UNIVERSITAT POLITÈCNICA DE VALÈNCIA

SCIENCE-SOCIETY INTERACTIONS IN THE SOCIAL SCIENCES AND HUMANITIES:

EMPIRICAL STUDIES OF THE SPANISH COUNCIL FOR SCIENTIFIC RESEARCH

Ph.D. DISSERTATION

Julia Olmos Peñuela

Supervisors:

Dra. Elena Castro Martínez
Dr. Hermenegildo Gil Gómez

Valencia, July 2013

Universitat Politècnica de València
Departamento de Organización de Empresas

SCIENCE-SOCIETY INTERACTIONS IN THE SOCIAL SCIENCES AND HUMANITIES: EMPIRICAL STUDIES OF THE SPANISH COUNCIL FOR SCIENTIFIC RESEARCH

Ph.D. Dissertation

Julia Olmos Peñuela

Supervisors:

Dra. Elena Castro Martínez
INGENIO (CSIC-UPV)

Dr. Hermenegildo Gil Gómez
Departamento de Organización de Empresas
Universitat Politècnica de València

Valencia, July 2013

In expanding the field of knowledge
we but increase the horizon of ignorance.

- Henry Miller -

AGRADECIMIENTOS

Pensé que escribir este apartado sería lo más fácil de la tesis. Sin embargo, ahora que estoy aquí sentada, frente a esta hoja en blanco, me he dado cuenta de lo complicado que es reflejar por escrito estos sentimientos contradictorios que tengo al echar la vista atrás: alegría, pena, miedo, pero sobre todo gratitud.

La *tesis doctoral,* la verdad es que se dice pronto pero ha costado lo suyo. Muchos años invertidos, mucho esfuerzo, pero sobre todo, muchas personas a las que recodar con cariño por haberme acompañado, e incluso sufrido, durante este largo periodo. Muchas gracias a todas estas personas (y entidades) que han contribuido directa e indirectamente a que hoy este escribiendo estas palabras.

Debería comenzar desde el principio y remontarme a mis primeras becas de colaboración en el Departamento de Análisis Económico de la Universidad de Valencia, donde tuve la oportunidad de trabajar con Bernardí, a quién le estoy tremendamente agradecida por ayudarme a iniciarme en el mundo de la investigación.

Crucé la calle y 'aterricé' en la Universidad Politécnica, más concretamente en INGENIO (CSIC-UPV). Este instituto de investigación me acogió con los brazos abiertos, ofreciéndome toda la infraestructura necesaria así como el apoyo profesional y personal sin el cual no hubiera sido posible alcanzar mis objetivos. Por ello quiero agradecer tanto al Instituto como a todos sus integrantes la ayuda que me han prestado para poder hacer de esta tesis, una realidad.

Asimismo, embarcarme en esta experiencia no habría sido posible sin la financiación recibida por parte del Ministerio de Educación, mediante la concesión de una beca de Formación del Profesorado Universitario (FPU). Esta beca me ha permitido dedicarme por completo al desarrollo de mi tesis tanto en España como en el extranjero mediante la financiación de estancias cortas de investigación en otros centros de reconocido prestigio.

Gracias también al Departamento de Organización de empresas, por aceptarme como alumna de doctorado, ofreciéndome formación y la posibilidad de adentrarme un poco más en el mundo académico. Más concretamente, quisiera agradecerle a Herme el apoyo que me ha ofrecido, brindándome la posibilidad de colaborar en tareas docentes y de lidiar con estudiantes universitarios. Mi gratitud también hacia Cristina por haberme hecho más fáciles los aspectos burocráticos ligados a la tesis que, como bien sabemos, no son ni pocos ni sencillos.

La colaboración de los investigadores del Consejo Superior de Investigaciones Científicas (CSIC) ha sido también indispensable para el desarrollo de esta investigación. En especial, quisiera agradecer a los investigadores del área de humanidades y ciencias sociales su participación en las distintas entrevistas y encuestas que se han realizado. Asimismo, extender mi agradecimiento a la coordinación del área por impulsar y apoyar esta iniciativa.

Entre tantos agradecimientos, Elena se merece una mención especial puesto que ha sido mi referente durante estos años y la persona que me ha guiado desde que entré en INGENIO. Elena ha sido el alma del proyecto sobre las humanidades y las ciencias sociales. El ímpetu y la pasión que siempre ha mostrado por la investigación que hemos llevado a cabo han sido inspiradores. Muchas gracias por todo el tiempo que has dedicado para formarme y enseñarme. Por tu disponibilidad y paciencia, por esas reuniones 'mano a mano' (y con Ignacio) para intentar que mi curva de aprendizaje en forma de 'S' alcanzara pronto el punto de inflexión. Costó lo suyo, pero al final lo conseguimos y aquí está el resultado. Muchas gracias por la confianza que has depositado en mí todos estos años.

En el plano personal, también quiero destacar el apoyo que me ha brindado siempre Vicente. Ha sido mi 'apagafuegos' cada vez que he tenido una crisis 'existencial' ligada o no al doctorado. Gracias por las noches en vela ayudándome a desdramatizar las situaciones difíciles a las que me he enfrentado. Gracias por intentar hacerme ver que la vida es mucho más sencilla de lo que parece, o por lo menos, de cómo me la planteo. Gracias en definitiva, por estar incondicionalmente a mi lado.

Pensar en las estancias que he realizado en el extranjero es pensar en Isabel. Muchas gracias por haber querido siempre lo mejor para mí, por intentar hacerme pensar con la cabeza en vez de con el corazón y sobre todo por tu insistencia sobre la importancia de salir fuera. Gracias a esa insistencia me hice al ánimo, y ahí me encontré, haciendo una estancia al otro lado del océano, en Canadá. Mi destino fue *Université Laval* (KUUC),

donde sólo tengo buenas palabras para Réjean Landry y Nabil Amara, quienes me acogieron y se esforzaron en que la estancia fuera lo más provechosa posible para mi desarrollo profesional. Isabel seguía insistiendo y mi siguiente destino esta vez fue más cercano: *University of Twente* (CHEPS) en Holanda. Allí tuve la oportunidad de colaborar con Paul Benneworth. Su acento británico dio pie a alguna que otra situación graciosa, pero lo cierto es que conseguimos entendernos a la perfección y establecer una fructífera colaboración.

Esta tesis, en forma de compendio de artículos, refleja cuán importante es colaborar en la actividad científica. Prueba de ello es mi estrecha colaboración con Elena, Jordi, Pablo y Paul, reconocidos investigadores de los cuales he podido aprender mucho, pero sobre todo, fantásticas personas. Siempre dispuestos a ayudarme tanto en el plano profesional como personal, me han brindado todo su apoyo y han sabido sacar lo mejor de mí. Gracias por darme la oportunidad de 'empaparme' de vuestra experiencia.

El apoyo profesional y personal recibido en INGENIO merece mi más sincero reconocimiento. A Encarna, Marisa, Mayte y Patricia por su apoyo constante en cuestiones administrativas, informáticas y documentales. A Ignacio, por abrirme las puertas de INGENIO, por hacerme entender que los agobios no llevan a ninguna parte y que con trabajo, el tiempo lo pone todo en su debido sitio; en definitiva, por haber apostado por mí. A Antonio, por ayudarme a tomar decisiones prácticas cuando más me han hecho falta. A Dani, Emi, Jorge, Fran, Ele y Richard, compañeros de despacho que han contribuido a un ambiente inmejorable en la oficina, donde tantas horas hemos compartido. Y en este tramo final de la tesis, en especial a Ele por estar siempre dispuesta a echarme una mano con la tesis y a Richard por sus impagables correcciones de inglés y sus sabios consejos.

Gracias a los compañeros de INGENIO que han pasado a convertirse en buenos amigos pero sobre todo, apoyos fundamentales en todos los ámbitos de mi vida. A François, 'mi chico para todo', al que he 'masacrado' con miles de cuestiones laborales y no tan laborales. A Liney, que se armó de paciencia para introducirme en el 'mundillo' del SPSS y fue mi pilar y punto de apoyo dentro de INGENIO. A Sean, con él empecé el doctorado; gracias por estar siempre dispuesto a tenderme una mano, pero sobre todo, por no asustarse con mi espontaneidad y naturalidad. A Ester, siempre con una sonrisa

solucionando mis problemas informáticos; sin ti, esta tesis estaría escrita a mano. A África, Ana, Anabel, Óscar y Xavi por las aventuras compartidas en conferencias y *summer schools*. A Mabel por atender mis numerosas consultas de estadística. Y en general, a todos aquellos 'ingeniosos' y allegados que de una manera u otra habéis hecho que estos años sean dignos de recordar, y en especial a Alberto, Carolina, Davide, Davinia, Dioni, Jaider, Marian, Marta, Mónica y Roberto.

Por último, y no menos importante, quería agradecer a todas las personas de mi entorno que, aunque no hayan estado directamente relacionadas con el ámbito de la investigación, han sabido escucharme, entenderme, apoyarme, animarme e incluso se han atrevido a 'meterme caña' cuando ha sido necesario. A mis amigos Andrea, Carre, Coralia, Fran, Guaxu, Jess, Jota, Laura, Paz, Roberta y Tere por vuestros innumerables consejos y por haberme dado siempre fuerzas para seguir adelante. A mi familia y 'agregados', en especial a mi madre, a mi padre, a mis hermanos, a Ale, Bebi, Carol, Juancar, Lin, Loli, Miguel y Migui por haberme animado a no rendirme nunca y por transmitirme día a día lo orgullosos que estáis de mí. A todos ellos, les quiero agradecer que sean como son, y sólo les pido que lo sigan siendo. A vosotros va dedicada esta tesis.

Muchas gracias a todos.

ABSTRACT

Science-society interactions in the social sciences and humanities: empirical studies of the Spanish Council for Scientific Research

Interactions among agents in the innovation system are critical for the promotion of knowledge exchange, learning processes and the innovation process. The analysis of interactions between universities or public research organisations (science) and social agents (society) has received great attention in the scientific community because, among other reasons, the results of these interactions can have implications for the design of science and innovation policies and organisation management.

This thesis analyses the interactions between researchers in the social sciences and humanities (SSH) and social agents. The SSH community is a collective that has been little studied from this perspective and presents particular characteristics as compared to other scientific fields. The three studies included in the thesis address different aspects of the topic and are based on empirical data obtained through surveys and interviews conducted in the Spanish Council for Scientific Research (CSIC).

The first study explores whether the knowledge produced by the SSH is less useful than that produced in STEM fields (Science, Technology, Engineering and Mathematics), as science policy seems to presume when establishing measures based on indicators (patent licenses, R&D contracts with companies, creating spin off) that are difficult to apply to the SSH community. The empirical analysis shows that SSH research outputs are no less useful than those from STEM because, in both cases, there are social agents interested in them. However, the preferred type of collaborative mechanism varies across fields, as does the type of agent with whom researchers interact. Firms are the prevailing type of agent collaborating with STEM researchers whilst SSH researchers collaborate with a varied group of social agents (i.e. government, NGOs, etc.).

The second study explores the extent to which SSH research groups engage with a variety of social agents through non-formalised collaborations. To do this, two complementary analyses (quantitative and qualitative) are conducted. Results show that most of the collaborations are not institutionally formalised, which means that the

research organisation does not identify, record or value them. However, engagement in these informal collaborations, that do not necessarily have an economic counterpart, are attractive due to the relatively low cost (in time and economic terms) of many such activities, the absence of restrictive conditions (e.g. IPR, confidentiality) and other intangible benefits accruing to the researcher.

The third study examines the extent to which SSH research groups interact with social agents through different knowledge transfer (KT) activities –consultancy, contract research, joint research, training and personnel mobility– and identifies the determinants of each. Results show that the most frequent KT activities are consultancy and contract research, while personnel exchange is a marginal activity among those analysed. The study of the factors determining the engagement in these activities shows that consideration of the social uses of the research outputs from the beginning enhances research groups' engagement in all the knowledge transfer activities analysed.

Overall, the three studies support the conclusion that SSH research produces knowledge and outputs that are of interest to society. However, differences from other scientific fields are found in terms of the prevalent type of interaction mechanisms used and the variety of social agents with whom interactions are established. These findings may have practical utility for the design of policies aimed at encouraging and enhancing the range of interactions, for improving managerial practices and for the assessment of these interactions through indicators able to capture the type of interactions identified in this thesis.

