesel is a market leader in the provision of diesel engines for marine and plant applications. It is also involved in other business areas, such as the resale of engines and the sale of components. The firm is headquartered in Copenhagen and is 100% owned by the German company MAN, which employs more than 6,400 staff members, primarily in their subsidiaries in Germany, Denmark, France, the United Kingdom, the Czech Republic and China. The Copenhagen subsidiary was established more than 100 years ago, and is mostly dedicated to research and development (R&D) activities. As of February 2007, it employed 2,488 people. Given to the nature of the functions performed in MAN Diesel and the knowledge-intensive nature of the company, most of the employees are engineers. Yearly sales per employee were 1,246,000 DKK (approximately USD 237,000). MAN Diesel's organizational structure is hierarchical and departmentalized, showing lines of responsibility from the top to the bottom. Knowledge sharing within and between departments is a key managerial concern.

A questionnaire was pre-tested with MAN managers and four management scholars who specialize in survey design and knowledge sharing to ensure the clarity of the questions and to avoid problems with interpretation. The web-based questionnaire was then distributed (by an email from management containing a URL) to employees in select departments in February 2007 through a firm representative, who mediated the distribution of the questionnaires and the collection of responses. Social desirability bias (Tsai and Ghoshal, 1998) was reduced by informing the respondents that their answers would be kept completely confidential and that the data was being collected on a server external to the company. We obtained data from 263 of the 505 employees who were invited to participate, giving an overall response rate of 52%. However, some responses were removed because of missing values for some items, so that the final data set included 170 responses. This yields the quite satisfactory response rate of 34%.

All data used in the analysis were collected from a single company. This implies that we have controlled for contextual factors that may impact intra-organizational knowledge sharing (Tsai and Ghoshal, 1998). Such a research context may be seen as advantageous relative to data sets encompassing a large number of firms with only a few respondents per company. Our objective was to reach those employees of the firm potentially involved in knowledge-sharing activities. To do so, we selected departments specifically involved in knowledge sharing: Engineering, R&D, Sales and Marketing, Technical Service, and Purchasing. As our goal was to examine employees' motivations, job autonomy, climate and knowledge-sharing behaviors, we used self-reporting to operationalize and measure the variables, similar to most studies of work motivation (Bal et al., 2012; Reinholt et al., 2011) and human behavior (Howard, 1994). Similarly, job characteristics (Foss et al., 2009) and climate features (Argote et al., 1990; Quigley et al., 2007) have previously been captured through self-reporting.

3.4.2 Common Method Bias

Common method bias might be a concern owing to the use of self-reporting (Podsakoff and Organ, 1986; Spector, 2006). To diminish this risk, we reversed some of the scales used in our questionnaire (Rust and Cooil, 1994). Furthermore,

according to Evans (1985), models with interaction effects, such as our model, mitigate the risk of common method bias. We also note that "[c]ommon method bias can be effectively controlled by including other independent variables, which exhibit small bivariate correlation (< 0.3) among each other and those measures that suffer from common method variance (CMV). Thus, CMV is less of a problem in OLS models with many independent variables, especially if these variables are not highly correlated (Siemsen et al., 2010). Our model includes nine continuous independent variables. As expected, the only correlation above 0.3 is obtained between tenure and age (see Table 1).

In addition, we performed a Harman's one-factor test on the items to assess the severity of the common method bias. Harman's one-factor test is the most widely used approach for assessing CMV in a single-method research design (Podsakoff et al., 2003). CMV is assumed to exist if: (1) a single factor emerges from unrotated factor solutions or (2) one factor explains the majority of the variance in the variables (Podsakoff and Organ, 1986, p. 536). In our model, our first two factors capture only 20% and 14% of the total variance, respectively. Furthermore, we conducted an analysis based on marker variables (Lindell and Whitney, 2001; Podsakoff et al., 2003). While these marker variables did have separate explanatory power in some cases, they did not remove the significance of the key variables. Although the statistical tests do not eliminate the threat of CMV, they show that results are not highly affected by CMV.

The relatively high response rate (34%) makes non-response bias less of a concern. Nevertheless, we compared the demographic variables (age, tenure and level of education) between the early and late respondents (wave analysis) and tested the assumption that the group of late respondents with missing values was more similar to the non-responding group than the group of early respondents (Rogelberg and Stanton, 2007). We performed an ANOVA analysis of the differences in means for the two groups for the demographic variables in order to test this assumption. The results indicate that the hypotheses of differences in the means are all rejected (with F-values < 2), which leads us to believe that our data does not suffer from major problems of non-response bias.

3.4.3 Dependent Variable: Knowledge-Sharing Behavior

According to the extant literature (Davenport and Prusak, 1998), an assessment of knowledge sharing should consider two actions: (1) the employee's acquisition and use of knowledge, and (2) the employee's provision of knowledge. The acquisition of knowledge was measured by asking individual respondents to indicate the extent to which they had received/used knowledge from colleagues in their own department (two items). Similarly, to assess the provision of knowledge, we asked individual respondents to indicate the extent to which colleagues from the same department had received and used the respondent's knowledge (two items). These four items were measured on a seven-point Likert scale, where 1 = "no or very little extent" and 7 = "very large extent". The construct shows satisfactory reliability and validity (alpha = .74, AVE = .57, composite reliability = .84). The construct of knowledge-sharing behavior was calculated as the average of the four items.

3.4.4 Independent Variables

Cooperative climate. We derived our items for the measurement of the cooperative climate from Husted and Michailova (2002) and Michailova and Husted (2004). These scholars do not explicitly use the construct of "cooperative climate"; instead, they focus on the determinants of knowledge hostility. However, similar constructs are used by Bock et al. (2005) and Collins and Smith (2006) to assess the influence of a cooperative climate on the exchange of knowledge among employees. To conceptualize cooperative climate, we specifically asked employees to indicate the extent to which they agreed with the following statements: "Employees in my department cooperate well with each other", "Employees in my department prefer to create their own knowledge rather than reusing others' knowledge" and "Employees in my department perceive of each other as competitors". All items were measured on a seven-point Likert scale ranging from 1 = "strongly disagree" to 7 = "strongly agree". The last two items were reverse-coded for the statistical analysis. The values of the construct reliability and AVE are .84 and .64, respectively, which are highly satisfactory. The alpha of the construct is .72, which denotes a high level of internal consistency.

Job autonomy. We measured job autonomy by adapting measures of job characteristics from Sims, Szilagyi and Keller (1976). This measurement for job autonomy has been proven adequate in a previous study (Foss et al., 2009). Specifically, the variable was assessed by asking respondents to indicate the extent to which their job was characterized by "The freedom to carry out my job the way I want", "The opportunity for independent initiative" and "High levels of variety in the job". The four items were measured using a seven-point Likert scale ranging from 1 = "strongly disagree" to 7 = "strongly agree", and the construct was calculated as the average of the three items. The alpha for the construct is .74 and the composite reliability is .85. The AVE value also shows a satisfactory value of .66.

Intrinsic motivation. To assess the intrinsic motivation to share knowledge, we adopted scales from the Self-Regulation Questionnaire (Ryan and Connell, 1989), which is based on SDT. We adapted the intrinsic motivation questionnaire in order to create a construct that captures the intrinsic motivation to share knowledge. Thus, the construct used in our questionnaire reflects the intrinsic motivation to engage in a specific behavior – knowledge sharing – across time. To operationalize this construct, we asked respondents to indicate the extent to which they agreed with three items: "I share knowledge because I enjoy doing so", "I share knowledge because I like it" and "I share knowledge because I find it personally satisfying". All three items were measured using a seven-point Likert scale ranging from 1 = "strongly disagree" to 7 = "strongly agree". The construct of intrinsic motivation was calculated as the average of the three items. The obtained alpha for the construct is .75, and it shows satisfactory levels of reliability with variance extracted (AVE) of .66 and composite reliability of .85.

Control variables. As in previous studies, our analysis includes a number of control variables. Some of the controls relate to the employee's job, while others refer to motivational and socio-demographical factors that may affect the dependent variable. As employees can use both formal and informal channels to share knowledge (Stevenson and Gilly, 1991), employees with more informal contacts may have more opportunities to share knowledge. To control for this possibility, we asked respondents: "How often do you have the opportunity to talk informally with colleagues?" We also controlled for the extent to which employees

were included in job rotation activities because job rotation may represent an opportunity to share knowledge with colleagues. Concretely, we asked employees "To what extent are you included in job rotation?", which we measured using a seven-point Likert scale. Furthermore, we controlled for employees' education levels by classifying the respondents' education as: high school or below, middle-range training, diploma degree, bachelor's degree, master's degree and PhD. We also included the number of years of employment in the firm and respondent age as control variables.

Finally, we included the external motivation to share knowledge as a control variable. Existing studies reveal that employees may be willing to share knowledge in exchange for external gains, such as money and praise (Cabrera et al., 2006; Kankanhalli et al., 2005). As with the intrinsic motivation construct, we adapted a number of items from the Self-Regulation Questionnaire to measure this construct. External motivation was assessed by asking respondents to indicate the extent to which they agreed with the following: "I share knowledge because I want my supervisor to praise me", "I share knowledge because I want my colleagues to praise me", "I share knowledge because I might get a reward" and "I share knowledge because it may help me get promoted". All items were measured using a seven-point Likert scale. The reliability of the construct is satisfactory with an alpha of .83, an AVE of .58 and a composite reliability of .83.

Table 6 shows the zero-order correlations among the variables used in the regression analyses. None of the correlation coefficients exceeds the threshold of .3, which indicates that multicollinearity in the data is a minor concern. The mean value for the dependent variable (knowledge sharing) is 5.76 (on a seven-point Likert scale). Notably, the level of intrinsic motivation to share knowledge is 5.54 (on a seven-point Likert scale). Furthermore, significant positive correlations exist between job autonomy and a cooperative climate. On average, individuals in a cooperative climate also appear to have high levels of job autonomy in the organization.

Table 6: Correlation matrix

	1	2	3	4	5	6	7	8	9	10
1.Knowledge sharing behavior	1.00									
2.Cooperative climate	0.29**	1.00	0.12							
3.Intrinsic motivation	0.37**	0.12	1.00							
4.Job autonomy	0.33**	0.18**	0.23**	1.00						
5.Age	-0.03	0.03	0.00	0.03	1.00					
6.Education	0.01	-0.14*	0.17*	0.09	0.02	1.00				
7.Tenure	0.03	0.08	-0.02	0.17*	0.67**	-0.10	1.00			
8.Extrinsic motivation	-0.02	0.03	0.19**	0.14*	-0.07	0.16*	-0.02	1.00		
9.Informal contacts	0.32**	0.21**	0.08	0.09	0.04	-0.12	0.08	-0.18**	1.00	
10.Job rotation	0.13	0.22**	0.03	0.02	-0.10	-0.08	-0.05	0.19**	0.11	1.00
Mean	5.76	5.39	5.54	5.69	2.42	3.32	13.7	3.29	5.96	2.83
Std. Dev	0.93	1.09	0.91	1.01	1.02	1.24	10.62	1.26	1.09	1.82
Min. values	2.50	2.00	1.33	1.00	0	1	0	1	1	1
Max. values	7	7	7	7	4	5	49	6.25	7	7

Note: ** and * indicate significance levels of 1% and 5%, respectively.

3.5 Results

We used a hierarchical regression model to test the hypotheses. The independent variables were mean-centered before the interaction term was created (Aiken and West, 1991). Furthermore, the variance inflation factor (VIF) was calculated in order to detect potential problems of multicollinearity. The highest VIF value is 1.97 (Tenure, Table 7, Model 3), indicating no concerns regarding multicollinearity (Hair et al., 2006). The results of the regression are reported in Table 7.

Table 7: Hierarchical Moderated Regression Models (N = 170) [a, b]

Standard errors are listed in parentheses and the VIF-values in italics.

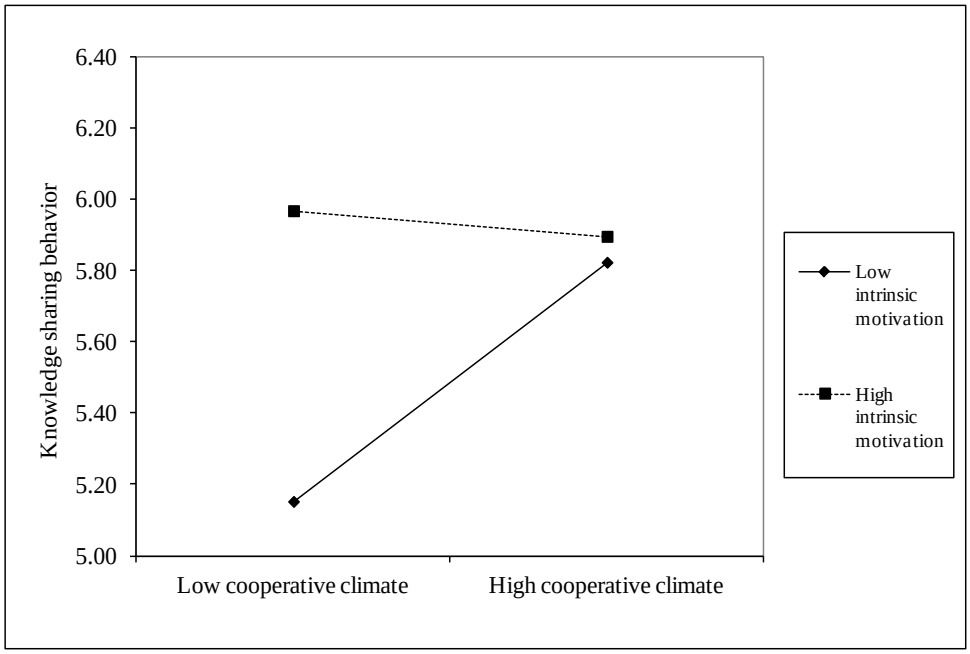
	Knowledge Sharing Behavior			
	Model 0 **Control variables**	***Model 1*** **Independent variables**	***Model 2*** **Hypothesis 1**	***Model 3*** **Hypothesis 2**
Intercept	5.74*** (0.07)	5.71*** (0.06)	5.73*** (0.06)	5.70*** (0.06)
Cooperative climate		0.15* (0.07) *1.15*	0.15* (0.07) *1.15*	0.15* (0.06) *1.15*
Intrinsic motivation		0.28*** (0.07) *1.13*	0.29*** (0.07) *1.13*	0.25*** (0.07) *1.24*
Job autonomy		0.23** (0.07) *1.16*	0.27*** (0.07) *1.21*	0.32*** (0.07) *1.33*
Cooperative climate * Intrinsic motivation			-0.20** (0.06) *1.10*	-0.20** (0.06) *1.10*
Cooperative climate * Job autonomy				0.12* (0.05) 1.20
Age	-0.08 (0.09) *1.86*	-0.05 (0.08) *1.89*	-0.03 (0.08) *1.91*	-0.03 (0.08) *1.91*
Education	0.06 (0.07) *1.07*	0.01 (0.07) *1.13*	0.00 (0.07) *1.13*	0.00 (0.07) *1.13*
Tenure	0.07 (0.10) *1.88*	0.01 (0.09) *1.96*	0.01 (0.08) *1.96*	0.00 (0.08) *1.97*
Extrinsic motivation	0.01 (0.08) *1.12*	-0.09 (0.07) *1.18*	-0.07 (0.07) *1.19*	-0.05 (0.07) *1.21*
Informal contacts	0.32*** (0.08) *1.07*	0.22** (0.07) *1.13*	0.21** (0.07) *1.13*	0.22** (0.07) *1.13*
Job rotation	0.09 (0.07) *1.08*	0.07 (0.06) *1.12*	0.07 (0.06) *1.12*	0.08 (0.06) *1.12*
N	170	170	170	170
F-value	3.71	8.07***	8.70***	8.55***
R-squared	0.12	0.31	0.35	0.37
Adjusted R-squared	0.09	0.27	0.31	0.33
F-test for increment in R^2		14.89***	10.18**	4.93*

[a] ***, ** and * indicate significance levels of 0.1%, 1% and 5%, respectively.
[b] All independent variables are standardized.

In the first step (Model 0), we entered the control variables related to personal characteristics (age, education and tenure), opportunities to engage in knowledge sharing (job rotation and informal contacts) and extrinsic motivation. The explanatory power of the control variables in this model is limited (R-squared = .12, $p < .01$) and only the variable "informal contacts" is significant ($\beta = .32$, $p < .001$). In the second step (Model 1), we included the three independent variables (cooperative climate, intrinsic motivation and job autonomy) to test the first-order association. All three variables are significant in this model, which has an R-squared of .31 ($p < .001$).