RESUMEN

Interacciones ciencia-sociedad en ciencias sociales y humanidades: estudios empíricos en el Consejo Superior de Investigaciones Científicas

Las interacciones entre los agentes del sistema de innovación son una pieza clave para el fomento del intercambio de conocimiento, los procesos de aprendizaje y el proceso innovador. El análisis de las interacciones entre universidades y organismos públicos de investigación (ciencia) y los agentes del entorno social (sociedad) ha recibido una gran atención en la comunidad científica, entre otras razones, porque los resultados de estas interacciones pueden tener implicaciones en el diseño de las políticas de ciencia e innovación y en la gestión de la organización.

En esta tesis se analizan las interacciones entre los investigadores del área de ciencias sociales y humanidades (CCSSHH) y los agentes sociales, dado que es un colectivo que ha sido escasamente estudiado desde esta perspectiva y presenta características específicas respecto a otros ámbitos científicos. Los tres estudios que componen la tesis abordan aspectos diferentes del tema objeto de estudio y se basan en datos empíricos obtenidos mediante encuestas y entrevistas realizadas en el Consejo Superior de Investigaciones Científicas (CSIC).

El primer estudio pretende averiguar si la utilidad del conocimiento producido en las CCSSHH es menor que en las STEM (acrónimo inglés para ciencia, tecnología, ingeniería y matemáticas), tal como los enfoques de las políticas científicas al uso parecen presuponer al establecer medidas basadas en indicadores difíciles de aplicar a este colectivo (licencias de patentes, contratos de I+D con empresas, creación de *spin off*). El análisis empírico realizado muestra que los resultados de las investigaciones en CCSSHH no son menos útiles que los de las STEM porque, en ambos casos, hay agentes sociales interesados en ellos. Sin embargo, se aprecia que el tipo de mecanismo de colaboración varía entre áreas del conocimiento, al igual que el tipo de agente social con el cual los investigadores interactúan. Las empresas predominan entre los agentes sociales con los cuales colaboran los investigadores de las STEM mientras que los de

CCSSHH colaboran con un grupo más variado de agentes sociales (i.e. administraciones, organizaciones no gubernamentales, etc.).

El segundo estudio explora en qué medida los grupos de investigación del área de CCSSHH se relacionan con una variedad de agentes sociales mediante cauces no formalizados. Para ello, se realizan dos análisis complementarios (cuantitativo y cualitativo). Los resultados obtenidos ponen de manifiesto que la mayoría de las relaciones no se formalizan institucionalmente, lo cual significa que la institución no las identifica, registra o valora. Sin embargo, la participación en este tipo de colaboraciones informales, que no tienen necesariamente una contrapartida económica, resulta atractiva por su coste relativamente bajo (en términos económicos y de tiempo), por la ausencia de condiciones restrictivas (p. ej. derechos de propiedad, confidencialidad) y por la existencia de beneficios intangibles para el investigador.

El tercer estudio analiza en qué medida los grupos de investigación de CCSSHH interactúan con su entorno mediante diferentes actividades de transferencia de conocimiento (TC) –consultoría, investigación contratada, investigación conjunta, actividades de formación e intercambio de personal– e identifica los determinantes de cada una de ellas. Los resultados indican que las actividades de TC más frecuentes son la consultoría y la investigación contratada, mientras que el intercambio de personal representa una actividad marginal entre las analizadas. El estudio de los factores que determinan la participación en estas actividades de TC muestra que considerar el potencial uso social de los resultados desde el principio aumenta la participación de los grupos de investigación en todas las actividades de TC analizadas.

En conjunto, los tres estudios permiten concluir que la investigación en CCSSHH produce conocimiento y resultados que son de interés para la sociedad. Sin embargo, se diferencian de otras áreas científicas en los mecanismos de interacción predominantes y en la variedad de agentes sociales con los que interactúan. Estas conclusiones pueden tener utilidad práctica para el diseño de políticas destinadas a fomentar el amplio conjunto de interacciones identificadas, para la mejora de las prácticas de gestión y para tratar de evaluar las citadas interacciones mediante indicadores capaces de recoger el amplio espectro de mecanismos identificados en esta tesis.

RESUM

Interaccions ciència-societat en ciències socials i humanitats: estudis empírics en el Consell Superior d'Investigacions Científiques

Les interaccions entre els agents del sistema d'innovació són una peça clau per al foment de l'intercanvi de coneixement, els processos d'aprenentatge i el procés innovador. L'anàlisi de les interaccions entre universitats i organismes públics d'investigació (ciència) i els agents de l'entorn social (societat) ha rebut una gran atenció en la comunitat científica, entre altres raons, perquè els resultats d'aquestes interaccions poden tenir implicacions en el disseny de les polítiques de ciència i innovació i en la gestió de l'organització.

En aquesta tesi s'analitzen les interaccions entre els investigadors de l'àrea de ciències socials i humanitats (CSH) i els agents socials, perquè és un col·lectiu que ha sigut escassament estudiat des d'aquesta perspectiva i presenta característiques específiques respecte a altres àmbits científics. Els tres estudis que componen la tesi aborden aspectes diferents del tema objecte d'estudi i es basen en dades empíriques obtingudes per mitjà d'enquestes i entrevistes realitzades en el Consell Superior d'Investigacions Científiques (CSIC).

El primer estudi pretén esbrinar si la utilitat del coneixement produït en les CSH és menor que en les STEM (acrònim anglés per a ciència, tecnologia, enginyeria i matemàtiques), tal com els enfocaments de les polítiques científiques a l'ús pareixen pressuposar en establir mesures basades en indicadors difícils d'aplicar a aquest col·lectiu (llicències de patents, contractes d'R+D amb empreses, creació d'empreses derivades). L'anàlisi empírica realitzada mostra que els resultats de les investigacions en CSH no són menys útils que els de les STEM perquè, en ambdós casos, hi ha agents socials que hi tenen interés. No obstant això, s'aprecia que el tipus de mecanisme de col·laboració varia entre àrees del coneixement, igual que el tipus d'agent social amb el qual els investigadors interactuen. Les empreses predominen entre els agents socials amb els quals col·laboren els investigadors de les STEM mentre que els de CSH

col·laboren amb un grup més variat d'agents socials (administracions, organitzacions no governamentals, etc.).

El segon estudi explora en quina mesura els grups d'investigació de l'àrea de CSH es relacionen amb varietat d'agents socials mitjançant vies no formalitzades. Per a això, es realitzen dues anàlisis complementàries (quantitativa i qualitativa). Els resultats obtinguts posen de manifest que la majoria de les relacions no es formalitzen institucionalment, la qual cosa significa que la institució no les identifica, registra o valora. No obstant això, la participació en aquest tipus de col·laboracions informals, que no tenen necessàriament una contrapartida econòmica, resulta atractiva pel cost relativament reduït (en termes econòmics i de temps), per l'absència de condicions restrictives (p. e. drets de propietat i confidencialitat) i per l'existència de beneficis intangibles per a l'investigador.

El tercer estudi analitza en quina mesura els grups d'investigació de CSH interactuen amb l'entorn per mitjà de diferents activitats de transferència de coneixement (TC) – consultoria, investigació contractada, investigació conjunta, activitats de formació i intercanvi de personal– i identifica els determinants de cadascuna. Els resultats indiquen que les activitats de TC més freqüents són la consultoria i la investigació contractada, mentre que l'intercanvi de personal representa una activitat marginal entre les analitzades. L'estudi dels factors que determinen la participació en aquestes activitats de TC mostra que considerar el potencial ús social dels resultats des del principi augmenta la participació dels grups d'investigació en totes les activitats de TC analitzades.

En conjunt, els tres estudis permeten concloure que la investigació en CSH produeix coneixement i resultats que són d'interés per a la societat. No obstant això, es diferencien d'altres àrees científiques en els mecanismes d'interacció predominants i en la varietat d'agents socials amb què interactuen. Aquestes conclusions poden tenir utilitat pràctica per al disseny de polítiques destinades a fomentar l'ampli conjunt d'interaccions identificades, per a la millora de les pràctiques de gestió i per a tractar d'avaluar les esmentades interaccions per mitjà d'indicadors capaços de recollir l'ampli espectre de mecanismes identificats en aquesta tesi.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

In the contemporary society, it is widely accepted that knowledge is a key factor in socio-economic development. However, it was not until the 1990s that the term knowledge-based economy (OECD, 1996) was coined to recognise the centrality of knowledge as the driver of productivity and economic growth. Three main aspects show a rupture with previous periods (David and Foray, 2002). The first aspect is the acceleration of the production, accumulation and depreciation of knowledge, which is in part the result of rapid scientific and technological progress. The second distinguishing aspect is the increasing share of intangible compared to tangible capital (Abramovitz and David, 1996). Differences in productivity are less linked to the natural resources of a country and increasingly dependent on the new knowledge generated and incorporated in equipment (factors of production) and assimilated by people (human capital). In this context, scientific and technologic knowledge are becoming the main input in the innovation process. The third distinctive aspect is the technological revolution that has taken place in the digital age, which involves technologies for knowledge and information production and dissemination.

These unprecedented changes have given rise to the concept of knowledge-based society, characterized by its ability to generate, appropriate and use knowledge to meet its needs and build its own future (Vilalta and Pallejà, 2003). Indeed, the increasing impact of knowledge is manifested in all spheres of society (Cloutier, 2003), going beyond economic transformation and extending also to social and cultural changes (Olivé, 2006).

In this context in which society and its economy are directly influenced by the production, distribution and use of knowledge, the science system plays a relevant role as a producer of new knowledge.[1] The Organisation for Economic Co-operation and Development (OECD) explicitly identifies public research organisations[2] as the core of the science system, having to contribute three key functions namely: (i) knowledge production –developing and providing new knowledge through research; (ii) knowledge transmission –educating and developing human resources through teaching; and (iii) knowledge transfer –disseminating and transferring knowledge to socio-economic agents[3] and providing inputs to solve problems (OECD, 1996).

The science system arises as a subsystem of society rather than an autarkic system (Hessels et al., 2009). Indeed, science has become more central as the economy and society become more reliant on knowledge (Martin, 2003). Studies of knowledge production have addressed the changing relationship between science and society, which affects the characteristics of knowledge generation –e.g. post-academic science (Ziman, 2000) or Mode 2 of knowledge production (Gibbons et al., 1994).

Otherwise, the growing interest in science-society interactions[4] has been partly boosted by the increasing recognition of the relevance of agents' interactions for the innovation process. The linear model of innovation started to lose favour in comparison to the so-called interactive model. Within this new perspective emerged the system of innovation approach which quickly became a 'hot' topic in the literature and was adopted by policy-makers for the design of science and innovation policies (Sharif, 2006; Uriona-Maldonado et al., 2012). According to the system of innovation approach, interactions between the different agents of the innovation system are critical for the promotion of knowledge exchange, learning and innovation processes. Within this context, relationships between researchers and social agents have received great attention in the academic community,

---

[1] The science system has a central and sizeable role as a knowledge producer although it is acknowledged that knowledge can be produced in a broad diversity of sites.

[2] Public research organisation is defined as "any organisation that as part of its mission on a regular basis performs research (and experimental development) and regularly receives public funding for this. This typically includes universities and other research oriented higher education institutions, non-profit research organisations, and research hospitals, both in the public and private sectors." (European Commission, 2009: 1).

[3] Hereafter, the term social agents is used as shorthand for socio-economic agents.

[4] In the dissertation, interaction, relationship and collaboration are used interchangeably as described in section 2.3.

leading to various bodies of literature focusing on these science-society interactions.

In the policy arena, the study of the returns of publicly funded research has created an important debate. One strand of the literature has addressed and conceived science-society interactions as a ‘social contract for science’ (Guston, 2000), and tackled the shifts from the former contract –generally linked to the Bush report (1945)– toward a new social contract demanding a greater orientation of scientific activities to the context of application and a greater social responsibility among researchers whose investigations are supported by public funds (Guston and Keniston, 1994; Martin and Etzkowitz, 2000; Hessels et al., 2009). Another stream of studies emerged during the eighties focusing exclusively on the utilization of social science research results within the public policy sphere (Weiss, 1979; Knott and Wildavsky, 1980; Beyer and Trice, 1982). These studies have been picked up in the last decade by several authors (Molas-Gallart et al., 2000; Landry et al., 2003; Lavis et al., 2003; Amara et al., 2004).

Science-society interactions have also been widely addressed through studies on university-industry relationships (e.g. Bonaccorsi and Piccaluga, 1994; Lee, 2000; D’Este and Patel, 2007; Manjarrés-Henríquez et al., 2008). The emergence, three decades ago, of this stream of the literature responds, in part, to policy-makers’ increasing interest in research commercialization and in the creation of stronger ties between scientific research and societal needs. From the late 1970s, changes in legislation[5] in several countries to support mechanisms fostering university-firm interactions have reflected policy concern about linking scientific research to industrial innovation.

The dissertation is framed within this stream of studies addressing university-industry interactions. Recent studies on this topic have highlighted the heterogeneous nature of these relationships and have also criticized the biased policy focus towards too few interaction mechanisms, too few disciplines and too few types of agents (Gulbrandsen et al., 2011). Indeed, when analysing empirical

[5] For instance, the Bayh-Dole Act enacted in 1980 in the U.S has been the subject of an extended debate in the literature (e.g. Mowery et al., 2001, 2004; Sampat et al., 2003; Shane, 2004; see also the special issue in Research Policy (2011) nº40, issue 8: 1045-1144).

studies on university-industry interactions, one observes the following trends. Studies are primarily focused on natural sciences and engineering fields[6] (e.g. D'Este and Patel, 2007; Ponomariov, 2008; Manjarrés-Henríquez et al., 2009; Landry et al., 2010; Ding and Choi, 2011; Haeussler and Colyvas, 2011; Amara et al., 2013). In the same vein, studies address interactions with industry to the exclusion of other partners (e.g. Cohen et al., 2002; Schartinger et al., 2002; Bekkers and Bodas-Freitas, 2008; Ramos-Vielba et al., 2010; D'Este and Perkmann, 2011). Furthermore, commercial activities such as academic patenting and spin off creation have been traditionally at the centre of the policy debate and of academic studies. However, this trend has been overcome by several authors that have conducted theoretical and empirical works aimed at identifying, exploring and addressing a diversity of interaction mechanisms and activities[7] (e.g. Bonaccorsi and Piccaluga, 1994; Meyer-Krahmer and Schmoch, 1998; Schartinger et al., 2001; Cohen et al., 2002; Molas-Gallart et al., 2002; D'Este and Patel, 2007; Arza, 2010; Ramos-Vielba et al., 2010).

Bearing this in mind, the dissertation focuses on these unexplored (or little analysed) aspects of the relationships between researchers and social agents. Specifically, it aims to shed light on the interactions between Social Sciences and Humanities (SSH) researchers and social agents. First, it focuses on the SSH field as opposed to the traditional studies that are restricted to natural sciences and engineering. Second, it opens the interaction to government agencies and non-profit organisations, as opposed to previous studies that primarily focus on science interactions with industry (i.e. firms). And third, it considers a wide spectrum of interaction mechanisms following studies that analyse more collaborative interaction activities as opposed to the burgeoning literature on commercial activities.

Under the inclusive and broader approach adopted in the dissertation, it makes sense to shift from university-industry interactions to a broader label that better

---

[6] Following OECD nomenclature, natural sciences and engineering include: natural sciences, engineering and technology, medical and health sciences and agricultural sciences. Available at http://ec.europa.eu/eurostat/ramon/nomenclatures/index.cfm?TargetUrl=LST_NOM_DTL_LINEAR&StrNom=CL_FOS07&StrLanguageCode=EN.

[7] In the dissertation the terms mechanisms and activities can be found as used interchangeably.

fits the interest of the research: science-society interactions. In doing so, the dissertation aims to contribute to opening up research issues regarding science-society interactions in the SSH.

1.1. Structure of the dissertation

The dissertation includes three independent studies (scientific articles) containing their own introduction, literature review, methodology, results, conclusions and references. These studies have been set in a broader context in the dissertation through the first four chapters (introduction, conceptual background, research objectives and context of the studies) and the conclusion chapter. Furthermore, since scientific research is increasingly a collaborative enterprise (Laudel, 2001), each of these studies is developed with two colleagues and has been submitted into the peer review process.[8]

The remainder of the dissertation is structured as follows. Chapter 2 provides an overview of how research into knowledge production and the innovation process have been approached in the last decades. Moreover, it delimits the study of science-society in the dissertation and distinguishes controversial concepts through the provision of definitions and a conceptual framework. Chapter 3 establishes the research objectives and presents an overview of the studies included in the dissertation. Chapter 4 focuses on the context of the studies by describing the Spanish Council for Scientific Research (CSIC) and, in particular, the SSH area. Chapters 5, 6, and 7 correspond to the Studies 1, 2, and 3, respectively. Finally, Chapter 8 summarises the finding of the three studies, describes the main limitations of the research conducted and offers suggestions for future lines of research.

[8] According to University regulations, each of the three studies of the dissertation retains the format and styles particular to the respective journals to which they have been submitted (including the format of the bibliography). However, chapter numbers have been added to the subsections, tables, and figures for clarity.

CHAPTER 2

CONCEPTUAL BACKGROUND

This chapter provides a wider contextualization for the studies presented in the dissertation by complementing the specific literature review of each of the three studies. The first section presents an overview of the main approaches regarding knowledge production highlighted in the literature in the last decades, along with its implications for science-society interactions. The second section provides a better understanding of the innovation process through the description of how the relationships of science and technology to the economy have evolved from a linear to an interactive process. Based on the interactive view, the system of innovation approach is presented as a framework describing iterative flows of knowledge among a network of agents learning from their interactions and contributing to the innovation process. The third section delimits the analysis of science-society interactions within the dissertation and provides definitions and the dimensions of knowledge exchange.

2.1. Knowledge production

Knowledge produced by the science system and exchanged with its environment is strongly influenced by how the science system is configured, by the culture prevailing in the scientific organisations, by the objectives pursued by scientists[9] to conduct their research, by their motivations, by how 'good' science is defined, by the (social) duties expected to be accomplished by scientist, by how the interactions between scientists and social agents are established, and so on.

Bearing this in mind, an overview of the main approaches addressing the way in which knowledge is produced and the changes undergone in the production of

[9] Scientist and researcher are used interchangeably in the text.

knowledge provides a clear understanding of the current place of the science system within the society. More specifically, the aim of this section is to identify the features surrounding the scientific–knowledge production process as well as the social role expected to be played by the science system. Note that it is not intended to set up an exhaustive review but an overall idea of the main approaches underlying the transformations of the knowledge production process and therefore the underlying context of the studies included in the dissertation. To do so, this section starts from the classical vision of academic science –widely identified with the Mertonian norms (1942)–, and moves towards more recent approaches, namely post-academic science (Ziman, 2000) and the Mode 2 of knowledge production (Gibbons et al., 1994).

2.1.1. Academic science and the Mertonian norms

From the perspective of the sociology of science emerged the work conducted by Robert K. Merton, from the forties to the late seventies of the past century, which has long been an influential approach about the standards to which scientists aspire. The ethos of science, presented in Merton's essay entitled 'The Normative Structure of Science' (Merton, 1942), laid down the complex of norms and values which are held to be binding by the scientist. More specifically, it consists of four sets of institutional imperatives to be followed by the scientist to achieve the institutional goal of science, that is, the extension of certified knowledge (Merton 1973: 270). These institutional imperatives, characterizing pure academic science, are known as CUDOS, which is the acronym for *Communism*, *Universalism*, *Disinterestedness* and *Organized Skepticism*[10] (Merton, 1942). These norms were not codified or defined explicitly, but they could be inferred from the moral consensus of scientists, from their writings or from the observation of their attitude towards contravention of the ethos (Fernández-Esquinas and Torres-Albero, 2009).

Merton (1973: 267-278) defined each of these norms as follows. *Communism* implies that scientific findings are assigned to the community since they are the

[10] Originality and humility were included in the ethos of science later (Merton, 1949), originality corresponding then to the 'O' of the acronym CUDOS.

product of social collaboration. This norm reinforces the diffusion of scientific results in opposition to its secrecy. Since the fruits of academic science should be regarded as public knowledge, the intellectual property rights of the scientists are limited to that of esteem and recognition, which would be proportionally related to their contribution to the growth of the common fund of knowledge. *Universalism* refers to the canon that a truth-claim is to be subject to pre-established impersonal criteria based on previously confirmed knowledge and observation. In this sense, objectivity prevents particularistic criteria, and the acceptance or rejection of these claims is not based on the personal or social attributes of their protagonists but on the objective arguments and evidence presented. *Disinterestedness* means that the scientists are not motivated by benefits other than those provided by the personal satisfaction of the work conducted and the reputation of acting for the community interest. Finally, *Organized Skepticism* refers to the research, conducted by scientists, which extends to new areas of knowledge and discoveries that could be considered as an intrusion of science in other spheres (religion, politics, etc.). Under this norm, any phenomenon could be studied and questioned regardless of whether it is accepted by non-scientific institutions; thus, promoting a debate and critical evaluation based on scientific criteria and not on the existing authority or tradition.

Within this normative understanding of science, the main goal of scientists is to increase existing knowledge with production and validation based on the originality and scientific excellence of their research. Another feature is that science is regulated by academic and disciplinary interests rather than by considerations of application or socio-economic exploitation of knowledge (i.e. scientists are not primarily moved or influenced by utilitarian considerations). Following Merton's words, "the scientist came to regard himself as independent of society and to consider science as a self validating enterprise which was in society but not of it" (Merton, 1973: 268). Therefore, science organisation and knowledge production are developed regardless of the influence of its environment. Values and norms proposed by Merton permitted the establishment of the ideal conditions for scientists to develop their work, allowing them to maintain their autonomy and their scientific independence.

Critics[11] of the ethos of science did not take long (Sklair, 1972; Mirtroff, 1974; Mulkay, 1976). Along with questioning the internal organisation of science and the validity of the norms and values proposed by Merton, a new line of studies also addressed the way in which science institutions were related to other socio-economic actors. This lead to a change in the academic discourse: a shift towards a higher emphasis on analysing relationships and interactions between scientists and other social agents (i.e. firms, government agencies and other stakeholders in the socio-economic environment), as reflected through the emergence of new approaches such as post-academic science and Mode 2 of knowledge production.

2.1.2. Post-academic science

Post-academic science was coined by John Ziman to characterize a period of "radical, irreversible, worldwide transformation in the way that science is organized, managed and performed" (Ziman, 2000: 67). The author explicitly clarified that post-academic science[12] (or industrial science) was not a new mode of knowledge production but a whole new way of life, where science was redefined at every level and also in relation to other segments of society.

This shift from the Mertonian classic academic science to post-academic science was the result of a set of transformations that were bringing academic science closer to the practices of industrial science. Some of these changes were related to the increasing competition for public funds for science, since basic research did not receive unconditional support from government (Ziman, 1994). Governments were more selective, allocating their financial resources to get better value of their money. As a result, researchers were asked to be more accountable, highly concerned with the impact of their research outside the academic sphere and more responsive to societal needs.

Within this new context, researchers' independence and autonomy decreased, since their research agenda configuration was highly influenced by the social relevance of the research topics and the need to be useful for society. Another

[11] For a broad review see Fernández-Esquinas and Torres-Albero (2009).

[12] Post-academic science and industrial science are used interchangeably in the dissertation.

change that occurred in post-academic science dealt with the promotion of more collective research, where different kinds of institutions –academia, industry, government– were likely to collaborate (Kellogg, 2006). Bearing this in mind, it can be argued that, as opposed to what happened in classical academic science, in the industrial science model scientific activity becomes a more social project which might not be entirely developed within academia but which can include other external organisations.

This evolution from academic science to post-academic science leads to the imposition of a number of requirements in a science system that is foreign to the ethos (Ziman, 1996: 70). Post-academic science is strongly conditioned by industrial and commercial interests rather than by the purely scientific interest running academic science. Thus, Mertonian norms are no longer adequate to fully explain an industrial science characterized by producing *proprietary* knowledge that is not necessarily made public; focusing on *local* technical problems rather than on general understanding; with industrial researchers acting under managerial *authority* rather than as individuals; where research is *commissioned* to achieve practical goals rather than undertaken in the pursuit of knowledge; and where researchers are employed as *expert* problem-solvers rather than for their personal creativity (Ziman, 2000: 78-79).