In the third step (Model 2), we added the moderating effect of intrinsic motivation on cooperative climate to test Hypothesis 1. After adding the interaction, the explanatory power of the model reaches an overall R-squared of .35. The significance of this increase is tested using an F-test ($F = 10.18$, $p < .01$). As suggested in Hypothesis 1, the interaction between cooperative climate and intrinsic motivation is negative and significant ($\beta = -.20$, $p < .01$). To facilitate the interpretation of the interaction and following the recommendations of Aiken and West (1991), we plotted the simple slopes for the relationship between a cooperative climate and knowledge sharing at one standard deviation above and below the mean of intrinsic motivation (Figure 5).

Figure 5: Two-Way Interaction Between Cooperative Climate and Intrinsic Motivation



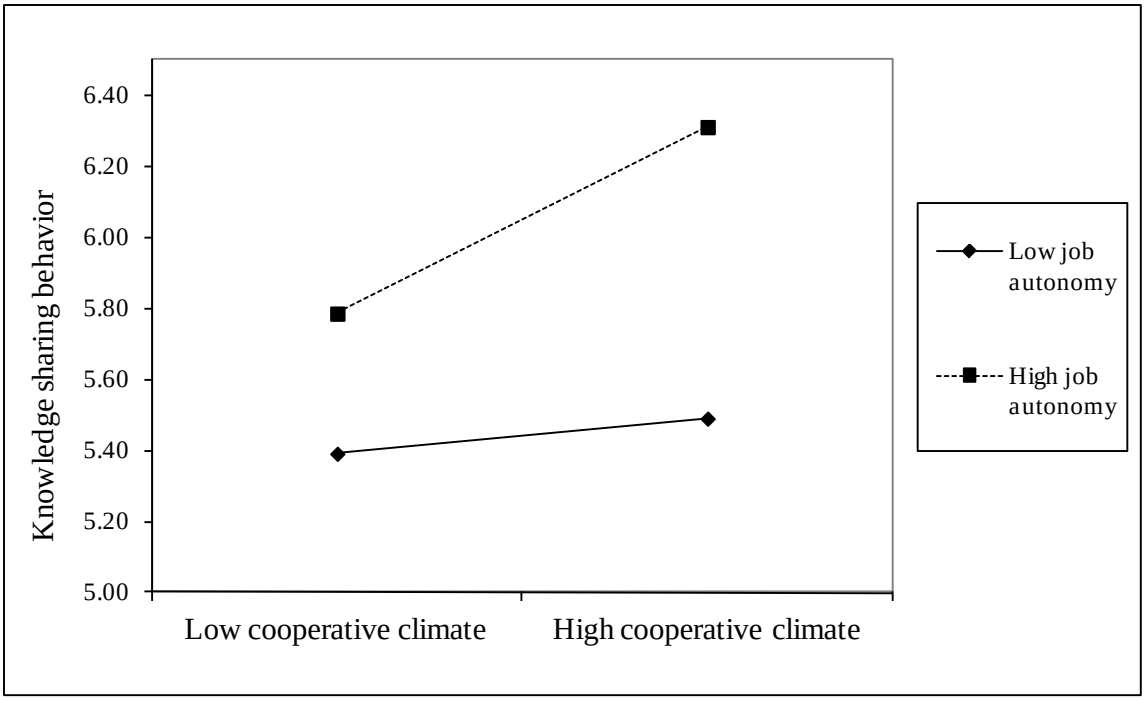
Regression slopes for the interaction of cooperative climate and intrinsic motivation predicting knowledge- sharing behavior.

The figure shows that the explanatory power of a social climate for cooperation is significantly higher for employees showing lower levels of intrinsic motivation to share. In contrast, those employees with greater intrinsic motivation are less influenced by a cooperative climate in their decision to share knowledge.

In order to test Hypothesis 2, we included the interaction effect between cooperative climate and job autonomy in the fourth step (Model 3). The F-test shows a significant increase in R-squared ($F = 4, 93$ $p < .05$), which jumps to .37. In support of Hypothesis 2, we found a statistically significant interaction between cooperative climate and job autonomy ($\beta = .12$, $p < .05$), indicating that the positive effect of a cooperative climate on knowledge sharing is stronger when employees have high levels of job autonomy.

As with intrinsic motivation, we plotted the simple slopes for the relationship between a cooperative climate and knowledge sharing at one standard deviation above and below the mean of job autonomy (Figure 6).

Figure 6: Two-Way Interaction between Cooperative Climate and Job Autonomy



Regression slopes for the interaction of cooperative climate and job autonomy predicting knowledge-sharing behavior.

The figure shows that knowledge-sharing behavior increases when both the social climate for cooperation and job autonomy are high. The dotted line shows that employees with high levels of autonomy are more influenced by a cooperative climate. In contrast, the effect of a cooperative climate is weaker for employees with low levels of job autonomy.

3.6 Concluding Discussion

3.6.1 Theoretical implications

This research has sought to expand our understanding of the relation between the cooperative climate and employees' knowledge-sharing behaviors. To do so, we developed and tested a model of how a cooperative climate affects knowledge sharing. We first theoretically reviewed the link between a cooperative climate and employees' knowledge-sharing behaviors. Although a number of mechanisms may be invoked to support this relation, researchers have generally assumed that the effect is positive and evenly distributed across all employees in

the organization. Our study challenges this assumption by raising the possibility that the effect has a heterogeneous impact on employees. To explore the contingent nature of this link, we introduced two potential moderators generally used as direct predictors of knowledge sharing--intrinsic motivation and job autonomy--and argued that the moderating effects of both variables should increase the explanatory power of a cooperative climate relative to knowledge-sharing behavior. The results support our hypotheses. A more nuanced view of the relation between cooperative climate and knowledge sharing may guide managers towards more accurate interventions in shaping an organizational climate towards cooperation.

Our first contribution is related to the moderating role of intrinsic motivation in the relationship between cooperative climate and knowledge sharing. Our findings indicate that a cooperative climate is particularly effective in fostering knowledge sharing when employees have little intrinsic motivation to do so. We find that cooperative climate and intrinsic motivation are substitutes with respect to predicting employees' knowledge sharing behaviors. Therefore, our results suggest that a cooperative climate can serve as a supplementary source of motivation for those employees who do not show a natural interest towards knowledge sharing. Furthermore, we develop the idea that some employees may conceive knowledge sharing as an intrinsically motivated behavior. We base this on the idea that engaging in knowledge sharing may be seen by some employees as a way to partially fulfill their basic psychological needs for autonomy, relatedness and competence. Also, knowledge sharing provides opportunities for individual learning and exploration. Our study thus presents a contingency perspective that is useful for understanding how contextual variations (e.g., cooperative climate) may have diverse effects when individual characteristics are considered. We contend that this finding is relevant because they provide a finer-grained view of the relationship between the social climate of the organization and the employees' knowledge sharing behavior. Given that the willingness and effort of employees to share knowledge cannot be taken for granted (Tortoriello and Krackhardt, 2010), our results suggests that the existence of a cooperative climate is fundamental for employees showing lower levels of intrinsic motivation to share knowledge. Our study also provides new insights into the importance of job-design features to

explain the relation between a cooperative climate and knowledge sharing. In particular, we argue for a moderating effect of job autonomy in the link between cooperative climate and knowledge sharing. We developed and tested the argument that granting employees increasing levels of autonomy will strengthen the positive influence of a cooperative climate on their decisions to share knowledge. By arguing that employees with greater discretion about how to perform their tasks will be more inclined to share knowledge with colleagues, we propose that they will be more likely to positively respond to the social cues provided by a cooperative climate. As a result, they will show higher levels of knowledge-sharing behavior. The results presented here suggest that job design features play a role in strengthening the potential positive effects of a cooperative climate in organizations. Altering the structural design of employees' jobs (e.g.: by providing them more autonomy), may be a way to reinforce the potential benefits of a cooperative climate in the organization. This is good news for managers, given that a managerial intervention through job design is likely to be less costly than an attempt to shape the social climate of the organization or department.

The results yield a number of theoretical implications that build upon and clarify prior research. This research is framed on the recent stream of person/situation interaction studies in organizational behavior research (e.g.: Bogaert et al., 2012; van Olffen and De Cremer, 2007). First, they add to our understanding of the factors that are important for greater levels of intra-organizational knowledge sharing. Previous research shows that facet-specific climates and motivators (e.g., Lin, 2007) are related to knowledge sharing. We show that a cooperative becomes crucial when employees are less intrinsically motivated to share knowledge. By the same token, the influence of a cooperative climate is lower for employees with higher levels of intrinsic motivation towards knowledge sharing. These findings are important because they suggest that the explanatory power of the social drivers of knowledge sharing is not evenly dispersed across all individuals. Too much attention in promoting a cooperative climate in the organization may overlook the fact that some employees are naturally attracted towards knowledge sharing even without the existence of a supporting climate. Second, the finding that job autonomy moderates the link between a cooperative climate and knowledge sharing provides insight into how

job-design features can be managed to benefit from a favorable climate towards knowledge sharing. Previous research suggests a positive link between job autonomy and knowledge sharing (Cabrera et al., 2006). By integrating job autonomy with the cooperative climate, we can view job autonomy as a source of heterogeneity that helps to explain why some individuals will be more affected by a cooperative climate than others.

3.6.2 Limitations and Future Research

This research is subject to a number of limitations. First, although our study suggests a causal relation between organizational climate and knowledge sharing, our cross-sectional data do not rule out the possibility of alternative causal pathways. For example, some studies of organizational climate suggest that perceptions of climate are affected by an individual's prior level of motivation (Parker et al., 2003). In this regard, James and McIntyre (1996) argue that because situations can serve to satisfy or frustrate individual needs, individuals may manipulate situations to increase the congruence with their psychological needs. Therefore, employees may perceive the organizational climate in accordance with their previous motivation to engage in a certain action (James et al., 1981). However, we believe that this is not a major concern in our investigation because some research indicates that individuals who are intrinsically motivated show greater precision in processing external information (Koestner and Losier, 2004; Ryan and Connell, 1989). Nevertheless, future research using experimental or longitudinal designs is recommended to examine the direction of causality.

Furthermore, we focus only on the cooperative climate, while researchers emphasize that organizational climate can take multiple forms (e.g., Kuenzi and Schminke, 2009; Schneider, 1975). Therefore, we encourage researchers to investigate how other types of organizational climates interact with employees' intrinsic motivations and job design. We expect that the more normative the climate is with respect to cooperation, the more linked it will be to knowledge sharing for low intrinsically motivated employees because these employees will feel a sense of obligation arising from the group. On the other hand, a more normative climate may have negative effects for more intrinsically motivated

employees due to crowding-out effects (Lam and Lambermont-Ford, 2010). In this sense, research indicates that employees' intrinsic motivation decreases when they perceived that their internal locus of causality is compromised by external pressures (Deci et al., 1999; Osterloh and Frey, 2000). Hence, putting too much emphasis in promoting a cooperative climate might have counterproductive effects on employees with high intrinsic motivation to share. Given the importance of the organizational climate in explaining employee behaviors, future research may investigate the interactive effects of several types of facet-specific climates and how they may better explain knowledge-sharing behaviors.

With regard to job autonomy, we suggest that researchers explore the interactive nature of autonomy under different types of organizational climates. In addition, in focusing on job autonomy, we did not examine other job characteristics that might affect the relationship between climate and behavior. Scholars who specialize in human resource management may be interested in a broader examination of different job designs and their interactions with the cooperative climate.

Our conceptualization of intrinsic and extrinsic motivation is based on self-determination theory. One of the strengths of this theory is that it differentiates among a range of motivations based on the perceived locus of causality. These motivations have been argued to influence behavior in different ways (Gagné and Deci, 2005). However, this study does not capture this motivational diversity. Hence, future research may focus on how the climate affects individuals with specific types of motivations and whether, for instance, a cooperative climate can be used to internalize the motivation to share knowledge.

Finally, our findings are limited to a sample from a single firm. It would be worthwhile for further research to test whether our results can be generalized to other organizations or industries, and to explore the extent to which our results can be applied to other organizational behaviors, such as helping or volunteering (Brief and Motowidlo, 1986).

3.6.3 Managerial Implications

Beyond the theoretical contributions, the effects we uncover are also meaningful from a managerial standpoint. Given the strategic importance of knowledge sharing for organizations, the creation and maintenance of a cooperative climate has become an increasingly important objective for management. Therefore, managers' understanding of how the effect of a cooperative climate may be moderated by individual characteristics and job features may be helpful in developing more effective human resource management policies. By recognizing that a cooperative climate has diverse effects for different employees, managers may better adjust the level of attention they devote to the development of a cooperative climate in the organization. This paper shows that the relevance of a cooperative climate is not homogeneous for all employees nor is such a climate always necessary. Rather, our findings suggest that it may be important for managers to attend employees' intrinsic motivation and job autonomy as a way to maximize the potential gains of a cooperative climate in the organization. Indeed, our results suggest that managers can encourage employees to share knowledge by not only promoting a cooperative climate, but also by painting voluntary knowledge sharing as a stimulating activity in itself. For instance, our results indicate that, in a group solely composed by employees low in intrinsic motivation to share knowledge, managerial interventions to promote a cooperative climate becomes essential to enhance intra-group knowledge sharing. However, groups composed by employees with a higher natural tendency to share knowledge would not require such an managerial intervention to do so. Actually, in a group where intrinsic motivation towards knowledge sharing is already high, a managerial intervention may be potentially harmful. According to SDT, intrinsically driven behaviors may be compromised by a normative environment (Deci and Ryan, 1985; Harackiewicz and Manderlink, 1984). In order not to hamper employees' intrinsic motivation, managers may ensure that an intervention is actually needed to promote knowledge sharing.

Further, this research suggests that management can directly strengthen the impact of a cooperative climate on knowledge sharing by providing employees with high levels of job autonomy. We argue that increased levels of discretion about how to perform tasks permits employees to be more active in knowledge-

sharing activities. Given the extra-role nature of engaging in knowledge sharing, job autonomy allows employees to benefit from a cooperative climate by engaging in knowledge sharing. To the extent that providing employees with higher levels of autonomy is likely to be easier than shaping the organizational climate, managers should ensure that employees have enough autonomy to enable them to benefit from a cooperative climate. Thus, jobs may be designed to let employees to take advantage of being in a cooperative group. For example, when employees are provided with few specific instructions to perform their jobs, they are implicitly obligated to engage in knowledge-sharing practices in order to find efficient ways to carry out their tasks (Cabrera et al., 2006).

CHAPTER 4
SCIENTISTS' ENGAGEMENT IN KNOWLEDGE EXCHANGE: THE ROLE OF PRO-SOCIAL RESEARCH BEHAVIOR[3]

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4.1 Introduction

The previous chapter developed an empirical model to explain the individuals' engagement in knowledge sharing behavior in the context of an organization. This chapter aims to extent the discussion of the individual-level determinants of knowledge exchange in a different context. Specifically, it is brought into discussion the concept of "pro-social research behavior" as a potential antecedent of the scientists' engagement in knowledge exchange activities with social agents.

Researchers have devoted significant attention to the mechanisms through which scientific knowledge can reach the societal actors and be transformed in a source of value. Scholars, for instance, have proposed that scientists can use a number of formal and informal channels as conduits to exchange information and knowledge and to generate a positive impact with their work beyond the academic boundaries. Most of the existing research is, however, focused on the knowledge exchange mechanisms that are related to the commercialization of knowledge. That is, licensing, patenting or academic entrepreneurship are normally considered as the default channels through which scientists transcend the academic context and reach non-academic agents.

However, the propensity of existing research in focusing on the commercial side of knowledge exchange may have obscured the role of other socio-psychological processes that can play a role. Research shows, for instance, that researchers differ in their attitudes towards commercial involvement (Arvanitis, Kubli, & Woerter, 2008; Davis, Larsen, & Lotz, 2011; Etzkowitz, 2004; Goethner et al., 2012) and in their beliefs about the relationship between science and commerce (Owen-Smith & Powell, 2001). Further, they may decide to engage in exchange processes for a set of different motives, ranging from extrinsic factors such as personal income or reputation to intrinsic ones such as personal curiosity (Lam, 2011).

This chapter aims to contribute to this line of research by introducing the concept of "pro-social research behavior". We build on previous research on pro-social motivation (Grant, 2008) and pro-social behavior (Brief & Motowidlo, 1986) to propose that those scientists more aware of the potential beneficiaries of

their work may be more prone to search for ways to reach non-academic actors. This may be manifested in a higher propensity to engage in knowledge exchange activities, compared to those scientists that are less aware about the ways in which their work may benefit others.