Analogously to the Mertonian norms (CUDOS), the above characteristics describing post-academic science are known under the acronym of PLACE: *Proprietary*, *Local*, *Authoritarian*, *Commissioned* and *Expert*. The acronym PLACE has often been interpreted as the antithesis of CUDOS (Table 2.1), even if some authors consider this a forced contrast since PLACE is not normative (as CUDOS) but rather descriptive (Jiménez-Buedo and Ramos-Vielba, 2009).

Table 2.1: Norms of academic science vs norms of industrial science

Academic Science: CUDOS (ethos of science)	**Industrial Science: PLACE (post-academic science)**
Communalist	**P**roprietary
Universal	**L**ocal
Disinterested	**A**uthoritarian
Original	**C**ommissioned
Skeptical	**E**xpert

Source: Kellogg (2006).

2.1.3. Mode 2 of knowledge production

The transformations occurring in the science system have also been addressed by Gibbons et al. (1994) in the book 'The New Production of Knowledge'. Here they introduced the concept of Mode 2 knowledge production. The notion of Mode 2 is described in terms of a set of attributes which, taken together, are coherent enough to propose the emergence of a new way of producing knowledge (see Table 2.2).

Table 2.2: Attributes of knowledge production in Mode 1 and Mode 2

Mode 1	**Mode 2**
Academic context	Context of application
Disciplinary	Transdisciplinarity
Homogeneity	Hetereogeneity & organisational diversity
Autonomy	Social accountability & reflexivity
Traditional quality control (peers)	Quality control

Source: Gibbons et al. (1994).

Mode 2 arises alongside the existing Mode 1 and is arguably becoming more and more dominant in the modern science. Mode 2 is presented by its authors in terms of its differences from the traditional Mode 1, which is the logic followed to describe it here. According to Gibbons and colleagues, knowledge in Mode 1 is produced in a context governed by disciplinary and academic interests, where the practical goal of knowledge created is seldom considered. In contrast, Mode 2 of knowledge is generated in a context of application, under a continuous negotiation covering the interest of several actors participating in this process. Whereas problem solving in Mode 1 is carried out following the interest of the scientific community and according to the cognitive and social norms of specific disciplines; in Mode 2 knowledge is intended to be transdisciplinary (cannot be located on the prevailing disciplinary map), to be useful beyond the academic sphere and to be socially distributed (diffused throughout society).

Knowledge in Mode 1 is generated in homogenous organisations (i.e. universities and colleges), while in Mode 2, knowledge can be generated in a broad diversity of sites, other than universities (e.g. government agencies, consultancies, industrial laboratories, etc.) and can be linked through networks of research and communication. This organisational diversity results in a production of knowledge that becomes a heterogeneous practice in terms of the different skills and experiences brought to bear on a particular problem by people coming from these different organisations. Reflexivity is another important characteristic of Mode 2 since it promotes a dialogic process between the actors involved in the knowledge production process with the inclusion of all their standpoints. Unlike Mode 1 in which researchers enjoy a wide autonomy to choose their research topic, in Mode 2 researchers are more connected to society, and their research priorities are highly influenced by the social consequences of their potential research (social accountability).

Finally, Mode 1 knowledge production is controlled within the academic sphere, where good science is established by disciplinary peers according to the problems that are considered to be central within the scientific community. Conversely, knowledge produced in Mode 2 considers additional intellectual interest (e.g. social, economic, politics, etc.), which implies a quality control process that is not restricted to the judgment of disciplinary peers, but extends to its social acceptance.

One of the main critics to the Mode 2 refers to its historical perspective. Mode 2 is described through the new set of attributes previously described. Nevertheless, many authors claim that some of these attributes have always existed in the modern science[13] (Godin, 1998; Pestre, 2003; Hessels and van Lente, 2008). Indeed, some authors define Mode 1 as a construct developed to justify academic autonomy (when science institution was fragile) and reject it as the original type of research (Rip, 2002) in favour of the Mode 2, which represents the material base of science (Etkowitz and Leydesdorff, 2000: 166). Therefore, although there is a widespread consensus that Mode 2 is gaining relevance compared to Mode 1, it would be more appropriate to refer it as a shift in the balance between the already existing forms of Mode 1 and Mode 2 (Martin and Etzkowitz, 2000; Martin, 2003) rather than as the emergence of a new mode of knowledge production.

According to the abovementioned attributes, Mode 1 could be assimilated to the traditional academic science described by Merton whereas Mode 2 characteristics approach those of post-academic science. Indeed, there are no real contradictions between the content of Mode 2 and post-academic science approaches but on their scope (Hessels and van Lente, 2008). While post-academic science is presented as replacing academic science, Mode 2 is proposed as a new form of knowledge that comes next to the traditional Mode 1:

> “The new mode –Mode 2– is emerging alongside the traditional disciplinary structure of science and technology –Mode 1–. […] Mode 2 is not supplanting but supplementing Mode 1” (Gibbons et al., 1994: 14).

To summarize, this section has presented a number of approaches addressing the knowledge generation, as well as the importance of science-society interactions within the knowledge production process. Although it has been argued that research focused in practical and social problems has always existed, it has not been until these last decades that this way of conceiving and characterizing the science system in a context of application has been widely recognized. The concepts of post-academic science and the Mode 2 of knowledge production have marked a rupture with the traditional ethos of science in term of how knowledge is produced, how science is organised and regarding the external social function expected of the scientific community.

[13] Indeed, Godin argues that “the social sciences, as well as the humanities, have always been of Mode 2, much more than has been the case for the natural and physical sciences” (Godin, 1998: 472).

2.2. Innovation: concepts and processes

2.2.1. The innovation concept

In the last decades there has been a broad consensus on the relevance of innovation as a central aspect for the economic growth and the competitiveness of the countries. Much effort has been devoted in the policy sphere to define the concept of innovation, which has been traditionally linked to technological innovations and located in firms. As a proof of the policy concern about how to define the innovation concept and about finding appropriate methodologies to measure it, the OECD implemented in 1992 a document containing the guidelines for data collection on industrial innovation: 'The Measurement of Scientific and Technological Activities, Proposed Guidelines for Collecting and Interpreting Technological Innovation Data', commonly known as the Oslo Manual (OECD, 1992).

This first version of the Manual concentrated upon Technological Product and Process (TPP) innovation in goods, at the firm level and only in the business enterprise sector (mainly in manufacturing). This reflects a focus on manufacturing firms' technological development and their diffusion to other firms, leaving other types of non-technological innovations and other kind of organisations aside. What is alluded to here is that social sciences and humanities had little to say within this first narrow definition of innovation strongly linked to technological aspects.

However, a shift from the narrow definition of technological innovation to a broader conception of innovation was reflected in the new editions of the Oslo Manual, more specifically in the third and last version of 2005. Thus, the innovation concept come to be defined as the "implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations" (OECD, 2005: 46). As can be noted from the definition, in the last edition of the Oslo Manual, the technological term drops from the concept of innovation and additional types of innovation are included:

organisational innovation[14] and marketing innovation. Moreover, the last version of the Manual recognises the relevance of innovation in industries with low intensity in R&D such as low-technology manufacturing, but also in the service industries. What can be drawn from this broader approach is that non–technological fields have space to contribute to the innovation process through their knowledge on organisational and marketing aspects (e.g. helping to improve the workplace satisfaction, addressing users' needs) but also by contributing to the service sector, where the social sciences and humanities field has a relevant role to play.

Furthermore, another aspect to be highlighted from the last version of the Oslo Manual is that it emphasizes the role of firms' linkages with other firms but also with other institutions (e.g. universities and public research organisations) for the innovation process, which shows that a higher relevance is given to knowledge flows among different organisations for the development and diffusion of innovations, and then, the relevance of the interactions and the knowledge exchange between the parties.

This evolution from the technological innovation concept to a broader concept of innovation has led to new definitions of innovation. Benoît Godin (2004) proposed a more inclusive definition of innovation, considering both different forms of innovation and different types of organisations that can innovate. More precisely, the author defined innovation as new products, services or new practices that, thanks to invention and adoption modify ways of doing or contribute to the appearance of new ways of doing (Godin, 2004: 10).

In addition to technological innovation, new concepts of other types of innovation have started to emerge. An example is the concept of soft innovation which can be defined as the changes in either goods or services whose impact is not primarily on the functional appeal but upon sensory perception and aesthetic (Stoneman, 2007). Soft innovations are strongly related to innovations that are largely aesthetic in nature (e.g. music, books, film, fashion) and therefore, related to the cultural industry encompassing cultural, media and arts (Stoneman, 2008). Indeed,

[14] Organisational innovation was already discussed in the second edition of the Oslo Manual edited in 1997.

there is wide literature recently developed around innovation in the cultural and creative industries.[15]

Other types of innovations that are currently being addressed in different strands of literature are grassroots innovation (Gupta et al., 2003; Seyfang and Smith, 2007), green innovation and eco-innovation (Rennings, 2000), inclusive innovation (Johnson and Andersen, 2012) and social innovation (Andrew and Klein, 2010; Loogma et al., 2012; Mulgan, 2012). Among these types of innovation, the most extended in the literature is the concept of social innovation, that can be defined as "innovative activities and services that are motivated by the goal of meeting a social need and that are predominantly diffused through organisations whose primary purposes are social" (Mulgan, 2006: 8).

It is not the aim of this section to provide a deep review of all variety of innovations concepts that have emerged over time, but to provide an overview of how the innovation concept, that started from technological considerations and with the firm at the center of the innovation process, has evolved and expanded to other innovation concepts that put society at the centre of the process and allow for the inclusion and contribution of non-technological disciplines to the innovation process.

2.2.2. The innovation process

The study of the relation of science and technology to the economy, especially in the innovation process, has been a matter of discussion in the last decades, both in the policy and academic spheres.

The work of Joseph Schumpeter is often referred back to by economists interested in modelling the process of innovation (Godin, 2006). Schumpeter (1934) introduced a broad definition of innovation as the result of new combinations of existing knowledge and defined five types of innovation, namely: (i) introduction of a new product; (ii) introduction of a new process; (iii) opening a new market;

[15] For more details about innovation in the cultural and creative industry see Hirsch, 2000; Pratt, 2005; Miles and Green, 2008; Jaaniste, 2009; Potts, 2009; Bakshi and Throsby, 2010; Hotho and Champion, 2011.

(iv) use of a new source of supply or raw materials; and (v) creation of a new type of industrial organisation. Moreover, the author highlighted the potential impact of innovation in the economy in his book 'Business Cycles' (Schumpeter, 1939). Furthermore, he conceived it as a process of 'creative destruction' whereby a new innovation displaces established methods, products, and firms through its superior performance and reconfigures the industry structure (Schumpeter, 1942).

Additionally, Schumpeter established the distinction between *invention* (i.e. act of intellectual creativity, in general as a result of scientific activities but without importance to economic analysis), *innovation* (i.e. the commercial exploitation of the knowledge, that is related to its economic use) and *diffusion* (i.e. process through which innovation is adopted by other actors than those that have developed it).

Although Schumpeter did not establish a dependent relationship between invention and innovation,[16] his interpreters used the sequence invention-innovation-diffusion[17] to describe the innovation process. Indeed, Schumpeter did not develop a formal model of innovation; neither did he devote much attention to the role of science (Maclaurin, 1953). However, his ideas were at the base of the linear model of innovation that conceived the innovation process as a linear sequence of activities starting with basic research, followed by applied research and development and ending with production and diffusion[18] (Godin, 2006).

Thus, from the 1950s, the innovation process has been defined in terms of the steps (linear sequence) needed to bring technology to commercial production. The science push model and the demand pull model have been among the more recognized theoretical frameworks emphasizing the linearity of the innovation process. The so-called science push model (or technological push) postulates that innovation responds to a linear sequence of activities starting with basic research

---

[16] "Innovation is possible without anything we should identify as invention and invention does not necessarily induce innovation" (Schumpeter, 1939: 84).