The chapter is structured as follows. First, we provide arguments to justify the increasing importance of generating knowledge that is "socially valuable", and how this importance has been reflected in the new modes of knowledge production. Further, we advocate for a deeper emphasis on the scientists' awareness of the social usefulness of their research as a predictor of the actual engagement on knowledge exchange with non-academic actors. Then, we propose that "pro-social research behavior" may be a useful concept in capturing this awareness. We build our arguments around the idea that being aware of the consequences that one's' work has on others is particularly relevant in explaining subsequent attempts to reach those beneficiaries. For the case of scientists, this may be related to knowledge exchange. The chapter also provides a descriptive analysis on a sample of researchers from the Spanish Council of Scientific Research (CSIC), where we show that scientists' differ in their "pro-social research behavior" and that this behavior is related to their participation in various forms of knowledge exchange activities.

4.2 Science and Societal Impact of Research

4.2.1 Mertonian norms and the academic logic

Traditionally, scientists' behavior have been explained under an "academic logic" (Sauermann & Stephan, 2012) based on the classical model of science. In "The Normative Structure of Science", Merton (1973) acknowledges that scientists' behavior is governed by a set of imperative norms that distinguish science from other types of intellectual activities or institutions. The "ethos of science" represents a set of ideal values to describe the institutional structure of science and to distinguish science from other modes of knowledge production or institutional settings. This set of values is embedded in social norms that are shared by the scientific community. They are not explicitly learned or taught, but they are internalized by scientists as part of their professional activity.

Merton classified the social norms of science into four types: universalism, communism, disinterestedness and organized skepticism. *Universalism* means that the acceptance or rejection of the claims of science does not depend on the personal or social attributes of the scientist. Aspects such as race, nationality or any other individual characteristics are irrelevant with respect to the validity of a given scientific claim. Rather, science is judged through "*preestablished impersonal criteria consonant with observations and with previously confirmed knowledge*" (Merton 1973: 270). The second imperative, *communism,* refers to the idea that scientists should openly share their knowledge with their scientific community for the common good. Intellectual property is strictly limited to that of recognition from the academic peers. Hence, all scientists should be free to test the results of their fellows, and property rights are not considered in any form under the academic logic. *Disinterestedness* is related to the altruistic concern and idle curiosity that drive the scientists' work. According to this notion, scientists are mainly committed to the advancement of science, so they act for the benefit of the scientific community rather than for personal gain. Lastly, *organized skepticism* refers to the fact that scientific claims should exposed to critical scrutiny and routine practices such as hypotheses testing and experimental control.

The production of knowledge under the Mertonian model is governed by the above indicated norms. Knowledge is normally produced in a scientific context and is evaluated and validated by other scientists. The knowledge generated under this system is normally mono-disciplinary, and intended to solve fundamental problems or for the advancement of basic understanding of a particular field of research.

4.2.2 New modes of scientific knowledge production

The system of science has suffered important changes during the last decades. The idealistic view of science offered by Merton has been transformed, and a new system of science production is shifting the way scientists think about their research and the ultimate goals of their research activities. This transition has widely affected the goals, practices and structures of the research system (Okubo & Sjöberg, 2000). Such transition may be viewed as a modification of the social

norms governing scientists' behaviors. Social norms are defined as standards of behavior based on widely shared beliefs about how to behave under particular situations (Fehr & Fischbacher, 2004). If shared beliefs change, then the social norms towards particular situations should change as well. Therefore, a change at the individual level is the starting point of analysis to understand a more general shift of the scientific production system.

The case concerning the production of scientific knowledge reflects a clear example of a deep change in scientists' social norms and behaviors. New models of knowledge production such as the "Mode 2" research (Gibbons et al., 1994), the "academic capitalism" (Slaughter & Leslie, 1997), the "entrepreneurial science" (Etzkowitz, 1998) or the "post-academic science" (Ziman, 2002) have caused a striking transformation in the way science is organized and performed. All these models have in common the idea that the production of scientific knowledge should be more "social" and should consider the needs and requirements of non-academic actors such as the general population or the private organizations. For instance, the term "Mode 2" research was coined by Michael Gibbons (1994) to distinguish it from the traditional way of knowledge production, or "Mode 1" research. Compared to Mode 1, Mode 2 research is created in a particular context, involving the potential users of the knowledge generated from the research. Mode 2 research is trans-disciplinary in nature and it is co-created by scientists and their surrounding community. This critical emphasis in the social accountability of research results is clearly reflected by Hessels & Van Lente, (2008).

> *"Mode 2 knowledge is rather a dialogic process, and has the capacity to incorporate multiple views. This relates to researchers becoming more aware of the societal consequences of their work (social accountability). Sensitivity to the impact of the research is built from the start" (p. 742).*

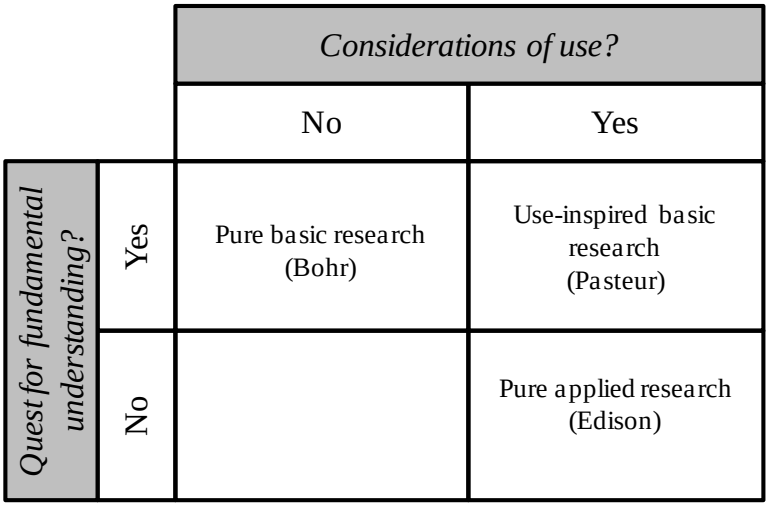
This model reveals that researchers are being pushed in the direction of delivering a clearer social utility of the knowledge they produce. That implies that scientists are expected to being much more conscious about the particular needs and interests of other societal actors and infuse a clearer social orientation to their work. A close interaction and knowledge exchange of many players is increasingly

required to create knowledge that is more "socially accountable" (Okubo & Sjöberg, 2000).

The quest for a societal impact of scientific research is also a key argument in what Stokes (1997) has called the "Pasteur's Quadrant" (see figure X). This typology of research modes suggests that scientific research can be classified in four types, depending on its quest for fundamental understanding and its consideration of use. This typology results into three types of research. The "*pure basic research*" quadrant refers to the production of science that is primarily aimed to increase the fundamental understanding of a basic problem, with little consideration of the societal use or the knowledge generated. For example, Niels Bohr's work with quantum mechanics and atomic structure would fall into this quadrant. Research falling into the "*pure applied research*" quadrant refers to science that is guided solely by applied goals, with no specific interest in the advancement of the fundamental understanding of the phenomena. Hence, this type of research seeks to provide commercial and societal value but is not targeted to extend the frontiers of understanding. The work of Thomas Edison is considered as a paradigmatic example of this type of research. Finally, the "use-inspired basic research" includes research that aims to advance the basic understanding of a field and also has societal and commercial purposes. Louis Pasteur's discoveries are an example of such type of research, because he did not only advance in the basic understanding of his scientific field, but also produced societal benefits related to the pasteurization process.

By including the Pasteur's quadrant, Stokes' challenged the traditional classification of basic science versus applied science. By emphasizing the notion of "societal value", Stokes argued that, even if scientists direct their efforts to the generation of fundamental knowledge, there is still room for different degrees of inspiration by the potential considerations of use of research results. In other words, having in mind the potential impact of scientific research to non-academic agents was explicitly recognized as an individual-level preference which is -at least to some extent- independent from the nature of research performed by the scientist.

Figure 7: Stokes' "Pasteur Quadrant"



Source: Stokes (1997)

The development of those new models of knowledge production places the decision to exert a societal impact at the forefront of the generation of scientific knowledge. In this sense, the direct participation of scientists into knowledge transfer activities with non-academic agents, such as companies or public institutions may be viewed as a signal of their acceptance of the macro-level pressures derived from the new models of knowledge production. An increase in the knowledge transfer activities between scientists and organizations may be a reflection of the production of a more socially relevant and useful knowledge (Mohrman, Gibson, & Jr., 2001). A broad range of channels are available for scientists to materialize this "social accountability" of their research. In this sense, most researchers differentiate between formal and informal mechanisms of knowledge transfer (Link et al., 2007). A formal mechanism is reflected in a legal instrumentality such as a patent or a license. An informal mechanism, however, comprises the exchange of knowledge between the parties in a more informal form, such as by providing technical assistance or by participating in exceptional consulting activities (Salter & Martin, 2001).

In spite of the considered mechanism, existing research shows that the participation in knowledge transfer activities is highly concentrated in few researchers (e.g.: Bercovitz & Feldman, 2008; Haeussler & Colyvas, 2011). If an actual engagement in knowledge transfer activities is taken as a proxy for the

social accountability of the scientists' research results, evidence suggests that scientists differ in their tendency to consider the potential social impact of their research activities. This raises the possibility that psychological processes related to the perceived usefulness of the scientists' research activities may help to account for the origins of such differences. Psychological aspects such as the perceived beneficiary impact, the feelings of task significance (Grant, 2007; Grant et al., 2007) or the other-orientation (De Dreu & Nauta, 2009) may play a role in understanding why some researchers are more willing to engage in knowledge transfer activities while others not. In an attempt to bring such issues to the discussion, the next section builds on the pro-social behavior literature.

4.3 Conceptualizing "social accountability": Pro-social research behavior

The new models of knowledge production explained in the previous section require paying close attention to the individual-level processes. Empirical evidence suggests that the transit from the traditional model of knowledge production to the "mode 2" of knowledge production is not easy. For instance, Jain, George, & Maltarich (2009) argue that university scientists deciding to place their knowledge into the market typically requires them to modify their role identity. This change often entails a source of stress and extra pressure for scientists. When confronted with norms from two different social environments – academia and society -, scientists need to engage in a sense-making process in which they give meaning to their research activities.

Other scholars assume that this sense-making process is based on a cost-benefit analysis (Tartari & Breschi, 2012) where scientists carefully evaluate the potential costs and benefits of participating in knowledge exchange initiatives with non-academic actors. Scientists also point to the importance of taking others' perspective for producing more socially useful knowledge (Mohrman et al., 2001). Because academics and practitioners belong to different communities, the interpretation of the other parties' needs and expectations is particularly challenging. Academics, for instance, might find difficult to understand the needs coming from non-academic actors. Hence, extant research provides evidence for the idea that the adaptation to the new system of scientific knowledge production

means a great cognitive challenge for scientists, and not all scientists are likely to be equally capable to cope with it. Also, scholars who participate in knowledge exchange activities should acquire a new set of skills and abilities that are significantly different than those required for advancing in the academic setting. Evidence reveals, for instance, that having entrepreneurial skills is particularly useful for scientists to engage with industrial partners (Fini, Grimaldi, Marzocchi, & Sobrero, 2012).

Thus, the above indicated issues leave room to suggest that the transit towards the engagement in knowledge exchange activities is very complex. Scientists need to invest significant efforts in creating and maintaining knowledge exchange activities with non-academic actors, and there are many sources of individual heterogeneity that may influence such decision. Following the discussion introduced in Chapter 1, we claim that there is a need to pay deeper attention to the individual-level processes governing such phenomena. An "individual-first" approach is suggested in this aim.

Research on organizational behavior and social psychology may be taken as the starting point. Scholars from those fields have provided valuable insights to study the individual tendencies to consider others' needs and the concern about positively affecting others. We argue that the tendency of scientists take into account the "social accountability" of their knowledge may be better captured if research on pro-social research behavior is introduced (e.g.: De Dreu & Nauta, 2009; Grant & Sumanth, 2009; Grant, 2007; McNeely & Meglino, 1994). This line of research has been particularly important for organizational behavior and social psychology literatures. Brief & Motowidlo (1986) conceptualized pro-social behavior in organizational settings such as *"behavior which is (a) performed by a member of an organization, (b) directed toward an individual, group, or organization with whom he or she interacts while carrying out his or her organizational role, and (c) performed with the intention of promoting the welfare of the individual, group, or organization toward which it is directed."* (711:1986). Acts such as helping, sharing, donating and cooperating are forms of pro-social behavior, since these actions share the central notion of intent to benefit others while not formally specified as role requirements.

It is well ingrained in organizational behavior literature that individuals differ in their tendency to engage in pro-social behaviors and in their pro-social values (Audrey, Meglino, & Lester, 1997; Meglino & Korsgaard, 2004). Pro-social behavior is consistently related to increased levels of commitment and dedication toward ones' job requirements (Grant & Sumanth, 2009; Thompson & Bunderson, 2003), better coordination and cohesion among organizational members (Organ, Podsakoff, & MacKenzie, 2005) as well as higher levels of work-group performance (Puffer, 1987). It is also recognized that coordination costs decline when individuals are more inclined to benefit others through their work. Further, the engagement in pro-social behaviors helps individuals to experience their work as more meaningful, enhancing their feeling of social worth in the workplace (Perry & Hondeghem, 2008).

Given its importance for the organizational functioning, a substantial amount of research has gone into explaining the determinants of pro-social behavior. Pro-social behavior is thought to be influenced by a complexity of factors ranging from biological and psychological bases (Buck, 2002) to social and contextual issues (Kerr & MacCoun, 1985). Recent research revealed that, while carrying out their work, individuals define their identities in terms of helping within specific roles (Penner, Dovidio, Piliavin, & Schroeder, 2005). Hence, it has been argued that the particularities of the work itself are likely to exert a considerable effect in the emergence of pro-social identities and pro-social behaviors among individuals. Nevertheless, understanding the particular combination of individual attributes and working features more prone to activate pro-social behaviors still remains an open issue for further research. The emergence and maintenance of pro-social behaviors is particularly interesting in the context of mission-driven organizations (Brickson, 2007). Those organizations refers to those whose purposes transcend economic profit, such as hospitals, government agencies, universities and public research centers (Hammer, 1995). Indeed, one of the critical goals of mission-driven organizations is to generate a positive contribution towards others' needs.

However, evidence reveals that not all individuals working in mission-driven organizations have clear information about the positive effect they may exert on others through their work (Grant & Sumanth, 2009). For instance, it can

take years for biomedical researchers to see a positive impact of their work on patients. In the section below, we move to the determinants of the emergence of pro-social behaviors within the context of a public research organization.

4.4 Pro-social research behavior as an antecedent of knowledge exchange

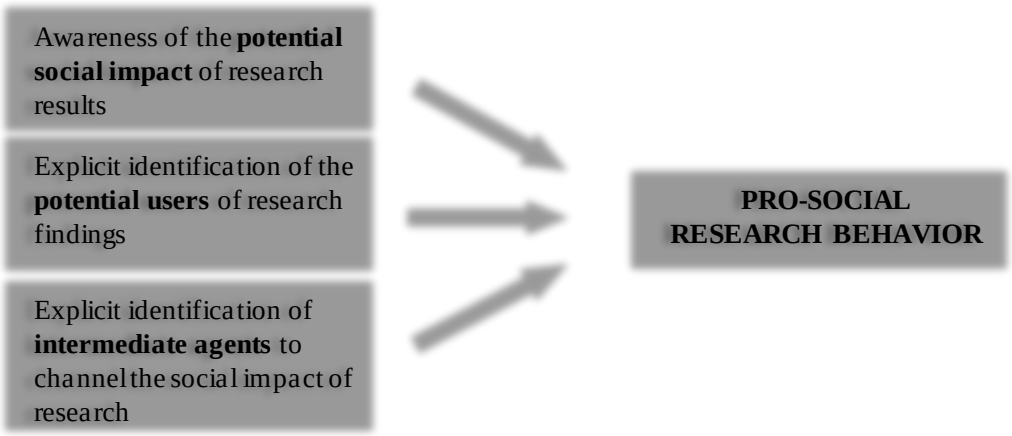
The focus of this section is on the causes and effects of the emergence of a pro-social research behavior among scientists, and how this particular behavior may be correlated to a higher propensity to engage in knowledge exchange activities. Bringing the literature of pro-social behavior into the scientists' decision to participate in knowledge exchange with social agents may help to understand why some scientists show a higher awareness about the social impact and uses of their research results. In the academic context, we propose that pro-social research behavior may play an important role in guiding researchers towards considering their research activities as socially relevant and thus, to prompt them towards the engagement in knowledge transfer activities. Specifically, we conceive pro-social research behaviors as these conducts that place social relevance as a primary goal of research. We argue that this social relevance may be reflected in three different but highly related conducts that may be performed by scientists.