[17] Also understood as basic research-applied research-development (Godin, 2006).

[18] A broad variety of sequences to describe the linear model of innovation have been proposed by several authors (for more details see Godin, 2006).

that leads on to applied research, technological development and ends with production and marketing (Kline and Rosenberg, 1986: 285-286).

This model was taken for granted during several decades and used to define the debates in the policy arena (Mowery, 1983), but also among the scientific community. Many authors have tracked the origins of this general accepted linear model of innovation on the report elaborated by Vannevar Bush (1945) entitled 'Science: The Endless Frontier'[19] which widely recognized the scientific progress as essential for the national welfare (in terms of better health, more jobs, higher standard of living, and cultural progress). According to this report, government should then promote the flow of new scientific knowledge through the support of basic research. Bush also stressed that scientific work should be conducted in an atmosphere of personal intellectual freedom, where scientists feel free from the adverse pressure of commercial necessity (Bush, 1945), from which the idea of pure science or academic science can be inferred.

For many authors, Bush's approach laid the foundations of the science push view. However, as noted by Godin (2006), Bush only dealt with part of the model of innovation (basic research → applied research) but he did not use it as a sequential model for explaining links between science and society. Indeed, as Godin argues, we owe the linear model of innovation to three scientific communities (natural scientist, industrialist and economist) which entered the field of scientific studies and added successively the concepts of basic research, applied research, experimental development, production and diffusion.[20]

One of the most important critics of the science push theory is the absence of economic factors in the innovation process. Indeed, as Dosi (1982: 151) noted, paraphrasing the economist Joan Robinson, one feels uneasy in accepting a view of technical change "as given by God, scientist and engineers". The economist Jacob Schmookler challenged the established wisdom that pointed to supply factors as drivers of technological innovation, conducting an extensive analysis on patent

[19] Progress in social sciences and the humanities is not considered in Bush's report since the program for science warrants immediate attention.

[20] See Godin (2006) for further information on the discussion of the historical development of the linear model.

data to determine whether inventions were knowledge induced or demand induced (Schmookler, 1966: 12). According to Schmookler, the mere fact that inventions are feasible is not enough and therefore, supply determinants only provide a partial explanation of the process.

Bearing in mind the critics to the science push model, an alternative approach to explain the innovation process emerged: the demand pull model. According to this model, knowledge is mainly generated in response to demand factors, on the basis of market forces and the recognition of needs. The basic argument of demand pull theories maintains that the direction in which the market is pulling the inventive activity of producers can be known a priori and the signaling process mainly operates through the relative movements of prices and quantities (Dosi, 1982: 149).

Overall, the main difference between the science push model and the demand pull model is the starting point of the innovation process. Nevertheless, both models describe a process in which new knowledge is transformed into new products via a (linear) sequence of phases, which is why they are known in the literature as linear models (Smith, 1995).

The linear models consolidated and were widely used for decades to explain the technological innovation process and the role of science within this process. On the one hand, from a policy perspective, the concepts presented in the linear model and their easy measurability appeared as an opportunity for the development of official statistics and decisions on resources allocation. On the other hand, the idea of basic research as the main source of innovation was strengthened by the scientific community since it justified the allocation of public funding to science.

However, the linear model also had its opponents. For instance, the role of science in the innovation process was questioned in the Hindsight project funded by the U.S. Department of Defense (1969) where results indicated that less than 10% of military innovations were derived from basic innovation.[21]

[21] However, opposite results were found in the project TRACES funded by the National Science Foundation (IIT Research Institute, 1968) where basic research was responsible of 70% of the innovations. Results of these studies have then to be interpreted carefully since they can be highly influenced by different interests and approaches.

This report marked the beginning of a set of critics to the linear model. The work conducted by Kline and Rosenberg (1986) entitled 'An overview of Innovation' gathered the main criticisms of a linear model which failed to capture and explain the relationships between science and the economy. The linear model, in terms of its nature, is depicted as a simple, smooth and well-behaved process. However, for these authors, innovation is seen as a complex and interactive process, which they represented through the development of the chain-linked model of innovation (Kline and Rosenberg, 1986: 289-294), also known as the interactive model. This model stresses that innovation is a path-dependent and interactive process with many actors linked at different levels. Under this view, knowledge is characterized by a complexity of feedback loops and interactions occurring between different actors and activities.

This shift from the conventional linear model to the interactive model of innovation represented a turning point in the way of explaining the innovation process and the role to be played by different scientific and social agents[22]. Under this new interactive approach, relationships between different agents arise as a key factor in the innovation process, which can be considered as a social and collective process conducted by firms in collaborations with other industrial, scientific or governmental agents. In this sense, universities and public research organisations are not anymore conceived as isolated agents that are excluded from the innovation process once they have contributed to the innovation process through the basic research, but gain presence in all this dynamic process and contribute through the generation and transfer of knowledge to socio-economic needs.

For both the knowledge production and the innovation processes, it has been seen a shift towards approaches that emphasizes the links between agents. Based on the interactive model, analytical frameworks have emerged emphasizing the complexity and the relevance of interactions between the agents of the innovation process. Indeed, as noted by Edquist (1997: 5) "interactivity paves the way for a systemic approach". The next section focuses on the most important conceptual

[22] Despite the shortcomings recognized for the linear model, it still influences policy in many regions (Fernández-de-Lucio et al., 2010).

framework used in the theorizing of innovation (Edquist, 2005) based on interactivity: the system of innovation approach. As one will observe from the following section, the system of innovation approach shares some characteristics with the Mode 2 of knowledge production (Hessels and van Lente, 2008) such as the rejection of the linear model of innovation and the heterogeneity of production of knowledge.

2.2.3. Systems of innovation

The System of Innovation (SI) is a concept that emerged in the mid-eighties for the study of innovation in the economy. There are many variants of this approach that have been applied at different levels of aggregations: *national* systems of innovation (Freeman, 1987; Lundvall, 1992; Nelson and Rosenberg, 1993) *regional* systems of innovation (Cooke 1992, 1996) and *sectoral* systems of innovation[23] (Carlsson and Stankiewicz, 1995; Breschi and Malerba, 1997; Malerba, 2002). However, the first work on SI is referred to *national* system of innovation and was first explicitly introduced by Chris Freeman (1987) in his book on technology policy and economic performance in Japan. Lundvall (1992), in particular, also contributed to the popularisation of this approach.

There is no consensus whether the SI concept arose either in the scientific community or in the policy arena since many of their proponents occupied roles in both realms. However, what is not questionable is that the SI approach has been rapidly diffused and widely used in academia and policy making (Sharif, 2006).

The SI approach is implicitly based on evolutionary theories[24] and puts interactive learning and innovation at the centre of analysis. Learning is considered as an interactive process that cannot be understood without taking into account its institutional context (Lundvall, 1992).

[23] Carlsson and Stankiewicz (1995) talked about technological systems.

[24] Evolutionary theories consider technical change as an endogenous factor, an open ended and path dependent process; and assume that innovations lead to long-run disequilibrium and that the system does not reach a state of equilibrium as argued within neoclassical theories (Edquist, 1997: 6). Thus, the system of innovation approach has been developed as a response to the mainstream orthodox economic theories which disregarded the fundamental role and special character of the technical change (Sharif, 2006).

The systemic approach is the point of departure of the SI. Within this approach, innovations are not only determined by the elements of the systems but by the interactions between the elements, which arises as one of the most important characteristics of this approach. Overall, SI stresses the relevance of relationships and feedback mechanisms between all the agents involved in innovation. The role of institutions constitutes another crucial aspect in the innovation process although it must be noted that the meaning of institutions has varied across authors as will be explained below.

Freeman (1987: 1) defined national system of innovation as "the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies". According to Lundvall (1992: 2), a "system of innovation is constituted by elements and relationships which interact in the production, diffusion and use of new, and economically useful, knowledge". Nelson and Rosenberg (1993: 4) described it as a "set of institutions whose interactions determine the innovative performance of national firms".

All these authors understand the SI as a set of public and private actors (i.e. elements) and their interactions. However, there is a conceptual ambiguity surrounding the term institutions (Edquist, 1997), which can be understood broadly either as "sets of common habits, norms, routines, established practices, rules or laws that regulate the relations and interactions between individuals, groups and organizations" (Edquist and Johnson, 1997), or in the sense of organisations, as "formal structures that are consciously created and have an explicit purpose" (Edquist and Johnson, 1997). For example, Lundvall (1992) considered institutions in the sense of guides for actions and routines whereas Nelson and Rosenberg (1993: 9-13) defined them in the sense of organisations.

Overall, the SI approach has proven to be an "adequate focusing device to understand the complex interrelationships emerging between different actors from the public, private and academic sector to achieve economic development" (Uriona-Maldonado et al., 2012: 990). The dissertation focuses on the relationships between science (through the analysis of a public research organisation) and different social agents, from the perspective of the former. Knowledge distribution is "a crucial issue since distribution and access to knowledge is a *sine qua non* condition for increasing the amount of innovative opportunities" (David and Foray 1995: 40). Bearing this in mind, the dissertation analyses, by the means of three studies, a research organisation as an agent that produces, distributes and exchanges scientific knowledge with social agents.

2.3. Defining science-society interactions

The focus of the dissertation is on direct interactions, in the sense that researchers can easily identify the agents with whom they interact and the potential users of their research results.[25] This approach implies that the analysis of scholarly publications, public outreach activities, and teaching activities (referring to those undertaken in the framework of traditional and regular courses such as degree or masters courses) are beyond the scope of the studies even if they can be tangentially addressed.[26]

It has been shown in other work contexts that direct interactions with beneficiaries increase the perceived task significance and the motivations of the workers (Grant et al., 2007). Analogously, the establishment of direct interactions between researchers and social agents are relevant for the former since it enables them to understand how their work makes a difference in society.

A variety of terms have been used to address the study of researchers interacting with social agents. These include collaborations, relationships, linkages and engagement (e.g. Lee, 1996; Bozeman and Gaughan, 2007; D'Este and Patel, 2007; Perkmann and Walsh, 2007; Boardman and Ponomariov, 2009; Giuliani et al., 2010; D'Este and Perkmann, 2011; Perkmann et al., 2012). These terms are used interchangeably in the dissertation.

In a similar vein, many concepts have been used in the literature to refer to knowledge transfer or knowledge exchange. This variety of terminology has led to an inconsistency in their uses (Thomson et al., 2006). For instance, as noted by

[25] Studies are addresses from the science-side so the analysis is limited to the knowledge flowing between researchers and social agents that can be identifiable by the former.

[26] For instance, outreach activities (or popularisation activities) are addressed in Study 1.

Jacobson et al. (2004), knowledge transfer has been also termed research transfer, knowledge utilization (usually used in the political science field) or technology transfer. Bearing this in mind, this section is devoted to delimit and clarify what is considered by knowledge transfer or knowledge exchange in the dissertation.

2.3.1. From technology transfer to knowledge exchange

To analyse the evolution from technology transfer to knowledge exchange implies to focus on two aspects: on the one hand, the shift from technology to knowledge, and, on the other hand, the shift from the concept of transfer to the concept of exchange.

In the literature, many scholars have used the terms of technology transfer and knowledge transfer as interchangeable because they have considered that the creation of knowledge involves the understanding and absorption of certain new technologies (Gopalakrishnan and Santoro, 2004: 57). Indeed, following Sahal (1981, 1982), the concept of technology and knowledge transfer are not separable since when a technological product is transferred, the knowledge upon which it is based is also diffused and remains inherent to it.

On the other hand, some studies point out that knowledge and technology transfer are different, the former being a much broader and encompassing concept than the latter (Gardner et al., 2007; Castro-Martínez et al., 2008). Nevertheless, it is difficult to reach a consensus in this regard because there is no a clear definition of these concepts. As indicated by Zhao and Reisman (1992) technology transfer definition may vary substantially according to the discipline (economy, sociology, policy, anthropology, etc.).

Part of the popularity of the emphasis upon technology transfer has a historical explanation. The Bayh–Dole Act of 1980 signaled the starting point for the focus upon technology transfer and commercial transfer activities, as it granted universities the right to patent research results in their name and the authority and responsibility for their subsequent commercialization. Moreover, the establishment of technology transfer offices reflected the universities attempts to formalise university-industry technology transfer and to effectively capture the economic rents associated with their technological knowledge (Siegel et al., 2003).

However, the emergence of the knowledge-based economy concept (OECD, 1996) marks a shift in the way technology transfer is conceived (Amesse and Cohendet, 2001). Technology transfer is view as an incomplete and partial approach that needs to be revisited or even replaced.[27] Indeed, as indicated by Castro-Martínez et al. (2008), coinciding with the emergency of the knowledge-based economy, the use of knowledge transfer in the literature has considerably increased. In the present dissertation and in line with the scope of analysing science-society interactions in SSH, the technology transfer term is considered as a too narrow a concept that is absorbed by the concepts of knowledge transfer or even knowledge exchange.

The concept of technology transfer is linked to the lineal model of interactions, that is, a process in which the flow is unidirectional and later stages of the lineal sequence do not provide inputs for earlier stages: basic research → applied research → development → commercialization. As already addressed in section 2.2.2, there has been an evolution from the linear model of innovation to the interactive model of innovation. Linked to changes in the innovation process approaches are the idea that there has been an evolution from a unidirectional process (transfer) towards a bidirectional process (exchange) in which the agents of the system of innovation interact, learn and exchange knowledge. Therefore, the evolution of these concepts has been closely linked to the evolution of the innovation models. However, it should be noted that, even if transfer is often associated with a unidirectional process, it can be the case that some authors defined it as a bidirectional process as showed later in this section. This is further evidence that there is not yet a clear consensus on the terminology to be used and the meaning of the concepts associated with science-society interactions.

There are several advantages to abandon technology transfer in favour of knowledge exchange. First, it allows the inclusion of areas of knowledge that have traditionally been neglected in the technology transfer studies (i.e. SSH) since the

[27] See Bradley et al. (2013) for a recent review on the technology transfer model and its limitations.

type of knowledge produced and exchanged in some fields does not fits into the technology transfer model that privileges the kind of research outputs (more tangible) produced in engineering and experimental sciences (Hartley and Cunningham, 2001; Bakhshi et al., 2009; Jaaniste, 2009). Second, to abandon the technology transfer approach allows the extension of the study from the limited framework of science-industry relationships to a wider one namely science-society interactions. This shift results in the inclusion of a broad range of social agents – government agencies or non-profit organisation, among other– previously neglected from a technology transfer approach focused on firms (Hughes and Kitson, 2012). Finally, to consider knowledge exchange allows us to go beyond the traditional commercial technology transfer mechanisms to include a wider range of mechanisms of knowledge exchange. Indeed, technology transfer studies have traditionally been closely linked to a limited set of commercial activities (R&D contracts, patent licenses, spin off creation) which only represents a small part of the possible channels of knowledge transfer (Meyer-Krahmer and Schmoch, 1998; Cohen et al., 2002; D'Este and Patel, 2007). A knowledge exchange approach increases the inclusion of a wider diversity of collaborative and relational activities of interactions.

For the abovementioned advantages, the dissertation adopts the terminology of knowledge transfer and knowledge exchange which suits better the current context and the research field analysed, the SSH. Indeed, it can be noticed that the use of the term knowledge exchange has gained support over the last years (Abreu et al., 2008; Christopherson et al, 2008; Hughes et al., 2011; Hughes and Kitson, 2012).

For clarification, some definitions are provided for a better understanding of the object of study of the dissertation. Specifically, the focus is on interactions between public research organisations and the rest of society by analysing collaborative practices or activities "concerned with the generation, use, application and exploitation of knowledge and other university[28] capabilities outside academic environments" (Molas-Gallart et al., 2002: 2). Another definition is the one

[28] In the context of the dissertation, university can be replaced by public research organisations.

proposed by Holi et al. (2008) in which knowledge transfer[29] is defined as "the process by which the knowledge, expertise and intellectually linked assets of Higher Education Institutions are constructively applied beyond Higher Education for the wider benefit of the economy and society, through two-way engagement with business, the public sector, cultural and community partners"[30] (Holi et al., 2008: 8).

The abovementioned definitions highlight (bi-directional) interactions between academics and social agents for the exchange of knowledge and its use outside the academic sphere, which properly reflect the focus adopted in the dissertation.

2.3.2. The dimensions of knowledge exchange

The identification of the characteristics surrounding the knowledge exchange process is crucial to improve our understanding about the underlying factors shaping the knowledge flows between researchers and social agents.

To do so, the study by Barry Bozeman (2000) is used. In this work, Bozeman conducted a vast review of the literature on domestic technology transfer from universities and government laboratories. This review referred to the technology transfer process. However, Bozeman's identification of the different dimensions affecting technology transfer can be extended to other context or concepts. Thus, part of the contingent effectiveness model of technology transfer offered by Bozeman is used as the starting point to identify the key aspects that can shape the knowledge exchange process, in terms of who is involved in the knowledge exchange and how it is done.

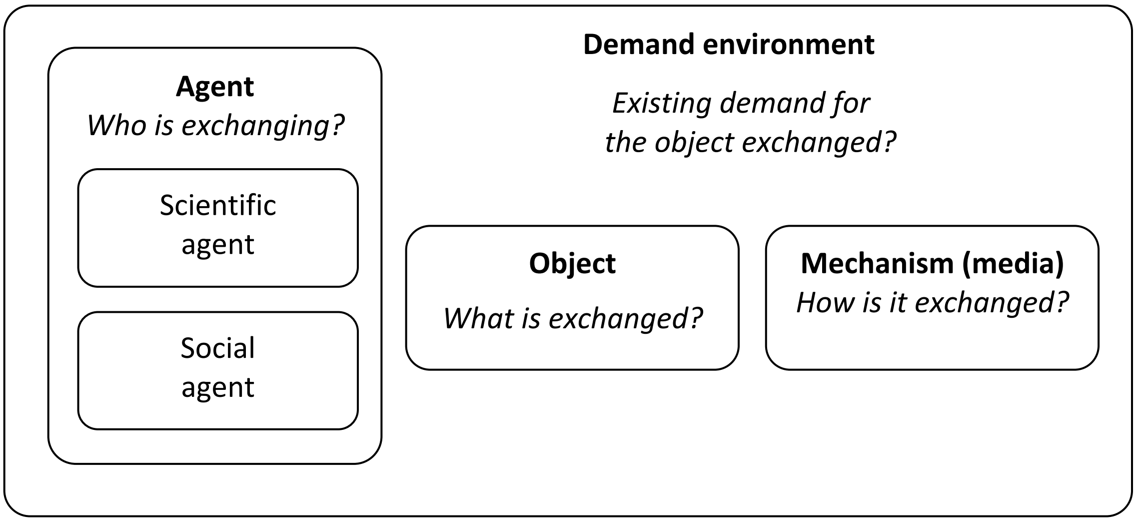
Specifically, Bozeman's model establishes a framework that groups, categorizes, classifies and simplifies a number of technology transfer aspects into five broad dimensions that include most of the factors likely to affect the technology transfer process. Inspired by this model, it is developed a conceptual framework adapted for science-society interactions and the knowledge exchanged between these two

[29] In this definition knowledge transfer is defined as a two-way flow, therefore, under this definition, it can be used as interchangeable with knowledge exchange.

[30] Analogously, this definition that refers to higher education institutions can be applied for public research organisations.

realms. The five dimensions of the knowledge exchange process are described below (see Figure 2.1).

Figure 2.1: The dimensions of knowledge exchange



Source: own elaboration inspired by Bozeman (2000).

(i) *Academic agent*

The characteristics of the scientific agent refer to the nature of the scientific organisation (university or public research organisation), its culture, its history, its policies, its structure and its organisation. All these factors are likely to shape the behaviour of researchers engaging with society. Indeed, organisational factors (e.g. promotion and tenure guidelines, resources and funding, structures, knowledge exchange orientation and documentations) and the actions and instruments implemented by the research organisation are likely to influence researchers' willingness to participate in knowledge exchange processes (Jacobson et al., 2004).

Furthermore, the analysis of science-society interactions and the engagement in knowledge exchange processes can be undertaken at different levels: public research organisations or universities (Göransson et al., 2009), departments (Schartinger et al., 2001, 2002), research groups (Castro-Martínez et al., 2008; Ramos-Vielba et al., 2010) or individuals (Landry et al., 2007; Boardman and Ponomariov, 2009; D'Este and Perkmann, 2011). In the case of analysing knowledge exchange across different organisations, it might be necessary to control for differences in institutional characteristics (see Abreu and Grinevich, 2013 for a recent example).

The three studies contained in the dissertation refer to a single organisation, the Spanish Council for Scientific Research (CSIC). However, the studies are approached through different levels of analysis regarding the scientific agent. Study 1 focuses on the researcher but aggregates the data by fields (SSH and STEM). Study 2 focuses on research groups and aggregates some of the results by research institutes. Finally, Study 3 analyses research groups, but also considers the individual characteristics of the group leader.

(ii) *Social agent*

The characteristics of the social agents are related to the societal collectives or individuals interacting with researchers. It is frequent that social agents benefit from the research outputs generated by the scientific community, but also that the researchers' benefit from the experiences and knowledge provided by their social environment. One of the most basic questions about this dimension is what type of organisation is involved as a knowledge exchange partner (Bozeman, 2000). There is a wide variety of agents that establish interactions with the academic sphere: private sector companies (i.e. firms), public sector organisations (i.e. government agencies, public companies) and non-profit organisations (i.e. charitable or voluntary organisations, foundations and associations). Although the literature has primarily focused on researchers' engagement with industry and firms (Meyer-Krahmer and Schmoch, 1998; Schartinger et al., 2002; Perkmann et al., 2012), recent studies have brought into consideration other collectives traditionally disregarded (Castro-Martínez et al., 2008; Abreu et al., 2009; Hughes and Kitson, 2012).

The dissertation addresses the analysis of knowledge exchange primarily from the perspective of the scientific agent. This means that, although the bidirectional flow of knowledge between researchers and social agents is acknowledged, special attention is devoted to the researchers as those who primarily deliver the knowledge and to social agents as those who benefit from it (however, the other direction of the knowledge exchange is also addressed in Study 2 through the case studies analysis).

The type of social agent with whom SSH researchers engage is explicitly addressed in Studies 1 and 2. More specifically, Study 1 looks at differences between fields regarding the type of social agent with whom researchers are involved. Study 2 aims at quantifying the involvement of a diverse range of social agents in collaborations with SSH research groups.

(iii) *The object*

The characteristics of the object exchanged regard the content and the form of what is being exchanged. This can be scientific knowledge, technological devices, databases, know-how, etc. For instance, Harmon et al. (1997) distinguish between different types of technological product and Molas-Gallart (1997) focuses on a diversity of dual-use technologies.[31] Depending on the object transferred, it may be the case that restrictions arise for its diffusion and use –e.g. confidentiality requirements, output protection through IPR (Castro-Martínez et al., 2008).

The characteristics of the object transferred are tangentially addressed in Study 2 through the case studies analysis which allows understanding of the type of knowledge, database or know-how researchers are exchanging with their social partners through the collaborations established.

(iv) *The mechanism or media*

The characteristics of the media or mechanisms refer to the means used for the knowledge exchange, that is, the nature and the type of activities of engagement. A first distinction can be made related to the nature of the mechanisms used: informal vs formal (e.g. Link et al., 2007; Grimpe and Hussinger, 2008; Grimpe and Fier, 2010; Abreu and Grinevich, 2013; Amara et al., 2013). A second way to address these mechanisms is to identify their diversity and to categorise them (e.g. Bonaccorsi and Piccaluga, 1994; Molas-Gallart et al., 2002; Abreu et al., 2008, 2009).

The nature of the mechanism of interaction and of the type of collaborations (informal or formal) is addressed in Study 1 and 2. Furthermore, Study 3 explores research groups' engagement in five specific collaborative activities for the

[31] For Molas-Gallart (1997) dual-use refers to the opportunity for the wider exploitation of research efforts beyond their initial (military or civilian) goal.

knowledge exchange (i.e. consultancy, contract research, joint research, training and personnel mobility).

(v) *Demand environment*

The characteristics of the demand environment refer to the aspects related to market, social, cultural and economic need for the object exchanged. In this regard, it is important to address what is the social demand existing for a determined object (or research output) and how the social value of the research can be measured beyond the economic dimension (Godin and Doré, 2005).