First, an explicit awareness and recognition that one's research results might have a potential social impact in other people or groups (Shane & Venkataraman, 2000). When individuals perceive that their work exerts a positive impact in others, they tend to be more willing to go above and beyond their call of duty (Grant, 2008; McNeely & Meglino, 1994), perform extra-role behaviors, show higher commitment and dedication (Grant & Sumanth, 2009; Thompson & Bunderson, 2003) and be less emotionally exhausted (Grant & Sonnentag, 2010). The participation in knowledge exchange activities with non-academics is - to a large extent – an activity that is not fully accounted for in the formal requirements of the job. Hence, being more aware of the social impact of the research results may facilitate the willingness of the scientist to materialize such awareness through the participation in knowledge exchange with non-academic actors. Second, an explicit identification of the potential users of research findings (Gibbons et al., 1994; Stokes, 1997). Similar to the previous idea, if scientists have

an explicit recognition of who might be the potential users of their research results, they will more prone to participate in knowledge exchange activities with such users. Being explicitly aware of those directly affected by ones' actions may reflect recognition of their values and needs (Mohrman et al., 2001), and hence, may predict a higher willingness to participate in knowledge exchange activities with non-academic communities. And third, an identification of those intermediate agents that may serve to channel the social impact of research (Jain et al., 2009). Being aware about the ways to reach others' needs clearly reflects that the social impact of research results is taken into consideration by the scientist.

We therefore propose that pro-social research behavior, conceived as a precursor of engagement in knowledge exchange activities, is comprised by these three conducts. This conceptualization of pro-social research behavior is reflected in Figure 8.

Figure 8: Conceptualization of "pro-social research behavior" among scientists



Source: Own elaboration

Fundamental to our argument is the claim that pro-social research behavior, as conceived above, enhances the likelihood of academic researchers to engage in knowledge transfer activities. Pro-social research behavior means that researchers are infused with an explicit interest in benefiting others through their research findings, even though actions that are not prescribed in job duties (McNeely & Meglino, 1994). Participation in knowledge transfer activities may be seen as an enabling mechanism for them to channel this interest. Put differently, delivering

knowledge that is not only valuable for academics, but also useful to external agents may be a form to reflect a concern of benefiting others through ones' work.

Pro-social identities are well-ingrained in academic entrepreneurship and technology transfer literatures. Some studies propose that scientists who have an aspiration to achieve a broader societal impact from their research and have a strong awareness about the implications of their research on the well-being of others, are more willing to embrace a favorable attitude towards knowledge transfer activities (Gibbons et al., 1994; Jain et al., 2009; Lam, 2011; Weijden et al., 2012). According to these studies, adopting attitudes and conducts that place social relevance as a critical goal of research are crucial to reconcile the conflicting priorities and incentives faced by scientists when planning to work at the interface between academic and business environments.

Further, previous research has consistently documented that individuals with other-focused outcome goals tend to be more committed and dedicated towards these goals (Thompson & Bunderson, 2003), are less emotionally exhausted in this endeavor (Grant & Sonnentag, 2010) and maintain higher levels of motivation in the workplace (Grant et al., 2007). Overall, then, these arguments lead us to suggest that the adoption of pro-social attitudes and behaviors, within the context of academic research might be seen as an immediate predictor of an actual participation in a broad range of knowledge transfer activities, compared to researchers who lack the motivation to generate a positive social impact from their research.

4.5 Pro-social research behavior in context: a study of CSIC researchers

Above, we have suggested that the introduction of the concept of pro-social research behavior might be useful to capture the social accountability of scientists when performing scientific research. Also, it has been pointed that a high score in pro-social research behavior may be correlated to a greater propensity to participate in a range of knowledge exchange activities with social agents. The aim of this section is to empirically test the pro-social research behavior of a set of scientists as well as to explore its relationship with the actual engagement of them in knowledge exchange activities. To do so, we draw on a sample of scientists

from multiple research fields from the Spanish Council of Scientific Research (CSIC).

4.5.1 The context of study: CSIC researchers

The context of this study is the Spanish Council of Scientific Research (henceforth, CSIC). CSIC is the main public research organization in Spain. The mission of the CSIC is the promotion, coordination, development and dissemination of multidisciplinary scientific and technological research in order to contribute to the advancement of knowledge and to economic, social and cultural development, as well as to staff training and advice to public and private entities in this matter.[4] The institution is dependent from the Ministry in charge of scientific research, and currently accounts for around the 20% of the national scientific production and 45% of patents applied.

The CSIC is formed by a network of 126 research institutes that are either fully managed by the CSIC (72 institutes) or managed in collaboration with Universities, regions or other entities (54 institutes). The scientific research carried out by the CSIC institutes is classified into eight fields of science: humanities and social sciences, biology and biomedicine, food science and technology, materials science and technology, physical science and technology, chemical science and technology, agricultural sciences and natural resources. CSIC employed around 14,000 people in 2011. The proportion of tenured researchers and technicians (civil servants) is 35%. Contracted researchers, technicians and grant holders account for the 50% of the staff, and administration is about 15% of the staff[5]. CSIC is funded by the Government (60%) and from other external resources such as international competitive R&D programs, contracts with companies and organizations and funds from the European Social Fund and the European Regional Development Fund (40%). It is important to note that the funding from the Government has diminished in favor of external funding such as contracts and agreements with private companies. Scientists are increasingly expected to interact with industry, as well as to shift their research towards more concrete needs of the societal actors.

[4] Art. 4 of the CSIC Statutes.
[5] Data from the 2011 CSIC Annual Report

This is reflected in the fact that the number of contracts signed by CSIC scientific staff with external organizations has tripled between 2006 and 2011. The main indicators of the CSIC for the year in which the study was carried out (2011) are shown on Table 8:

Table 8: Main indicators of the CSIC for the year 2011

	2011
CSIC Institutes (total)	**126**
CSIC institutes	72
CSIC joint institutes	54
Human resources (scientific staff)	**5,375**
Tenured researchers	3,122
Contracted researchers and grant holders	2,253
Economic resources (k€)	**728,715**
Core funding from Government (k€)	438,260
External Resources6 (k€)	290,455
Contracts and agreements with external entities **(k€)**	**6,226**
With private firms **(k€)**	1,957
Other entities[7] **(k€)**	4,269
Scientific Productivity	15,077
Articles in SCI/SSCI-listed journals	12,299
Articles in non SCI/SSCI-listed journals	1,328
Books	379
Doctoral thesis	881
Spanish patents	190

Source: CSIC 2011 Annual Report

[6] "External resources" include funds from regional, national and international competitive R&D programs, contracts with companies and organizations and funds from the European Social Fund and the European Regional Development Fund.

[7] " Other entities" include public companies, universities, regional and local governments, international entities, associations and other entities.

4.5.2 Sample and research instrument

To collect the data for this study, a survey was build based on existing literature on the diversity of knowledge transfer mechanisms available for scientists and their impacts (Azagra-Caro, 2007; D'Este & Patel, 2007). The questionnaire put special emphasis on the researchers' characteristics as well as on the expected gains of establishing different knowledge exchange relationships with a number of non-academic agents such as private companies, public entities and international organizations. Also, the survey included questions about the diversity of motives to engage in knowledge transfer activities. To ensure a proper understanding of all the questions, the survey was pre-tested with a sample of forty-five researchers from the eight fields of science comprised by CSIC.

The sample frame consisted of 3199 CSIC scientists, to whom we sent an invitation to participate in an on-line survey. The survey was conducted between April and May 2011. In order to ensure a satisfactory final sample, the sending of the on-line survey was complemented by follow-up phone calls. To maximize responses, an invitation to participate was also sent by the CSIC Presidency to all scientists included in the sample. We reached a 40% response rate, with 1295 valid responses. These responses were representative of the original population of CSIC scientists in terms of age, gender and academic rank[8]. However, as shown in Table 9, while response rates are overall similar by fields of science, there are some disciplines that are overrepresented (such as: Agriculture, Chemistry and Food Science & Technology) while Social Sciences and Humanities is significantly underrepresented.

[8] In both the target population and our sample of respondents, the average age is 50 and 35% of scientists are women. Regarding professional category, there is a 25% of Professors in the target population, while a 23% in our sample of respondents.

Table 9: Response rate by field of science

Scientific field	Surveyed population	Valid responses	Response rate
Agriculture Sc.& Tech.	365	191	52% *
Biology & Biomedicine	547	199	36%
Chemistry Sc. & Tech.	381	179	47% *
Food Sc. & Tech.	246	119	48% *
Natural Resources	482	190	39%
Physics Sc. & Tech.	424	163	38%
Social Sc. & Humanities	321	90	28% *
Tech. for New Materials	433	164	38%
Total	3199	1295	40%

* The response rates of these four scientific fields significantly differ (chi-square, $p < 0.05$) when compared to the overall response rate for the other fields in our sample.

In addition to the survey, we obtained data from administrative sources on socio-demographic characteristics of our population of scientists (i.e. gender, age, academic rank and institute of affiliation).

4.5.3 Measuring "pro-social research behavior" among scientists

Our variable "pro-social research behavior" is built from the responses to a question that asked scientists to report the frequency (according to a 4-point Likert scale ranging from 'never' to 'regularly') with which they engaged in the following three activities when conducting research projects: (i) *identifying potential results from research,* (ii) *identifying potential users* and (iii) *identifying intermediary actors to help transfer the results of their research.* Table 10 shows the descriptive scores of each item.

Table 10: Scores of the "pro-social research behavior" items

Variable	Obs	Mean	Std. Dev.	Min	Max
1.Identify the potential results of your research that can benefit users	1237	2,955	.858	1	4
2.Identify the potential users who can apply the results of your research	1227	2,229	.834	1	4
3.Identify intermediaries in order to transfer the results of your results	1230	2,362	.907	1	4

We then proceed to compute an average of the responses to these three items, as they were strongly correlated to each other, suggesting that all items of the scale were measuring the same construct and that the scale was consistent (Cronbach alpha of 0.80). Table 11 presents the inter-item correlation of the three items.

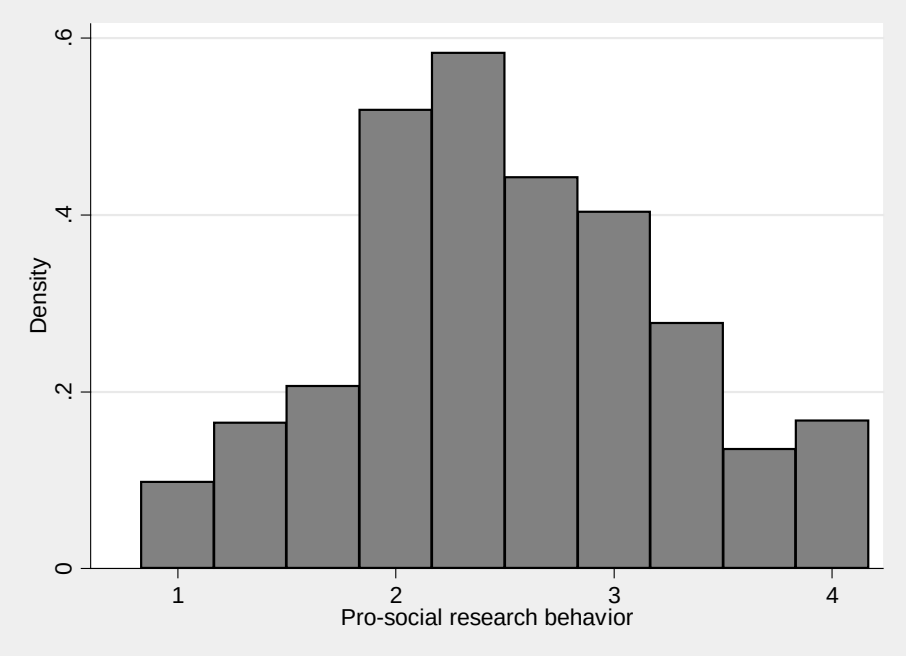
Table 11: Inter-item correlation of the "pro-social research behavior" items

	1	2	3
1. Identify the potential results of your research that can benefit others	1		
2.Identify the potential users who can apply the results of your research	0,5287	1	
3.Identify intermediaries in order to transfer the results of your results	0,5139	0,6568	1

As it is shown in Figure 9, our measure of pro-social research behavior follows a bell-shaped, close to normal distribution. The mean value is 2,515; median and mode is 2, 33; and the degree of skewness is well within the expected values for a normal distribution.[9] This indicates that, overall, scientists engage at intermediate or moderate levels in the three activities we have considered to measure pro-social behavior.

[9] The distribution departs however from normality due to significant levels of Kurtosis.

Figure 9: Distribution of pro-social research behavior scores



4.5.4 "Pro-social research behavior" across fields of science

To explore the influence of the field of science on the scientists' propensity to score high in "pro-social research behavior", we created a categorical variable to classify the scientists into "high pro-socials" and "low pro-socials" according to their average score to the three conducts presented above. Specifically, we distinguished between scientists who scored high in pro-social research behavior, (defined as those with pro-social levels within the highest quartile) and compared them to scientists who scored low in pro-social research behavior (defined as those with pro-social levels within the lowest quartile)[10].

Table 12 shows that a total number of 191 scientists from our sample are classified in the "low pro-social" category (15, 3% of all scientists), This group of scientists have scored more than 3 in the "pro-social research behavior" scale. Table 12 also shows that 236 scientists have been classified as "high pro-socials" (18, 9% of all scientists). Table 12 also shows the number of low pro-socials and high pro-socials across the different scientific fields.

[10] We defined "low pro-socials" as those scoring less than 2 in our "pro-social research behavior" variable. Similarly, "high pro-socials" were defined as those scoring more than 3 in our "pro-social research behavior".

Table 12: Distribution of "low pro-social" and "high pro-social" scientists across fields of science

	Low pro-socials	High pro-socials	Total
Biology and biomedicine	53	16	69
Food science and tech.	1	32	33
Tech for new materials	29	28	57
Physics science and tech.	31	36	67
Chemistry science and tech.	27	36	63
Agriculture science and tech.	15	44	59
Social sciences and humanities	7	16	23
Natural resources	28	28	56
Total	191	236	427

Figure 10: Distribution of high pro-socials and low pro-socials across fields of science

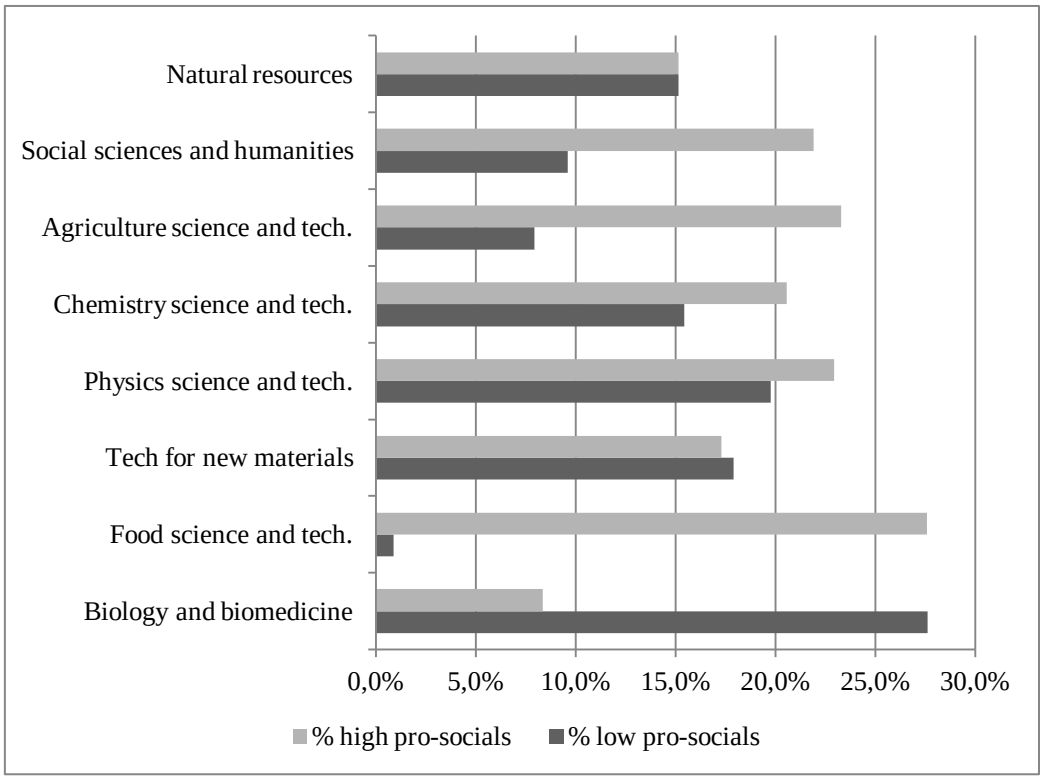


Table 12 and Figure 10 display the number and the rate of scientists classified as "high pro-socials" and "low pro-socials" across the total number of scientists from each scientific field. The highest proportion of "high pro-socials"

can be found in the "food science and technology" field of science, where 32 scientists fall into the category of "high pro-socials". Scientists involved in "agriculture science and technology" also show high scores of pro-social research behavior (44 scientists classified as "high pro-socials" and 15 scientists classified as "low pro-socials". It is also noticeable that the highest concentration of "low pro-social" scientists is located in the "biology and biomedicine" field of science. These results may be due to the fact that most of the scientists under the "biology and biomedicine" label are concentrated in performing basic science, while fewer scientists are working on the biomedical side.

In summary, data shows that the scientists' awareness of the social impact of their research results is partly driven by the field of research. As expected, "high pro-socials" tend to work in fields of science with a more applied orientation, such as food science and technology or agriculture. In contrast, lower levels of "pro-social research behavior" are associated with more basic sciences such as physics, biology or chemistry. However, results also show that the score in "pro-social research" is not fully determined by the field of science, which leaves room for the existence of potential lower-level factors that may help to explain the differences across scientists.

4.5.5 "Pro-social research behavior" and engagement in knowledge exchange activities

A critical point to justify our theoretical focus on the pro-social research behavior of scientists is the argument that it can be conceived as a precursor of an actual engagement in knowledge exchange activities with non-academic agents. In this section we aim to provide some preliminary evidence showing, from an empirical perspective, the validity of the former premise. While our current analysis does not seek to demonstrate causality, we do believe it is important to investigate whether there is a systematic connection between the extent to which scientists adopt a pro-social research behavior and their degree of involvement in knowledge transfer activities. To that effect, we used the information from the survey to examine the relationship between conducting pro-social research behavior and engaging in different forms of knowledge exchange. To assess each

scientist's pro-social research behavior, we employed the same classification of "low pro-socials" and "high pro-social" as in the previous section. We examined the pattern of their responses to a survey question asking whether researchers have been involved, over the three previous years, in any of the following interactions with businesses or technology transfer activities, including: (i) R&D contracts; (ii) joint research activities; (iii) consulting activities; (iv) licenses from patents; and (v) creation of businesses. Table 13 shows the proportion of scientists that participate in a range of interactions with industry, according to their pro-social research behavior.

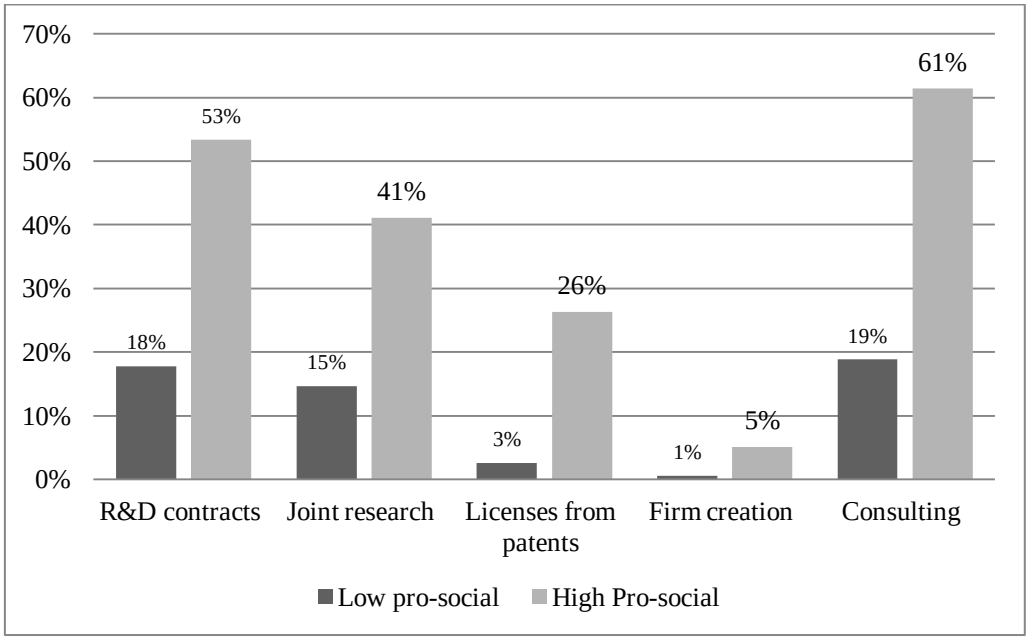
Table 13: Proportion of scientists involved in knowledge transfer activities according to their low/high pro-social behavior score

	Low Pro-socials	High Pro-socials	χ^2	*p*
R&D contracts	17,8%	53,4%	35,65	0,000
Joint research	14,7%	41,1%	57,065	0,000
Licenses from patents	2,6%	26,3%	44,65	0,000
Firm creation	0,5%	5,1%	7,44	0,006
Consulting	18,8%	61,4%	78,42	0,000

As Table 13 shows, we observe that, no matter what type of knowledge exchange mechanisms we look at, those scientists scoring high in pro-social research are at least twice as likely to engage in knowledge exchange activities compared to those scoring low. For instance, Figure 11 shows that more than half of the researchers who exhibit high levels of pro-social research behavior engage in 'R&D Contracts' with businesses (53,4%), compared to a proportion of 17,8% for the case of researchers scoring low in pro-social research behavior. Similarly "high pro-social" scientists are ten times more involved in the creation of a new company (5, 1% have done in the last three years) than "low pro-social" scientists (0, 5%). This pattern is consistent across all the different types of knowledge transfer activities examined, and the results from the χ^2 test show that these differences are significant in all cases. While this result does not support a claim on causality, it does provide confirmatory evidence about the existence of a strong link between pro-social research behavior and engagement in knowledge exchange activities with social agents.

The Figure 11 also reflects the engagement of "low-pro-social" and "high pro-social" scientists in different forms of knowledge exchange activities with social agents.

Figure 11: Proportion of scientists involved in knowledge transfer activities according to their low/high pro-social behavior score.



4.6 Conclusions

This chapter attempt to provide a deeper understanding of the drivers of knowledge and technology transfer engagement among scientists, by bringing to the foreground the concept of pro-social research behavior. In their efforts to understand the determinants of knowledge exchange among scientists, prior studies have paid little attention to its behavioral antecedents, and in particular, to those conducts that reflect a social awareness about the impact of research. Although new modes of scientific knowledge production (Etzkowitz, 1998; Gibbons et al., 1994; Ziman, 2002) stress the importance of considering the scientists' social relevance of their research, few previous studies had explicitly conceptualized such behavior. This study proposes a conceptualization based on three conducts that each scientist can carry out when performing research: (i) an explicit awareness and recognition that one's research results might have a potential social

impact in other people or groups; (ii) an explicit identification of the potential users of research findings and (iii) an identification of those intermediate agents that may serve to channel the social impact of research.

We examined empirically the "pro-social research behavior" of a group of scientists by asking them about the frequency they engage in the above mentioned conducts when performing their research activities. Data from a large-scale survey to CSIC researchers from all fields of science was used for the analysis. Our quantitative analysis highlights the following aspects. On the one hand, pro-social research behavior seems to be partly related to the field of science where the scientist works. Although we did not find a clear pattern between the field of science and the pro-social research behavior, results suggests that pro-social research behavior is, to some extent, related to the scientific field. Further, the measure of pro-social research behavior proposed in this study is found to be strongly associated with many different types of interactions with businesses and technology transfer activities. Therefore, scientists who exhibit a strong awareness about the social impact of research by frequently engaging in tasks associated with the identification of potential results from research or the identification of the potential beneficiaries of research, are more likely to be involved in every form of knowledge and technology transfer: contract R&D, joint research activities with business or firm creation (among others).

Our findings also indicate that, while extremely high levels of pro-social research behavior are rare, a large proportion of scientists exhibit intermediate levels of this type of pro-social behavior. This highlights that awareness about the social relevance and impact of research is largely to be an inherent part of research endeavors for most scientists.

CHAPTER 5
PREDICTING SCIENTISTS' PRO-SOCIAL RESEARCH BEHAVIOR: THE ROLES OF COGNITIVE DIVERSITY AND RESEARCH EXCELLENCE[11]

[11] Developed with Pablo D'Este (INGENIO – CSIC-UPV) and Alfredo Yegros (CWTS – Leiden University)

5.1 Introduction

Several studies have pointed out the importance of cognitive and motivational factors underlying academic entrepreneurship (Fini et al., 2012; Goethner et al., 2012). Firm creation is, however, a very specific and exceptional channel of knowledge and technology transfer associated to university-business interactions. Missing from much of this literature is the extent to which cognitive and social-psychological factors shape the adoption of a research mode (here, a "pro-social research behavior") that makes more likely to participate in various forms of knowledge exchange and co-production of knowledge with social agents.

This chapter aims to contribute to this subject by providing theoretical and empirical insights about the predictors of a pro-social research behavior. By doing so, we investigate the impact that different cognitive aspects have on the development of pro-social research behavior among a sample of tenured scientists from the Spanish Council of Scientific Research (CSIC). In particular, we examine if certain types of research skills (i.e. cognitive diversity and research excellence) have a positive impact in shaping a pro-social research behavior and, more critically, if they act as substitutes for prior experience in knowledge exchange activities. This work complements previous streams of literature that suggest that individual-level factors play an important role as precursors to the engagement in knowledge exchange activities (Bercovitz & Feldman, 2008b; Lam, 2011a; Tartari & Breschi, 2012).

The remainder of this chapter is structured as follows. In the following section, a series of hypothesis regarding the potential predictors of pro-social research behavior are provided. Specifically, the role of prior experience, research excellence and cognitive diversity is discussed. Then, a description of the sample and the variables used in this study is provided. The chapter then presents the results of the analysis, and concludes with a summary of the main findings and an analysis of the theoretical and empirical consequences of the results.

5.2 Antecedents of pro-social research behavior

5.2.1 Prior experience in knowledge transfer

First, we can reasonably expect that experience matters in shaping pro-social research behavior. Those scientists with previous experience as entrepreneurs, or in knowledge exchange activities more broadly, are likely to have developed the mindsets and skills necessary to gain a sense of perceived feasibility towards the engagement in knowledge transfer activities (Goethner et al., 2012; Hoye & Pries, 2009; Krueger JR, Reilly, & Carsrud, 2000; Landry, Amara, & Rherrad, 2006). Previous experience in knowledge transfer also provide scientists with an understanding of the state of the art outside academia and the main concerns of industry (Dokko, Wilk, & Rothbard, 2009; Owen-Smith & Powell, 2003). That may enable them to more clearly tailor their research efforts to the specific needs and expectations of non-academic actors (George, 2005; Kotha, George, & Srikanth, 2013)

Current theories on social psychology also point to the importance of prior contact with potential beneficiaries. Previous knowledge exchange activities mean that scientists have been in contact with potential beneficiaries of their academic work. Because existing research emphasizes that contact with beneficiaries is an important driver for the development of pro-social attitudes and behaviors, (Goldman & Fordyce, 1983. Grant et al., 2007; Grant, 2007), we propose that having previous knowledge transfer experience can increase scientists' pro-social research behaviors. From a scientist' perspective, previous contact with potential beneficiaries allows scientists to directly appreciate the potential beneficiaries' demands and give emphasis towards their needs (Brief & Motowidlo, 1986). Social psychology literature further points that developing interpersonal interactions with potential beneficiaries of one's work is a source of task significance (Grant et al., 2007), which directly enables to experience ones' work as more meaningful (Morgeson & Humphrey, 2006) and increase work persistence and job performance.

Building on this logic, we expect that having previous ties with beneficiaries of one' work should be particularly relevant among scientists to facilitate and inspire pro-social research behaviors. In an institutional work environment with high pressure to perform according to academic metrics (Bercovitz & Feldman, 2008b), previous experience in knowledge transfer may fuel the scientists' motivation to go beyond the Mertonian norms of science (Robert K. Merton, 1979). On average, such scientists will develop a greater concern about the social impact of their subsequent research activities, compared with those scientists with less or no previous knowledge transfer experience. Hence, that should make them more willing to put their best foot forward with the fulfillment of potential social beneficiaries' needs and embrace a broader range of conducts that reflect a stronger awareness about the social impact of their research activities. Accordingly, we put forward the following hypothesis:

> **Hypothesis 1***: Prior experience in knowledge transfer is positively associated with pro-social research behavior.*

5.2.2 Research excellence

A number of studies indicate that research excellence is likely to substantially affect the scientists' tendency to actively engage in knowledge exchange activities (Calderini, Franzoni, & Vezzulli, 2007; Link et al., 2007; Markus Perkmann, King, & Pavelin, 2011). First, the quantity and quality of academic publications is a recognized indicator of academic reputation. In this sense, previous research indicates that scientists with outstanding research performance may enjoy a particularly high visibility and prestige, exerting a signalling effect on potential users of their findings (Landry et al., 2006; Markus Perkmann et al., 2011). Scientists with high standards of research excellence are considered to embody more valuable human and social capital (Fuller & Rothaermel, 2012). As a consequence, star scientists are more able to send credible signals to external actors (Spence, 1973). A scientist with high scientific visibility may anticipate a potential to exert powerful signals to social beneficiaries and therefore, will be more likely to orient their research towards them. Second, scientists with an outstanding scientific record may exhibit an enhanced sense of

competence and greater confidence in one's ability. Such greater self-confidence may contribute to elicit a favorable attitude towards helping others and interact with potential beneficiaries of their research activities (see Brief & Motowidlo, 1986; Mowday, Porter, & Steers, 1982). Social psychology research suggests that a self-perception of one's helpfulness and competency is significantly important in shaping a positive disposition towards exerting a positive impact in others (Penner., Dovidio, Piliavin., & Schroeder., 2005). Scientists with an outstanding research tend to assume gate-keeping and boundary-spanning roles (Rothaermel & Hess, 2007), being more capable to understand and translate the contrasting coding schemes from academia and society.

While research excellence is likely to predict pro-social research behaviors, this relationship, however, may not be homogeneous across all levels of research excellence. Rather, the relation may exhibit a J-shape if scientists are reluctant to pro-social research behavior at low and intermediate levels of research excellence. This may happen due to scientists' fears that this type of pro-social behavior may endanger their efforts to achieve research priority and higher recognition among peers, as it may shift the focus of the dissemination of research findings away from the scientific community, towards non-academic stakeholders (P. E. Stephan, 2010; Weijden et al., 2012). While these negative effects might be irrelevant once a scientist has reached high status and recognition among peers, they may constitute an important factor in shaping behavior among scientists who have not yet made their mark in the scientific community. Building on this discussion, we put forward the following two related hypotheses:

> **Hypothesis 2a***: Research excellence is positively associated with pro-social research behavior.*
>
> **Hypothesis 2b***: There is a curvilinear J-shape relationship between research excellence and pro-social research behavior such that researchers exhibit lower pro-social research behavior at low and intermediate levels of research excellence.*

5.2.3 Cognitive diversity

Third, we hypothesize that cognitive diversity is positively linked to conducting pro-social research. Cognitive diversity refers to the cognitive spam of a research scientist, conceptualized as the diversity and balance of the areas of research in which the scientist works (Rafols & Meyer, 2010). We use the Shannon diversity index of each scientist, which accounts for the number of ISI subject categories where each scientist has published as well as the evenness of the distribution. A higher Shannon index reflects that the scientist is familiarized with a wider range of different knowledge bodies.

Our hypothesis is partly supported by research from the entrepreneurship literature (Fitzsimmons & Douglas, 2011; Philpott, Dooley, O'Reilly, & Lupton, 2011). Entrepreneurship research suggests that scientists with a broader expertise across fields of science are likely to conduct more distant search and to develop gatekeeper roles (within and outside the academic world), which should enhance identification of new lines of inquiry and awareness of social relevance and commercial opportunities of their research (Fleming, Mingo, & Chen, 2007; D'Este et al., 2012). As researchers are equipped with higher cognitive diversity, they are more likely to integrate the potential users' needs into their research agendas and therefore, show higher levels of pro-social research behavior. Being capable to integrate distant bodies of knowledge allows researchers to conduct research more useful for practitioners (Grant & Berry, 2011; Mohrman, Gibson, & Jr., 2001).