Study 1 addresses aspects related to the usefulness of research, that is, whether there are users for the research conducted in diverse fields. More particularly, the empirical study explores, among other aspects, whether there are differences in the demand for research output between scientific fields.

CHAPTER 3

RESEARCH OBJECTIVES AND OVERVIEW OF THE STUDIES

This chapter addresses the research objectives covered in the dissertation and the justification of the importance of the study and the context analysed. The evolution of the three studies and the coherence of the relationship between them are presented, along with the research questions tackled in each study. A final section is devoted to providing a more detailed overview of each of the studies.

3.1. Objectives and Justification

The objective of the dissertation is to contribute to our understanding of science-society interactions in a field that has traditionally received less attention in the literature: the social sciences and the humanities (SSH). The studies aim to provide a better understanding of how SSH researchers interact with social agents but also about differences in research and collaborative practices between SSH and non-SSH fields. Political and managerial implications can be derived from the acknowledgement of SSH contributions to society and from a better understanding of the characteristics of the interactions between researchers and social agents that allow the exchange of knowledge between the parties.

From a science policy perspective, the objective of the dissertation is to contribute to the policy debate around research usefulness and the allocation of public resources to science. In this sense, it is addressed whether there are differences between practices in scientific fields and whether such differences then imply differences in the usefulness of research outputs. From a managerial perspective, to deeply understand science-society interactions within the SSH field may allow the implementation of measures to promote knowledge transfer better adapted to the characteristics of the collaborative process. To do so, I go through the dimensions of the knowledge exchange process by analysing the agents involved in the interaction or the collaboration, the nature and type of mechanisms used for the knowledge exchange, as well as the type of knowledge flows. Moreover, to shed light on both the interactions and the determinants that foster these interactions can provide useful guidelines for implementing strategic plans and for taking decisions to promote researchers' engagement with their socio-economic environment.

The context in which the empirical studies are conducted is the Spanish Council for Scientific Research (*Consejo Superior de Investigaciones Científicas*, CSIC). The reasons for focusing on this organisation are multiple. First, the CSIC is the largest public research organisation in Spain and encompasses several scientific areas, including the Humanities and the Social Sciences. The advantage of focusing on the CSIC is that it is a homogeneous research institution embracing a wide range of fields which allows for their comparisons under a same institutional framework, and therefore, being affecting by the same institutional policies. From a methodological perspective, to focus on a single organisation is interesting because it allow us to control for external variance related to policies, culture, norms or values. Second, the primarily mission of CSIC researchers is to conduct research and to generate new knowledge, as opposed to university researchers for whom teaching (the first mission) represents an important work load and is very time consuming. Therefore, this means concentrating on a population of full-time researchers with more time to devote to non-teaching activities. Furthermore, analysing the CSIC implies that the output from the studies could be useful for the organisation itself possibly as an input to policy development. In this sense the study itself highlights the potential usefulness of SSH research. Indeed, the research project on the SSH started as a result of a policy need from the CSIC, which envisaged the implementation of institutional initiatives to promote relationships with the socio-economic environment in all scientific fields. Therefore, an analysis of the SSH area was required to guide institutional and operational strategies within the CSIC. As the thesis has been conducted within the

CSIC, we have benefited from the collaboration of CSIC researchers that have been willing to participate in the research project and we have had access to institutional information held by CSIC. These optimal conditions have benefited the feasibility and results of the studies.

3.2. Evolution of the dissertation

As SSH represents an important aspect of our research, the starting point of the studies has been to understand what are the differential aspects of this field compared to non-SSH fields, hereafter STEM (Science, Technology, Engineering and Mathematics). These potential differences have been addressed looking at the type of research conducted and the scientific practices of the researchers belonging to these two broad fields. From the results regarding whether there are differences between fields, some conclusions are drawn about whether the existence of differences imply differences in research usefulness and in which direction. This problematic is addressed in Study 1 through the following question:

- *Is social science and humanities research different to science, technology, engineering and mathematics research in ways that make it systematically less useful to society?*

Results from the empirical work conducted in Study 1 show differences between fields for some of the aspects analysed, particularly regarding the patterns of science-society interactions (nature of the collaborations and type of social agents with whom researchers collaborate). These findings motivate us to address these differential aspects in more detail by focusing exclusively on the SSH field. Therefore, Study 2 intends to deepen understanding of both the nature of science-society interactions and the type of social agents with whom collaborations are established in the SSH. Thus, the questions addressed in Study 2 are:

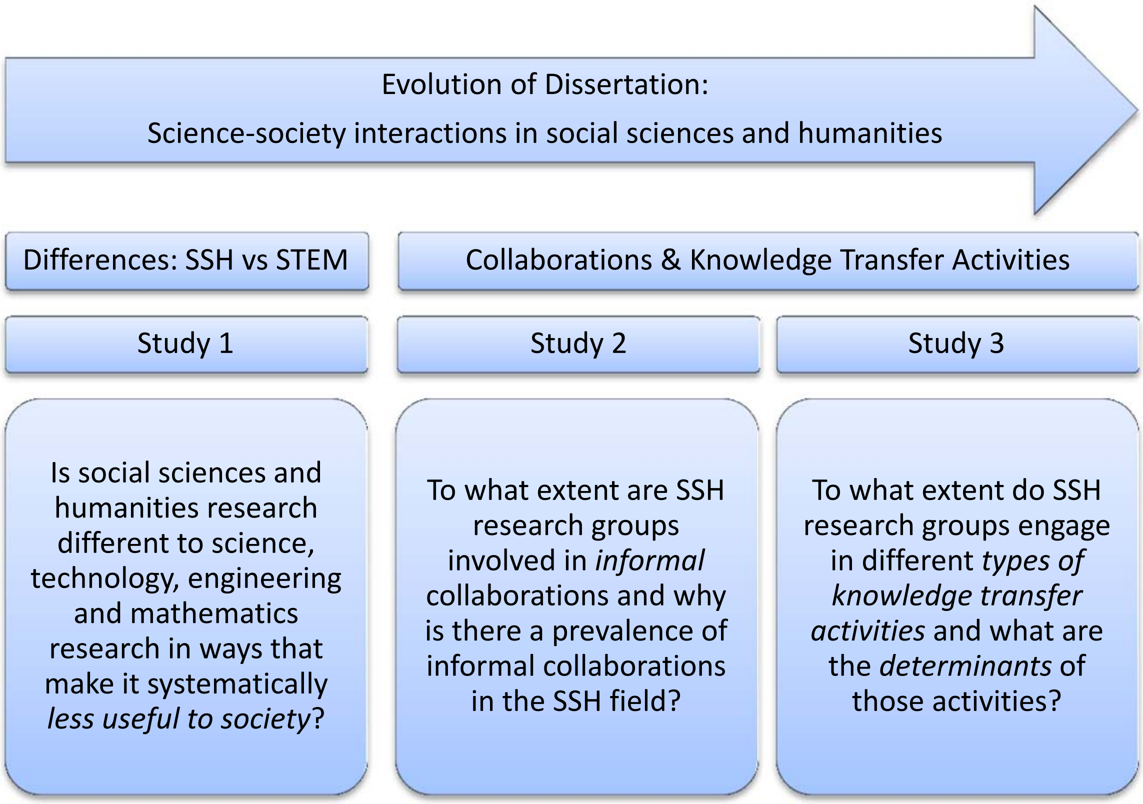
- *To what extent do SSH researchers establish informal collaborations with non-academic partners?*
- *What are the types of social partners with whom SSH collaborates?*
- *Which factors could explain the prevalence of informal collaborations in the SSH?*

Finally, the last study of the dissertation is focused on the diversity of activities in which SSH research groups engage to exchange knowledge with social agents. More specifically, it is explored the extent to which research groups are engaged in multiple knowledge transfer (KT) activities. The study also aims to identify the determinants related to the research group characteristics or to group leaders' characteristics that can be related to the propensity of research groups to engage in a variety of KT activities. Thus, the research questions addressed are the following:

- *To what extent do SSH research groups engage in knowledge transfer with non-academic communities and what forms of knowledge transfer activities are the most frequent?*
- *What are the factors that shape the engagement of SSH research groups in different forms of knowledge transfer activities?*

The three studies are summarised in Figure 3.1. and broadly described in the remainder of the chapter.

Figure 3.1: Scope and research questions of the three studies in the dissertation



3.3. The studies

3.3.1. Study 1 – A comparative of scientific practices between social sciences and humanities (SSH) and the fields of science, technology, engineering and mathematics (STEM)

Study 1 addresses whether there is evidence that substantiate the extended research policy discourse that seems to assume that SSH research is systematically less socially useful than STEM. In so doing, we approach research usefulness through the analysis of researchers' practices and we look for differences between the two fields. We argue that researchers' practices engaging users imply the existence of relationships with users; and from the existence of users for research, we can infer that research is useful for someone beyond the scientific community. We conduct a review of the claims made about the differences between SSH and STEM in terms of scientific research practices and engagement with users (British Academy, 2008; AHRC, 2009; Bakhshi et al., 2009; Bate, 2011; Hughes et al., 2011, among other). A set of hypotheses about differences in researchers' practices between fields are derived and classified according to whether, from these differences, it could be inferred that: (i) STEM research is more useful than SSH research; (ii) STEM research is differently useful to SSH research in the way of making social beneficial contributions. These hypotheses are tested using a database of researchers belonging to the CSIC. This study intends to challenge the quite settled disciplinary stereotypes of the social use of research on the basis of the empirical analysis conducted.

Study 1 aims to make different contributions. Firstly, it reviews the main claims about disciplinary differences and provides a typology of the claims analysed, which are classified according to whether we can infer that STEM research is more useful than SSH or whether they are just different. Secondly, it provides empirical evidence about the differences between fields regarding researchers' practices in terms of the characteristics of their research, their relationships with social agents and their dissemination practices. Finally, the study provides some implications for research policy.

3.3.2. Study 2 – An analysis on the prevalence and persistence of informal collaborations in the social science and humanities

Study 2 looks at science-society interactions by addressing the nature of the collaborations undertaken between researchers and social agents. More specifically, the study explores the importance of informal collaborations between SSH research groups and social partners and analyses the context under which this informality emerges. Previous studies suggest that formal engagement is preceded by informal links (Druilhe and Garnsey, 2004; Abreu et al., 2009). This implies that there is complementarity between formal and informal collaborative activities (Grimpe and Hussinger, 2008), with academics engaging simultaneously in both of them (Amara et al., 2013). However, a recent study points that researchers rarely use both formal and informal mechanisms for engagement, but one or the other (Abreu and Grinevich, 2013). This suggests the existence of a type of collaboration that is not formalised and remains informal over time. The aim of the study is the identification of these exclusively informal collaborations. To do so, we use a very restrictive definition of informality to capture those collaborations that are exclusively informal. Then, we conduct an empirical analysis within the CSIC structured in two phases. First, we carry out a quantitative analysis to identify: (i) the extent to which SSH research groups engage in formal and informal collaborations with social partners; and (ii) the type of partner with whom research groups engage. Our findings show a prevalence of informal collaborations and identify diverse social agents other than firms as the main partners of SSH research groups. Second, a more detailed study is conducted through a selected sample of SSH researchers and their social partners. This qualitative analysis sheds light on the characteristics that explain the emergence of informal collaborations that are maintained over time without being formalised.

Study 2 aims to contribute to the existing literature on knowledge exchange by highlighting a type of collaboration that has not been emphasized in the literature –collaborations that remain exclusively informal. Thus, we identify situations in which informal and formal knowledge exchange activities are not complementary and thus, where informal collaborations are not precursor of formal collaborations to date. We discuss the policy implication of our findings.