As for the case of research excellence, this potential relationship may not be homogeneous across all levels of cognitive diversity. Rather, we posit that this relationship may exhibit an inverted U-shape given that high levels of cognitive diversity may exert a negative impact on scientists' ability to conduct pro-social research, as a result of the increasing challenges for knowledge integration when broader and distant bodies of knowledge are dealt with (Rafols, 2007; Yegros, D'Este, & Rafols, 2013). Drawing on this discussion, we put forward the following two related hypotheses:

> **Hypothesis 3a***: Cognitive diversity is positively associated with pro-social research behavior.*

Hypothesis 3b*: This relationship may exhibit an inverted U-shape if increasing levels of cognitive diversity have a decreasing effect on scientists' pro-social research behavior.*

5.2.4 Moderating effects of research excellence and cognitive diversity

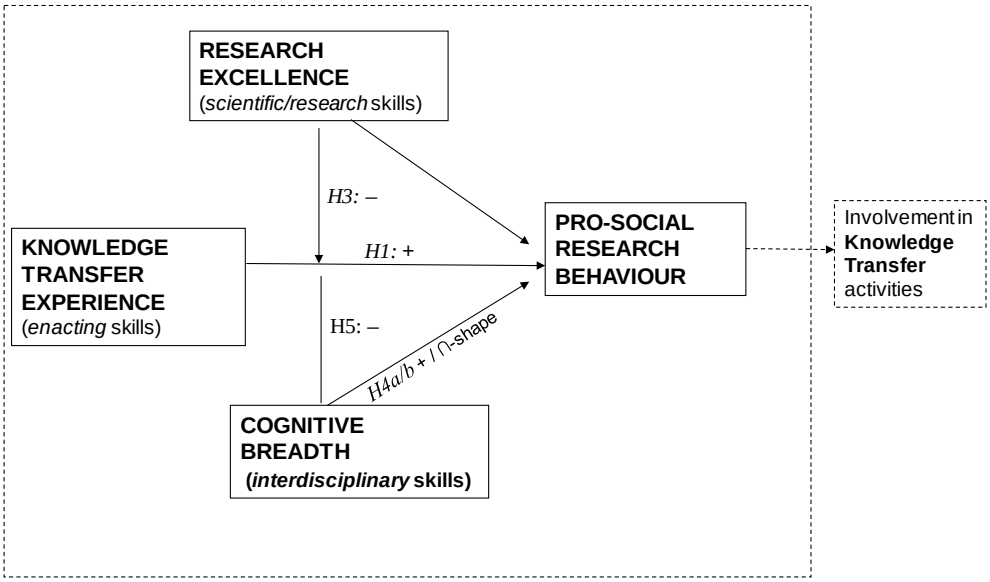
Finally, we also hypothesize that both research excellence and cognitive diversity are likely to act as substitutes for knowledge transfer experience, as we expect that these two skills should play a stronger role to elicit pro-social research behavior among scientists with no (or little) knowledge transfer experience, compared to those who have already developed the required enacting skills for knowledge transfer. We expect that high scientific visibility and self-confidence about one's research abilities would compensate for the absence of previous knowledge transfer experience, contributing to eliciting a pro-social attitude and conduct particularly among those with little or no prior knowledge transfer experience. Similarly, we expect that cognitive diversity would have a particularly stronger role in the formation of a pro-social research behavior among those who have no prior knowledge transfer experience, as compared to those scientists who have already built a well-established pattern of interaction with non-academic actors. We therefore put forward the following two related hypotheses:

Hypothesis 4*: Research excellence has a higher impact on pro-social research behavior at lower levels of experience in knowledge transfer activities.*

Hypothesis 5*: Cognitive diversity has a higher impact on pro-social research behavior at lower levels of experience in knowledge transfer activities.*

Figure 12 below provides a picture of the conceptual model and illustrates the hypotheses discussed in this Section.

Figure 12: Conceptual model



5.3. Data and measures

5.3.1 Sample

The analysis draws on the data from the large-scale survey conducted on all (tenured) scientists at the Spanish Council for Scientific Research (CSIC) that was also employed for the descriptive analysis in Chapter 4[12]. In addition to the survey and the administrative data, we complemented the database with bibliometric information of each scientist. To do so, we downloaded all publications of each scientist from the Thomson Reuters' Web of Science for which at least one of the authors was in our database. We adjusted for spelling variants because the same scientist may appear in different names in the Thomson Reuters' Web of Science. With this data we were able to extract publication and citation profiles, as well as the scientific field of specialization for all the scientists in our study.

Since we combined three different data sources, the potential problem of common method bias (CMV) is largely controlled (Podsakoff et al., 2003). Another potential concern with our data is that respondents may have a tendency to

[12] For more information about the sample and the context, see page X on chapter 4.

provide socially desirable answers to our "pro-social research behavior" question. To minimize the possibility of social desirability bias (SDB) (Moorman & Podsakoff, 1992), respondents were ensured full anonymity in their responses. Moreover, our respondents hold permanent positions and their evaluation is not directly linked to the generation of "socially useful" knowledge. Therefore, it seems unlikely that respondents inflate their responses in the questionnaire.

5.3.2 Variables

5.3.2.1 Dependent variable

Our dependent variable, ***Pro-social research behavior***, is built as in the previous chapter. That is, an average of the responses to a question that asked scientists to report the frequency (according to a 4-point Likert scale ranging from 'never' to 'regularly') with which they engaged in the following three activities when conducting research projects: (i) identifying potential results from research, (ii) indentifying potential users and (iii) identifying intermediary actors to help transfer the results of their research.

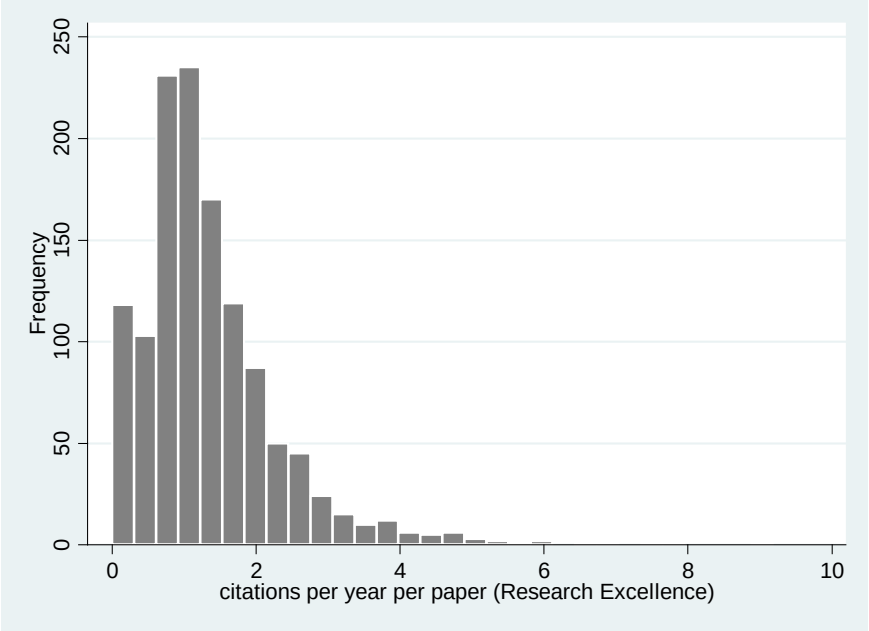
5.3.2.2 Predictor variables

The explanatory variables were measured as follows. We measure ***prior knowledge transfer experience*** as the total value (in €s) of R&D contracts, consulting activities and income from licences of intellectual property rights (i.e. patents) in which the scientists were engaged over the period 1999-2010, as reported in the administrative data provided by CSIC. This variable was transformed logarithmically, given its highly asymmetric distribution. While the mean value of income from knowledge transfer activities, for the scientists in our sample, corresponded to 89.6 thousand €, it is worth noting that 57% of the scientists who responded to the survey have not been involved at all in these types of activities (i.e. have no reported income from these activities).[13]

[13] Given the high proportion of zeros, this variable was logarithmically transformed after summing 1 to the original values, in order to retain the cases with zero levels of R&D contracts and consulting.

Research excellence was measured as the average number of citations per paper and year. Although citation count measures are by no means a perfect measure, they still provide a useful index for the relative salience of research (Cole, 2000; Murray & Stern, 2007). For each single paper we computed a score for the average received citations per year, from year of publication until 2010, and then we proceed to sum the scores for all the papers corresponding to each scientist and divided this aggregated figure by the total number of publications of the scientist. Figure 13 shows the distribution of the variable, displaying an asymmetric distribution indicating that few individuals score very high (10% of our sample of scientists have scores of 2.5 or above), while the wide majority fall in the range between 0.1 and 2 average citations per paper and year – there are very few cases (4.5% of scientists) with zero citations to their work. Similar to the previous variable (*knowledge transfer experience*), we also transformed this variable logarithmically.

Figure 13: Histogram of research excellence among scientists



Cognitive diversity. Our proxy for the scientists' cognitive diversity is based on the number of subject categories (ISI-SC) of the journal articles published by each researcher. To build this measure, we use the Shannon entropy index, as this index has the attribute that its scores depend on both the number of subject categories and the degree of balance with which the papers are distributed

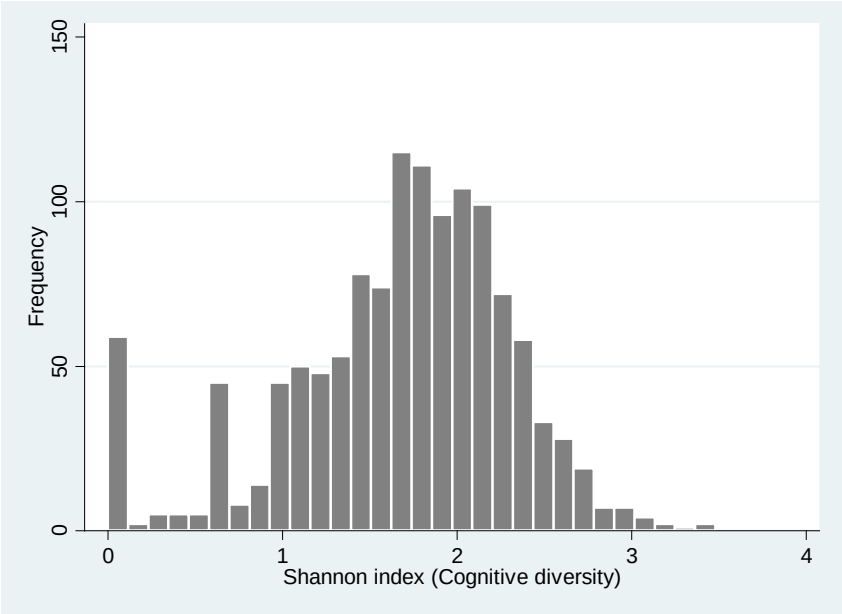
across the subject categories. For instance, scientists who display an even distribution of publications across subject categories are assigned a higher score compared to scientists whose publications cover a similar range of subject categories but are unevenly distributed – that is, highly concentrated in a few subject categories. The actual expression of this index is presented below:

$$CognitiveDiversity = \sum_{i=1}^{i=N} p_i \ln(1/p_i),$$

where p_i is the proportion of articles corresponding to the *i*th subject category, and N is the total number of subject categories of the journal articles published by a scientist.[14]

Figure 14 shows that the scores of this measure range from zero to 3.5, following a close to normal distribution with a spike in zero, reflecting the significant proportion of scientists whose research is concentrated in one single subject category (i.e. the distribution's mode is zero).

Figure 14: Histogram of cognitive diversity among scientists



[14] Given that an article can be attached to more than one subject category, we considered the total number of subject categories attached to all the articles of a scientist, and used this total (which can be potentially higher than the total number of papers) to compute the proportion of papers attach to each single subject category. Therefore, acknowledging that one paper might be assigned to more than one subject category.

In order to discuss in more detail the type of information provided by this measure, we display some examples drawn from our sample of scientists. For instance, a scientist in our sample exhibits a score for *cognitive diversity* close to the mean as she exhibits a pattern such as the following: 25 publications assigned to 10 different subject categories, including Applied Physics (in 11 publications), Materials Science (5 publications), Physical Chemistry (4), Spectroscopy (1), among other subject categories. The score of this scientist for Cognitive Diversity equals 2.05. A second, contrasting example corresponds to a scientist who, despite having the same number of publications as the previous one, has a score of cognitive diversity equal to zero because all his publications correspond to one single subject category – Astronomy & Astrophysics.

5.3.2.3 Control variables

In order to account for other individual attributes that could shape pro-social research behavior, we also considered some alternative individual-level control variables.

First, we included a set of socio-demographic characteristics of our sample that may have an influence on our dependent variable According to previous research, the age of the scientist has an ambiguous effect on the scientists' propensity to engage with industry (M. Perkmann, 2012). To account for such variable, we included *age* as a control variable. We also included the gender (whether the researcher is *male*), and the academic status of each scientist (i.e. whether researchers are *professors*). This information was obtained from the administrative data provided by CSIC.

Second, since motivational factors are likely to play an important role in shaping the disposition of scientists to adopt a pro-social research behavior, we included a number of variables taken from the survey questionnaire, to address motivational features connected to the different types of benefits expected by scientists from the interaction with social agents. These expected benefits included: a) fostering the research agenda of the focal scientist (*Advancing Research*); b) expanding the scientist professional network (*Expanding Network*), and c) increasing the scientist personal income (*Personal Income*). While the first two were computed as three-item scales, the latter one was measured as a single-

item scale. For details on the construction of these variables, see Table A1 in the Appendix. Moreover, we build on self-determination theory (Deci & Ryan, 1985, 2000) to assess the influence of two more general types of motivations towards the engagement in research activities: *autonomous* and *controlled* motivations . For details on the construction of these variables, see also Table AX in the Appendix.

Third, we also included as controls, information about the volume of articles published per scientist (i.e. log transformation of the total number of papers, *Number Publications*) and the average number of co-authors with whom scientists have published their work (i.e. log transformation of the average number of co-authors, *Average N^{o} Co-authors*). Finally, we included a number of controls regarding the environment in which our sample of scientists operates. On one hand, drawing on information from the survey, we built a measure of institutional climate to capture the extent to which scientists considered that their research institutes offered a supportive climate to undertake knowledge transfer activities - *Climate* (see details on this construct in Annex II). On the other hand, we considered a set of dummy variables to control for the scientific disciplines of our sample of scientists: Agriculture Sc. & Tech.; Biology & Biomedicine; Chemistry Sc. & Tech.; Food Sc. & Tech.; Natural Resources; Physics Sc. & Tech.; Social Sc. & Humanities; Tech. for New Materials. Table 14 shows the descriptive statistics for all the variables used in our analysis. Correlations are shown in table 15.

5.3.3. Estimation procedure

Since our dependent variable corresponds to a scale composed of three items whose values range between 1 and 4, the estimation procedure chosen was a Tobit regression model. The tobit model, also called a censored regression model, is designed to estimate linear relationships between variables when there is either left or right censoring in the dependent variable (Wooldridge, 2002).

Table 14: Summary statistics and description of variables

Variables	Mean	S.D.	Median	Min.	Max.	Obs.	Source	Description
1. Pro-social research behavior	2.52	0.73	2.33	1	4	1219	Q	*Please, indicate the frequency you engage in each of the following activities when you conduct a research project (1=never; 4=regularly):(1) Identify the potential results of your research that can benefit users; (2) Identify the potential users who can apply the results of your research; (3) Identify intermediaries in order to transfer the results of your results.*
2. Knowledge transfer experience (ln)	4.74	5.59	0	0	15.85	1249	A	*Total value (in €s) of R&D contracts, consulting activities and income from licenses of intellectual property rights (i.e. patents) in which the scientists were engaged over the period 1999-2010, as reported in the administrative data provided by CSIC.*
3. Research excellence*	1.34	1.00	1.14	0	9.18	1249	I	*Average number of citations per paper and year*
4. Cognitive diversity	1.68	0.64	1.76	0	3.48	1249	I	*Shannon entropy index*
5. Motive 1: Advancing research	1.11	0.52	1	0	2	1237	Q	*Please, indicate the degree of importance you attach to each of the following items, as personal motivations to establish interactions with non-academic organizations (firms, public administration agencies, non-profit organizations) (1=not at all; 4=extremely important): (1) To explore new lines of research, (2) To obtain information or materials necessary for the development of your current lines of research, (3) To have access to equipments and infrastructure necessary for your lines of research*
6. Motive 2: Expanding network	0.86	0.51	1	0	2	1235	Q	*Please, indicate the degree of importance you attach to each of the following items, as personal motivations to establish interactions with non-academic organizations (firms, public administration agencies, non-profit organizations) (1=not at all; 4=extremely important): (1) To keep abreast of about the areas of interest of these non-academic organizations, (2) To be part of a professional network or expand your professional network, (3) To test the feasibility and practical application of your research, (4) To have access to the experience of non-academic professionals.*

7. Motive 3: Personal income	0.26	0.55	0	0	2	1239	Q	*Please, indicate the degree of importance you attach to 'Increase your personal income' as a personal motivation to establish interactions with non-academic organisations (firms, public administration agencies, non-profit organisations) (1=not at all; 4=extremely important).*
8. Controlled motivation	2.84	0.71	3	1	4	1239	Q	*When you think of your job as a researcher, what is the importance attached to the following items? (1=no importance; 4=extremely important):(1) Salary; (2) Job security, (3) Career advancement*
9. Autonomous motivation	3.64	0.48	4	1.67	4	1248	Q	*When you think of your job as a researcher, what is the importance attached to the following items? (1=no importance; 4=extremely important): (1) To face intellectual challenges, (2) to have greater independence in your research activities. (3) To contribute to the advance of knowledge in your scientific field.*
10. Age	49.83	8.25	49	31	70	1249	A	*Number of years*
11. Gender	0.65	0.48	1	0	1	1249	A	*Male =1; Female =0*
12. Professor	0.23	0.42	0	0	1	1249	A	*Professor =1; no professor = 0*
13. Number Publications*	32.61	32.03	25	1	286	1249	I	*Total number of publications over the scientist career until 2010*
14. Average N°. Co-authors*	7.56	44.23	3.95	0	1183.50	1249	I	*Average number of co-authors per article, for each scientist.*
15. Climate	2.13	1.78	2	0	4	1249	Q	*Number of items assessed by the respondent as 'very positively', from the following question: Assess the experience you have had in your relationships with the personnel at your institute, regarding the following issues (1=very negatively; 4=very positively):(1) Attitudes of the personnel at your institute to address your queries and requests; (2) Accessibility to the human resources and services available at your institute; (3) Capacity to solve the problems in due time and form; (4) Technical capacity of the institute's personnel.*

*Q=Questionnaire; A=Administrative data; I= ISI-SCI

Table 15: Correlation matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Pro-social research behavior	1														
2. Knowledge transfer experience (ln)	0.258*	1													
3. Research excellence (ln)	-0.154*	-0.052	1												
4. Cognitive diversity	0.043	0.162*	0.239*	1											
5. Advancing research	0.252*	0.032	0.013	0.022	1										
6. Expanding network	0.298*	0.041	-0.051	-0.024	0.583*	1									
7. Personal income	0.073*	-0.023	-0.023	-0.073*	0.261*	0.226*	1								
8. Controlled motivation	0.085*	0.034	0.005	-0.051	0.103*	0.125*	0.377*	1							
9. Autonomous motivation	-0.012	0.001	0.082*	-0.079*	0.162*	0.139*	0.073*	0.249*	1						
10. Age	0.083*	0.236*	-0.104*	0.064*	-0.021	-0.056*	0.005	-0.029	-0.096*	1					
11. Gender (Male = 1)	-0.018	0.071*	0.066*	0.053	-0.181*	-0.194*	0.017	0.037	0.039	0.099*	1				
12. Professor	0.038	0.235*	0.116*	0.077*	-0.029	-0.028	0.003	0.060*	0.090*	0.436*	0.162*	1			
13. Number publications (ln)	-0.019	0.167*	0.392*	0.597*	-0.012	-0.064*	-0.078*	-0.035	-0.031	0.105*	0.065*	0.287*	1		
14. Avg. n^{o} co-authors (ln)	-0.012	-0.052	0.338*	0.186*	0.080*	-0.017	-0.061*	-0.012	-0.078*	-0.080*	0.016	-0.031	0.221*	1	
15. Climate	0.125*	0.136*	-0.031	0.041	0.127*	0.157*	-0.023	0.028	-0.008	0.006	0.024	-0.006	-0.004	0.04	1

* $p < 0.05$

5.4 Results

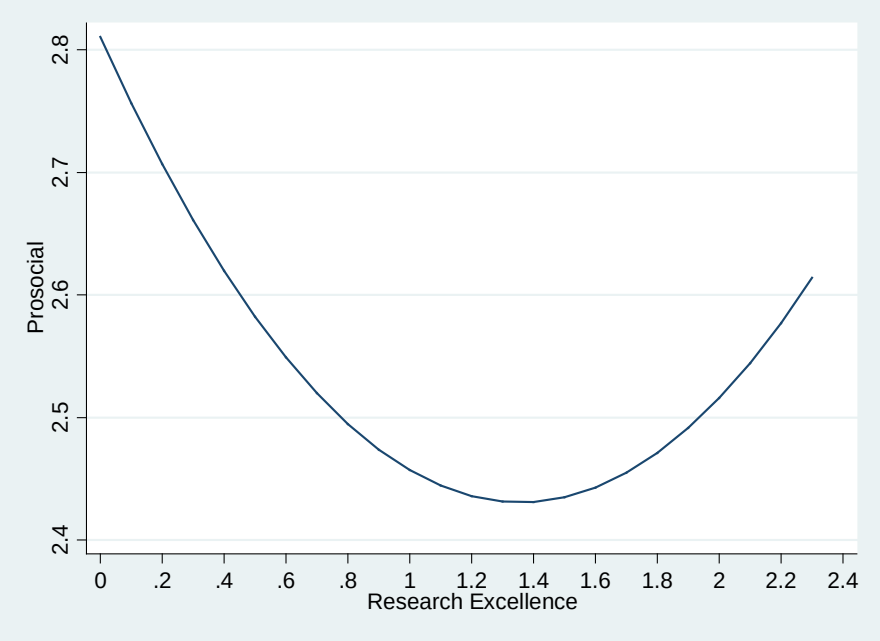
We run Tobit regression analysis to investigate the proposed hypotheses. We assessed the direct impact of prior experience in knowledge transfer, research excellence and cognitive diversity on pro-social research behavior, and the extent to which cognitive-related skills moderate the relationship between knowledge transfer experience and pro-social research behavior. In order to minimize potential multicollinearity problems, the variables used for the squared and interaction terms were standardized before entering them into the regression analysis (Aiken & West, 1991)

The results are presented in Table 17. In model 1, we included only the control variables (motives to interact, autonomous and controlled motivation, age, gender, professor / not professor, number of previous research papers, average number of co-authors, supportive knowledge-transfer climate and scientific field). In Model 2 we added all first-order associations between pro-social research behavior and previous knowledge exchange experience, research excellence and cognitive diversity. Our results show that, as expected, past experience in knowledge transfer activities is a very strong predictor of pro-social research behavior. This is a consistent result in all our specifications (see Models 2 to 6) and gives support to our first hypothesis, *H1*.

Table 17 shows that research excellence plays an important role in explaining pro-social research behavior, but contrary to our expectations, the linear effect is negative (see Model 2). Thus, we do not find support to our hypothesis *H2a*, which stated a positive relationship between research excellence and pro-social research behavior. However, when examining whether there is a curvilinear relationship between research excellence and pro-social research behavior, we find a U-shape relationship with pro-social research behavior. That is, scientists are comparatively reluctant to embrace pro-social research behavior at intermediate levels of research excellence, while exhibit high levels of pro-social research behavior for either low or high research excellence. This result is shown in Model 3 where we observe a positive and significant effect of research excellence together with a negative and significant effect for research excellence squared. This result is aligned with our hypothesis *H2b*, which anticipated a curvilinear

relationship where the positive effect of research excellence was expected only beyond a certain threshold of excellence. To illustrate this curvilinear relationship between research excellence and pro-social research behavior, we display this result in Figure 15.

Figure 15: Relationship between research excellence and pro-social research behavior



Further, our results also show that cognitive diversity has a positive and significant impact on pro-social research behavior, which is consistent throughout all the specifications in Table 17. This result is consistent with our hypothesis *H3a*. This result suggests that interdisciplinary research skills (the capacity to integrate multiple bodies of knowledge in research activities) positively contribute to fostering pro-social research behavior among scientists. However, we did not find any evidence of a curvilinear relationship, as the quadratic term of cognitive diversity is not statistically significant (see Model 4); thus, we find no support for our hypothesis *H3b*.

Finally, while our results show that past experience in knowledge transfer activities is a very strong predictor of pro-social research behavior, we find that cognitive diversity acts as a substitute for experience in knowledge transfer: see the negative sign of the interaction term in Model 6. That is, the impact of cognitive diversity on pro-social research behavior is stronger for scientists who

exhibit little or no previous knowledge transfer experience, at it is shown in Figure 16. This result supports our hypothesis *H5*. On the contrary, we did not find that research excellence moderated, in any way, the relationship between knowledge transfer experience and pro-social research behavior: the interaction term between research excellence and knowledge transfer experience is not statistically significant (see Model 5). Thus, we do not find support for our hypothesis *H4*.

Figure 16: Two-way interaction between knowledge transfer experience and pro-social research behavior.

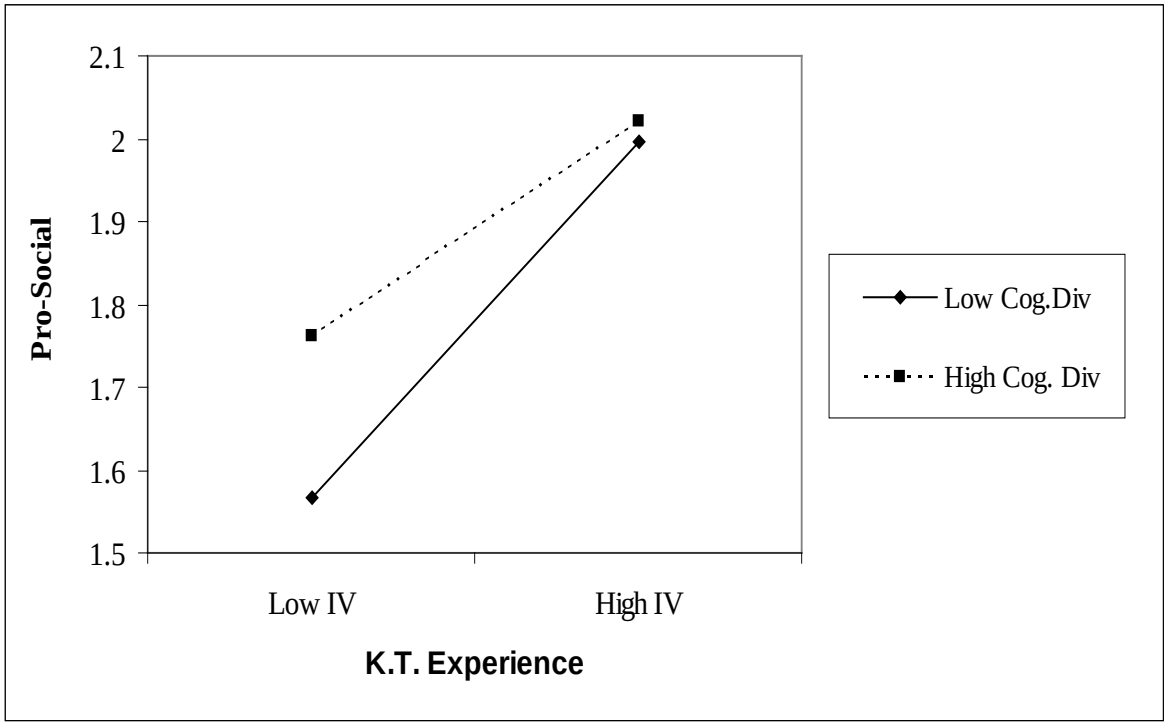


Table 16: Summary of results

		Supported
H1	Prior experience → Pro-social research behavior (lineal)	Yes
H2a	Research excellence → Pro-social research behavior (lineal)	No
H2b	Research excellence→ Pro-social research behavior (J-shape)	Yes
H3a	Cognitive diversity→ Pro-social research behavior (lineal)	Yes
H3b	Cognitive diversity→ Pro-social research behavior (∩-shape)	No
H4	Negative moderation of research excellence on H1	No
H5	Negative moderation of cognitive diversity on H1	Yes

Table 17 : Tobit estimates. Dependent variable: pro-social research behavior

	Pro-social research behavior					
Variables	*Model 1*	*Model 2*	*Model 3*	*Model 4*	*Model 5*	*Model 6*
Knowledge transfer experience		0.030***	0.029***	0.030***	0.030***	0.031***
		(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Research excellence		-0.183***	-0.239***	-0.181***	-0.184***	-0.179***
		(0.069)	(0.076)	(0.069)	(0.069)	(0.069)
Cognitive diversity		0.089**	0.095**	0.095**	0.089**	0.082**
		(0.042)	(0.042)	(0.044)	(0.042)	(0.042)
Ressearch excellence^2			0.206*			
			(0.110)			
Cognitive diversity^2				0.019		
				(0.036)		
Research Excellence* Knowledge transfer experience					-0.004	
					(0.010)	
Cognitive diversity * Knowledge transfer experience						-0.012**
						(0.006)
Motive 1: Advancing Research	0.201***	0.204***	0.205***	0.203***	0.204***	0.209***
	(0.047)	(0.051)	(0.051)	(0.051)	(0.051)	(0.051)
Motive 2: Expanding Network	0.278***	0.302***	0.302***	0.303***	0.302***	0.295***
	(0.051)	(0.052)	(0.052)	(0.052)	(0.052)	(0.052)
Motive 3: Personal Income	-0.035	-0.018	-0.019	-0.017	-0.018	-0.018
	(0.042)	(0.042)	(0.042)	(0.042)	(0.042)	(0.042)
Controlled motivation	0.058*	0.051	0.052	0.049	0.051	0.051
	(0.032)	(0.033)	(0.033)	(0.033)	(0.033)	(0.033)
Autonomous motivation	-0.078*	-0.064	-0.062	-0.062	-0.064	-0.061
	(0.041)	(0.047)	(0.047)	(0.048)	(0.047)	(0.047)
Age	0.008***	0.003	0.003	0.003	0.003	0.004
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Gender (Male = 1)	0.086**	0.067	0.067	0.068	0.067	0.068
	(0.044)	(0.046)	(0.046)	(0.046)	(0.046)	(0.046)
Professor	0.024	0.001	-0.005	-0.001	0.002	0.004
	(0.055)	(0.059)	(0.059)	(0.060)	(0.060)	(0.059)
N^o Publications	-0.006	-0.037	-0.021	-0.037	-0.037	-0.036
	(0.023)	(0.027)	(0.028)	(0.027)	(0.027)	(0.027)
Average N^o. Co-authors	0.013	0.046	0.047	0.045	0.046	0.048
	(0.040)	(0.041)	(0.041)	(0.041)	(0.041)	(0.041)
Climate	0.019*	0.008	0.008	0.008	0.008	0.007
	(0.011)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
Intercept	1.428***	1.750***	1.654***	1.736***	1.750***	1.738***
	(0.247)	(0.274)	(0.278)	(0.275)	(0.274)	(0.274)
Scientific Field Dummies	Included	Included	Included	Included	Included	Included
N. Observations	1195	1195	1195	1195	1195	1195
Log Likelihood	-1339.50	-1303.65	-1301.88	-1303.51	-1303.57	-1301.69
LR Chi^2 (d.f.)	201.7***	273. 4***	276.9***	273.7***	273.6***	277.3***
Pseudo R^2 – McKelvey & Zavoina	0.16	0.20	0.21	0.20	0.20	0.21

* $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$. Standard errors are in parentheses.

5.5. Conclusions

In their efforts to understand the determinants of knowledge exchange between academia and society, scientists are increasingly interested in understanding the micro-foundations of the engagement in knowledge exchange activities (Arvanitis et al., 2008; Jain et al., 2009). This chapter aimed to shed light on this issue by investigating the type of skills that shape the scientists' awareness of the potential impact of their research results over non-academic actors. We believe that focusing on this individual-level antecedent, referred such as pro-social research behavior, may be helpful to understand why some scientists are more willing than others in putting their knowledge into practice by engaging in a range of knowledge exchange activities with social agents.

Pro-social research behavior should, however, depend on a number of individual particularities of the scientist. In this paper, we examine empirically to what extent previous knowledge transfer activities, research excellence and cognitive diversity predict such behavior. We also examine whether research excellence and cognitive diversity have substitutive effects on previous knowledge transfer experience. That is, to what extent the lack of skills related to the previous engagement in knowledge transfer can be compensated by having a wide cognitive diversity or a prominent research track.

Our findings suggest that scientists' previous experience in knowledge transfer matter for pro-social research behavior. We find a robust and positive association between scientists' prior experience in knowledge transfer activities with non-academics and their current awareness about the social impact of their research results, measured as pro-social research behavior. As argued, this type of experience is likely positively affect a sense of perceived feasibility towards technology transfer activities and it is also likely to contribute to a better understanding of the needs and demands of potential beneficiaries of their research. Second, our empirical analysis indicates that cognitive diversity is an important driver of pro-social research behavior. In this sense, this study highlights that interdisciplinary research tracks could be a powerful means to enhance the formation of favorable attitudes and conducts to engage in knowledge transfer activities. Indeed, the importance of interdisciplinary research is amplified by its

moderating role on knowledge transfer experience, as cognitive diversity has a particularly strong impact in shaping pro-social research behavior among those scientists with no previous experience in knowledge transfer activities. Finally, our results indicate that pro-social research behavior may conflict with the search for peer recognition through scientific impact, as indicated by the negative sign of the relationship between the pro-social and research excellence, for a significant portion of our sample of scientists. In other words, this finding suggest that, unless researchers perform above average in terms of the scientific impact of their work or conform to the category of star-scientist (in terms of a comparatively high scientific impact of their research), the search for scientific impact may conflict with the development of a pro-social research behavior. This suggests that policies supporting a change in the set of incentives faced by scientists, such as the inclusion of knowledge transfer activities in the set of merits for academic promotion, could contribute to attenuating the obstacles towards pro-social behavior faced by a large proportion of scientists.

Notwithstanding the need for further research on the individual determinants of a favorable attitude towards knowledge exchange with social actors, we believe our contributions are important because they provide insights on the role of three particular factors at the individual level as predictors of a subsequent participation in a range of knowledge exchange activities. Also, we tried to build a comprehensive picture of the type of skills through which pro-social research behavior is formed and nurtured.

CHAPTER 6: CONCLUSIONS

6.1 General conclusions

The main purpose of this thesis has been to highlight the relevance of the individual as the primary level of analysis to understand the processes underlying the exchange of knowledge under a knowledge-based view (KBV) of the firm. Most of the existing literature from organization studies has been focused on the study of organizational constructs as explanatory mechanisms for the heterogeneous performance of organizations, giving less importance to the individual processes and behaviors. In this thesis, it has been argued that a deeper look at the individual level may be useful in understanding how knowledge is exchanged in two different contexts: within employees in a business organization and between scientists and social agents.

The theoretical foundations of the thesis are explained in Chapter 2. This chapter aims to provide arguments for the critical role of knowledge creation and knowledge exchange processes as key processes for the creation of value in a knowledge-based economy. Further, the chapter aims to support the need of a closer scrutiny at the individual level. The question of how to explain macro phenomena through the study at the micro level is a debate of interest to researchers mainly from strategic management (Felin & Foss, 2005), markets and institutions (Van de Ven & Lifschitz, 2012) and organizational theory (Gavetti, Greve, Levinthal, & Ocasio, 2012). Moreover, an increasing number of scholars from the university-industry field of research have adopted a micro-level approach to understand the determinants of knowledge transfer (Arvanitis et al., 2008; Bercovitz & Feldman, 2008; Jain et al., 2009). This thesis aims to provide an attempt to contribute to both lines of research by focusing on knowledge exchange at the individual level as a critical behavior for both contexts.

Our first empirical analysis is presented on Chapter 3. In this chapter we build on previous research to justify the importance of knowledge sharing behavior for individuals and organizations, defined as the provision or acquisition of task information, know-how and feedback on a product or a procedure (Hansen, 1999). Previous studies have suggested that a cooperative climate is relevant for employees to share knowledge. However, we adopt an individual-level lens to argue that such influence is unlikely to be homogeneous across all employees.

Specifically, we argued and tested that job autonomy and intrinsic motivation play a significant role in this relationship. A cooperative climate will be particularly relevant to encourage knowledge sharing among those scientists showing a lower intrinsic interest in doing so. Also, the influence of a cooperative climate on knowledge sharing behavior is higher when employees are given more job autonomy.

Chapter 4 introduces a different context: academic scientists and the decision to exchange knowledge with social agents. The argument is that, if societies aim to obtain social and economic value from the scientific knowledge generated at research institutions, it is critical to understand why and how scientists at these institutions form their decision to orient their research towards the social usefulness of the generated knowledge. In an attempt to capture this, we conceptualized "pro-social research behavior" as these conducts that place social relevance as a primary goal of research. In particular, we build on social psychology literature (e.g.: Grant & Mayer, 2009; Grant, 2007) to emphasize the importance of scientists' awareness about the positive effects they can exert on others through their work. We also suggested the critical role of being aware about the potential users and the intermediary agents that may channel the social impact of scientific research. We offered a descriptive analysis on a sample of scientists from the Spanish Council of Scientific Research (CSIC), where we explored the pro-social research behavior of these scientists. Our results suggest that there are systematic differences in individuals' pro-social research behavior, opening up the question about what are the underlying factors at the level of the individual that may account for such heterogeneity.

Chapter 5 was aimed to investigate the influence of three potential explanatory factors of pro-social research behavior among academic scientists. We focused on previous knowledge transfer experience, research excellence and cognitive diversity, providing arguments on why scientists with more knowledge transfer experience and higher research excellence and cognitive diversity may be more likely to exhibit a stronger pro-social research behavior. Then, we proposed that research excellence and cognitive diversity may be particularly important for scientists with little or no previous experience in knowledge transfer. Our results show that research experience is a strong predictor for the formation of a pro-

social research behavior. We also found that scientists are particularly reluctant to embrace a pro-social research behavior at intermediate levels of research excellence, suggesting that those scientists that have reached a distinguished position in academia are more willing to explicitly engage in activities that reflect a strong awareness about the social impact of their research. With respect to the role of cognitive diversity, our results show that having interdisciplinary skills facilitate the adoption of a pro-social research behavior. Perhaps more interestingly, we found that cognitive identity may act as a substitute for experience in encouraging a pro-social research behavior.

6.2 Practical implications

Because this thesis is focused on two different contexts, it may be useful to differentiate between the managerial implications and the implications at the policy level. Analyzing the contingent factors affecting the effect of a cooperative climate on knowledge sharing behavior shows that there are substantial differences in the way an individual decision to share knowledge is affected by the existence of a cooperative climate in the organization. Knowing that the effect of a cooperative climate is not evenly distributed across all employees suggests that managers should consider whether it is always needed to devote managerial attention and resources in promoting a cooperative climate among the employees. For instance, in groups where employees have high intrinsic interest in sharing knowledge, managerial efforts might be better allocated in different tasks rather than in fostering a cooperative climate to share. Conversely, those individuals with low intrinsic interest in sharing knowledge will ground their decision to share in the existence (or not) of a climate characterized by high levels of cooperation among employees. In these cases, it may be justified from a managerial perspective to devote efforts in promoting such contextual conditions. Our results also suggest that job autonomy affects the extent to which employees are influenced by a cooperative climate. Managers can maximize the positive influence of a cooperative climate over knowledge sharing if they grant their employees with high autonomy. The potential interactive effects between job features and organizational climate may provide managers tools to adjust the attention they devote to different contextual variables.

Our results from Chapters 4 and 5 offer implications for policymakers that are involved in the economics of science. Whereas there is a well-established political discourse supporting a higher commercialization of scientific knowledge, it is important to note that this idea implies a complex change in the way scientists' conceive and organize their research activities. Probably because of such complexity, a number of psychological mechanisms may come into play, justifying an "individual-first" approach of the phenomena. Our results confirm that not all scientists are equally prone to consider the social relevance of the knowledge they create, conceptualized as pro-social research behavior. Given that the academic and the commercial incentives are misaligned, some scientists prioritize their academic career over the social impact of the knowledge they produce. This calls for policies oriented to promote more explicit incentives to the engagement in knowledge transfer. For instance, including knowledge transfer activities in the set of merits for academic promotion and peer recognition may be a way to soften this misalignment. Also, our results provide arguments towards the promotion of interdisciplinary research tracks. Scientists that have worked in a wide range of scientific fields are more likely to adapt their research to the particular needs of the societal actors. Hence, the development of policies supporting interdisciplinary research may be useful in facilitating the transit from a focus on scientific impact to a broader perspective that explicitly accounts for the societal relevance of the research results.

6.3 Limitations and further research

This thesis is subject to a number of limitations. The first one comes from the theoretical framework adopted in this thesis. Opening the black box of individual heterogeneity makes extremely difficult to isolate and analyze the influences of individual-level characteristics on a particular behavior. For instance, the study on Chapter 3 focused on motivation and job autonomy as predictors of knowledge sharing. Although we included a number of control variables in our model, we cannot rule out that other sources of individual heterogeneity not considered in our model can play a role in explaining employees' knowledge sharing behavior, such as their personality traits or their particular abilities. Further, we build on self-determination theory (SDT) to dichotomize between intrinsic motivation and extrinsic motivation (Deci & Ryan, 1985, 2000). Although

this conceptualization is quite straightforward, it does not consider other types of motivations along the intrinsic-extrinsic continuum (Reiss, 2004).

Similarly, Chapter 5 suggested previous knowledge transfer experience, research excellence and cognitive diversity as potential explanatory variables to explain pro-social research behavior. Cognitive processes such as the formation of a favorable attitude towards the propensity of exchanging knowledge with non-academic actors are extremely difficult to predict by nature, because of the large number of potential factors that can affect the configuration of such behavior. As we did in Chapter 3, our study on the determinants of pro-social research behavior includes a range of control variables at the individual level in order to partially mitigate this thread.

This limitation opens an avenue for further research. Future work is needed to provide insights into how some other individual level variables may influence the individuals' propensity to exchange knowledge. For instance, it would be interesting to study the potential interactive effects of different types of motivation on knowledge sharing behavior. With regards to the predictors of pro-social research behavior, future research may explore the influence of particular personality traits as facilitators of the adoption of a pro-social research behavior. Moreover, future research may extend the analysis on the determinants of pro-social research behaviors by explicitly consider the importance of pro-social motivation (Grant, 2008; Grant & Sonnentag, 2010). Scholars have suggested that this type of motivation may be an antecedent of an actual engagement in commercialization activities (Lam, 2011). Therefore, it is expected that pro-social motivation can be a predictor of the scientists' engagement in various forms of knowledge exchange.

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APPENDIX

APPENDIX 1: QUESTIONNAIRE CHAPTER 3

Education *(please, tick one of the boxes)*

High school or below ( )

Middle-range training ( )

Diploma degree ( )

Bachelor's degree ( )

Master's degree ( )

PhD ( )

To what extent is your current job characterized by the following?

	No or very little extent		Moderate extent			Very large extent	
The freedom to carry out my job the way I want to							
The opportunity to get feedback on my job performance							
The opportunity to get to know other people							
The opportunity for independent initiative							
The opportunity to complete work that I started							
The opportunity to develop friendships in my job							
Control over the pace of my work							
The opportunity to do a job from the beginning to the end							

To what extent are you included in the following?

	No or very little extent		Moderate extent			Very large extent	
Individual performance-based bonuses							

Team based payment	1	2	3				
Profit sharing	1	2	3				
Employee shares	1	2	3				
Promotion based on the achieved level of competencies	1	2	3				
Formal acknowledgement	1	2	3				
Job rotation	1	2	3				
Career development	1	2	3				
General management training	1	2	3				
Specialized professional training	1	2	3				
Performance evaluation	1	2	3				
Quality circles / Total Quality Management Teams	1	2	3				
Self-managing teams	1	2	3				

To what extent do you agree with the following statements?

	Strongly disagree		Neutral			Strongly agree	
Employees in my department cooperate well with each other							
It is important to keep own ideas secret until one is acknowledged as the source of the idea							
Knowledge sharing reduces the incentive for others to create new knowledge							
Employees in my department prefer to create own knowledge rather than reusing							

others							
Employees in my department perceive each other as competitors							
In my department individual initiative is highly valued							
Employees in my department are primarily rewarded on the basis of individual performance							
My department's norms and values differ from those of the company as a whole							
Time spent on knowledge sharing could be spent on more important activities							
Sharing knowledge is risky because others may misinterpret the shared knowledge							
In my department employees have the right to make mistakes in their job							
Often there is a lack of consistency between the decisions of our department and those of other departments							

To what extent have you…

	No or very little extent			Moderate extent		Very large extent	
… received knowledge from colleagues in *your own* department?							
… used knowledge from colleagues in *your own* department?							
… received knowledge from colleagues in *other domestic*							

departments?							
… used knowledge from colleagues in *other domestic departments*?							
… received knowledge from colleagues in *foreign departments*?							
… used knowledge from colleagues in *foreign departments*?							

To what extent have colleagues…

	No or very little extent			Moderate extent		Very large extent	
… in *your own department* received knowledge from you?							
… in *your own department* used knowledge from you?							
… in *other domestic departments* received knowledge from you?							
… in *other domestic departments* used knowledge from you?							
… in *foreign departments* received knowledge from you?							
… in *foreign departments* used knowledge from you?							

Why do you share knowledge with others?

	Strongly disagree			Moderate extent		Strongly agree	
I want my supervisor(s) to praise me							
I want my colleague(s) to praise me							
I might get a reward							
I find it personally satisfying							
It may help me get promoted							

I like it							
I enjoy doing so							

The following questions are related to the characteristics of your current job

	Not at all or very little					Very much	
How repetitious are your tasks?							
How much are you left on your own to do your work?							
How often are you involved in the completion of tasks or projects?							
How much feedback do you receive from the head of your department on your job performance?							
To what extent do you find out how well you are doing on the job while you are working?							
How much of your job depends upon your ability to work with others?							
How much variety is there in your job?							
How often do you have the opportunity to talk informally with colleagues?							
How much feedback do you receive from your project manager on your job performance?							
To what extent do you have the opportunity to do your job independently of others?							

To what extent do you experience that knowledge sharing leads to…

	Not at all or very little					Very much	
Salary increases							
Increased chance of a bonus							
Increased chance of interesting assignments and projects							
Increased recognition from the head of my department							
Better reputation							
More recognition from my colleagues							
Increased chance of professional development							
Increased recognition from my project manager							

20. To what extent do you agree with the following statements?

	Strongly disagree			Moderate extent		Strongly agree	
I share knowledge in accordance with MAN Diesel's expectations							
There is lack of interaction between those who need knowledge and those who can provide knowledge							
Knowledge sharing is rewarded and acknowledged sufficiently							
It is difficult to identify colleagues with whom I ought to share knowledge							
Lack of communication skills hinders knowledge sharing							
There is lack of time to share knowledge							
The necessary IT systems to support knowledge sharing are in place							

The physical work environment hinders knowledge sharing							
There is lack of trust between employees							
I don’t know how to make new ideas and experiences available to other employees							
Employees do not share knowledge because they think knowledge is power							
There is lack of knowledge sharing facilitators							
There is lack of networks to support knowledge sharing							

APPENDIX 2: QUESTIONNAIRE CHAPTER 5

Pro-social research behavior

Please, indicate the frequency you engage in each of the following activities when you conduct a research project:

	1=Never			4=Regularly
1.Identify the potential results of your research that can benefit users				
2.Identify the potential users who can apply the results of your research				
3.Identify intermediaries in order to transfer the results of your results				

Motives to interact with social agents

Please, indicate the degree of importance you attach to each of the following items, as personal motivations to establish interactions with non-academic organizations (firms, public administration agencies, non-profit organizations)

	1=Not at all			4=Extremely important
1. To explore new lines of research				
2. To obtain information or materials necessary for the development of your current lines of research				
3. To have access to equipments and infrastructure necessary for your lines of research				
4. To keep abreast of about the areas of interest of these non-academic organizations				
5. To be part of a professional network or expand your professional network				
6. To test the feasibility and practical application of your research				
7. To have access to the experience of non-academic professionals				
8. To increase my personal income				

Motivations to perform research activities

When you think of your job as a researcher, what is the importance attached to the following items?

	1=Not at all			4=Extremely important
1. To face intellectual challenges				
2. To have greater independence in your research activities				
3. To contribute to the advance of knowledge in your scientific field				
4. Salary				
5. Job security				
6. Career advancement				

Favorable climate

Please rate the following services performed by your research institute

	1=Very negatively			4=Very positively
1.Attitudes of the personnel at your institute to address your queries and requests				
2.Accessibility to the human resources and services available at your institute				
3.Capacity to solve the problems in due time and form				
4.Technical capacity of the institute's personnel				