3.3.3. Study 3 – The extent of engagement of social sciences and humanities research groups in different knowledge transfer activities and its determinants

Study 3 examines the extent to which SSH research groups engage in a broad range of knowledge transfer (KT) activities identified in the literature (Meyer-Krahmer and Schmoch, 1998; Cohen et al., 2002; Schartinger et al., 2002; D'Este and Patel, 2007; Ramos-Vielba et al., 2010). In particular, we focus on five KT activities, namely consultancy, contract research, joint research, training and personnel mobility. From a review of the empirical papers on science-society interactions (mainly focused on university-industry interactions within the fields of natural sciences and engineering), we explore what are the determinants (related to the research group and to the group leader) that influence research group engagement in each of these KT activities. The empirical study is conducted on the research groups in the SSH field of the CSIC. Our findings suggest that the patterns of interactions (in terms of the types of KT activities) in the SSH do not differ considerably from those identified in the literature for other non-SSH fields, with consultancy and contract research being the most frequent activities. However, research groups' engagement in different KT activities is explained by different factors. A focus on users' needs enhances research groups' engagement in all of the five KT activities considered. The characteristics of the group leaders (status and academic reputation) as well as those of the groups (size and degree of multidisciplinarity) are also relevant but not for all the activities considered. Policy and managerial implications of the results are discussed.

Study 3 contributes to a growing body of KT literature by seeking to understand what influences the propensity of SSH research groups to engage in particular kinds of KT activities. It does it from the perspective of the research group, a collective that has received little attention in the literature. Moreover, KT studies have been traditionally addressed for non-SSH fields, and this study offers the possibility to verify whether patterns of collaborations are similar across fields.

CHAPTER 4

CONTEXT OF THE STUDIES

This chapter describes the Spanish Council for Scientific Research (*Consejo Superior de Investigaciones Científicas*, CSIC), the public research organisation empirically analysed in all the three studies included in the dissertation. It provides an overview of its origins and how it has evolved over time (its evolving role in their relationships with its environment). The first section introduces The Board of Advanced Studies (*Junta de Ampliación de Estudios, JAE*), the predecessor of the CSIC. The second section overviews CSIC's structure from its inception until today and provides background data corresponding to the period in which each of the three studies has been conducted (2006-2011). A final section addresses the area of Humanities and Social Sciences within the CSIC, which is the main focus of the dissertation.

4.1. The predecessor of the CSIC: the Board of Advanced Studies

History and culture are key factors in the scientific and technical progress of countries. The case of Spain is not different. The evolution of Spanish science policy and its public research organisations have been closely determined by different stages in the history related with (i) the political instability of Spain in the last century and the alternating of different forms of government; and (ii) the Spanish geographical position and its inclusion in the Europe construction (Santesmases and Romero-de-Pablos, 2008).

The predecessor of the CSIC was the Board of Advanced Studies (hereafter, the *Board*), created by Royal Decree on the 11th January 1907. The creation of the Board coincided with a period in which similar institutions emerged in other countries: the *National Research Council* (NRC) in Canada founded in 1916, the

Consiglio Nazionale delle Ricerche (CNR) in Italy established in 1923 or the *Centre National de la Recherche Scientifique* (CNRS) in France set up in 1939. The Board responded to the widespread feeling of the lack of an institution devoted to promote research. It was intended to be an institution formed by intellectuals belonging to different ideologies and free of political influence (Sánchez-Ron, 2007: 30). Its primary mission was to enable young and established researchers to broaden their knowledge, especially abroad, through the creation of the grants named *pensiones* (for further details see Formentín-Ibañez and Villegas, 2007). One of the main features of the research conducted within the Board –which was subsequently amended by the CSIC–, was its marked orientation towards pure research, with applied research being totally non-inexistent. The Board constituted the basic organisation for human resources development and the production of scientific knowledge, leading to a stage of development and diffusion of science and culture not previously seen in Spain.

However, the instability of Spanish politics marked the evolution of the support for science. During the First World War (1914-1919), the *pensiones* of the Board for Europe were almost completely paralyzed, and it was not until the period between the end of the war (1919) and the dictatorship of Primo de Rivera (1923) that the *pensiones* were re-launched. This relatively prosperity of the Board continued during the military dictatorship (1923-1930) and the second Republic (1931-1936). However, the spirit of modernization and reform represented by the Board did not have the sympathy of the sectors that promoted and supported the insurrection in 1936, and all the efforts of the Board were collapsed with the advent of the Civil War (1936-1939), which lead to a stagnation of the R&D activities in the country (Muñoz, 2001) and to its dissolution in 1937.

4.2. The Spanish Council for Scientific Research (CSIC)

The civil war ended in 1939 and General Franco enacted a law[32] to create the CSIC. This new institution was built on the remnants of the research centers within the dissolved Board. CSIC emerged as a hybrid agency aimed at both the design and

[32] Law 24/11/1939

promotion of science policy and the implementation of research through its own institutes. CSIC's scientific activity was conducted by its research institutes which were organised around six patronages[33] belonging to three main areas: (i) humanities and social sciences area; (ii) technological area; and (iii) experimental sciences area (Fernández-Esquinas et al., 2009).

As detailed by Fernández-Esquinas and colleagues (2009), the 1960s and the 1970s was a period of economic modernization and new ideas coming from the international scene which contributed to CSIC's development. It established intensive relationships with industry, leading to a dual funding system. As a public good, most of CSIC's financial resources came from the general budget of the Government, but also from external resources from its agreements with industry. Despite being a public organisation, the CSIC had a great degree of discretion and autonomy. However, problems related to the control and management of CSIC resulted in the dissolution of the patronages in 1975, and the implementation of a new internal Regulation (1977) that decentralized much decision-making to the institute level. The financial crisis of the 1970s directly affected the CSIC which felt a lack of resources from the Government and the private sector. Indeed, the second half of the 1970s was marked by a break in the institutionalization of science and technology in Spain. The main concern was to establish democracy in an extremely fragile political and economic environment. Thus political and social policies were prioritized leaving scientific policy absent from the policy agenda (Muñoz, 2001; Jiménez-Contreras et al., 2003).

During the 1980s and coinciding with the electoral victory of the socialist party (PSOE), we witnessed the full inclusion of R&D in the political agenda, pointing to the modernization of Spanish institutional structures and the development of the R&D system. The inclusion of Spain in the European Economic Community in 1986 contributed to promoting the modernization of the pathways toward a restructuration of the science and technology system, playing an important role in the selection of national R&D priorities and in the design of R&D programs (Sanz-

[33] Patronages were organisational divisions grouping research institutes around large branches of science.

Menéndez, 1995). The implementation of the Law of Science (*Ley de la Ciencia*)[34] generated a new scenario in which CSIC was a key actor, as the largest organisation participating in the R&D mechanisms contained in the National Plan. The National Plan was envisaged as the tool to distribute economic and human resources according to a well-defined strategic plan with well-established priorities. Moreover, together with the National Plan, the European Framework program arose as a source of competitive funding directly available to the researchers (organised in groups) rather than to the institutes. This is a period in which CSIC benefited from an increase of funds and of a simplification of its institutional and internal organisation resulting in the consolidation of eight research areas (Fernández-Esquinas et al., 2009).

The more recent change undergone by the CSIC was its transformation into an Agency[35] in 2007, which sought to increase the flexibility of the organisation. Nowadays, CSIC's mission 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[36] (Art.4 of the Statute).

Briefly, CSIC is part of the Ministry responsible for research and it is nowadays the largest public research organisation in Spain. It encompasses 6% of staff engaged in research and development in Spain, it generates about 20% of national scientific production and 45% of patents applied. CSIC is organised around the following eight areas of knowledge: 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; natural resources. Background data on the CSIC is provided in the Table 4.1 corresponding to the period in which each of the three studies has been conducted.

---

[34] Law 13/1986 "Law for the Promotion and General Co-ordination of Scientific and Technical Research" (see Muñoz and García-Arroyo, 2006).

[35] Royal Decree 1730/2007 of 21 December.

[36] "*el fomento, coordinación, desarrollo y difusión de la investigación científica y tecnológica, de carácter pluridisciplinar, con el fin de contribuir al avance del conocimiento y al desarrollo económico, social y cultural, así como a la formación de personal y al asesoramiento de entidades públicas y privadas en esta materia.*" (*Art. 4 del Estatuto del CSIC*).

Table 4.1: Main indicators of the CSIC (2006-2011)

	2006	2007	2008	2009	2010	2011
CSIC Institutes	116	125	128	128	128	126
CSIC institutes	75	75	77	77	75	72
CSIC joint institutes	41	50	51	51	53	54
Human resources (total staff)	10,263	12,885	12,317	13,538	14,144	14,050
Tenured researchers and technicians (civil servants)	41.4%	35.2%	39.2%	37.1%	36.1%	35.5%
Contracted researchers, technicians and grant holders	40.2%	52.4%	47.0%	50.9%	53.1%	49.3%
Administration and other	18.4%	12.4%	13.8%	12.0%	10.8%	15.2%
Economic resources: funding distribution (k€)	675,813	817,688	879,220	858,662	808,793	728,715
Core funding from Government	65%	68%	71%	66%	54%	60%
External Resources *	35%	32%	29%	34%	46%	40%
Contracts and agreements with private and public sector organisations and firms						
Number	1,247	1,314	1,447	1,170	3,099	4,269
Funding (k€)	53,052	63,149	64,742	59,638	78,600	68,968
Scientific Productivity						
Articles in SCI/SSCI-listed journals	7,478	7,824	8,754	9,754	9,899	12,299
Articles in non SCI/SSCI-listed journals	1,596	1,698	1,762	1,962	1,069	1,328
Books	261	348	314	368	270	379
Doctoral thesis	583	618	672	795	749	881
Spanish patents	138	139	180	180	175	190

Source: Own elaboration based on CSIC annual reports from 2006 to 2011 (CSIC, 2007, 2008, 2009, 2010, 2011, 2012).
*External resources include funds from regional, national and international competitive R&D programmes, contracts with companies and organisations and funds from the European Social Fund and the European Regional Development Fund.

Data presented in Table 4.1 show interesting trends regarding human and economic CSIC indicators over the period 2006-2011. There has been a constant increase of CSIC human resources and a change in the human resources structure. In particular, the proportion of civil servants has diminished in favour of contracted staff. On the other hand, economic resources transferred from the Government have lost weight in comparison to external resources, which mainly come from competitive R&D programmes, contracts and agreements[37] with external companies and organisations. Indeed, the number of contracts has tripled between 2006 and 2011. However, this has been accompanied by a modest increase of economic resources (30%). These data indicate that overall, the average value (in euros) of each contract has decreased from 42,500€ in 2006 to 16,000€ in 2011. This is a radical change, which has no doubt impacted on the research landscape investigated.

4.3. Social Sciences and Humanities in the CSIC

The origin of some of the SSH institutes is prior to the birth of CSIC and can be traced in the Board (1907), which brought together researchers in philology, history, archeology and art at the Centre for Historical Studies located at Medinaceli (Martín-Lou, 2002). Then, the creation of the CSIC (1939) was followed by a Regulation[38] that organised the area of humanities and social sciences around two boards of trustees namely *Raimundo Lulio* (philosophy, theology, jurisprudence and economics) and *Marcelino Menéndez Pelayo* (humanities). More institutes were progressively incorporated to the boards in the years ahead (for more details see Urquijo-Goitia, 2000).

During the dictatorship period, the area was closely linked to the University. Research institutes lacked their own research staff and university professors used these small institutes as an extension of their Chairs to conduct their research. New research topics studied in this area were highly influenced by the official doctrine of the dictatorship and by religion (Fernández-Esquinas et al., 2009).

---

[37] Hereafter in this section contracts is used as shorthand for contracts and agreements.

[38] *Decreto de 10 de febrero de 1940 regulando el funcionamiento del Consejo Superior de Investigaciones Científicas - BOE 17 febrero 1940*.

A turning point in the SSH area took place during the 1970s with the emergence of CSIC research staff assuming a greater role, to the detriment of university professors (Fernández-Esquinas et al., 2009). Moreover, the democratic transition was felt in SSH through the Regulation in 1997 (Sebastián and López-Facal, 2007) that led to a higher distancing of the university from SSH, which until then was dominated by university professors occupying management positions (Urquijo-Goitia, 2000). The new political situation (i.e. democracy) and generational change contributed to the removal of the connection between CSIC research and the dictatorial regime. An important restructuration of the SSH area took place at the beginning of the 1980s, when new social sciences research institutes were created (economic, sociology, political sciences, geography) and small units associated to universities were suppressed. This restructuration was based on obtaining a critical mass of researchers in each institute to better rationalize resources.

In 2007 the last important restructuration of SSH took place, which gave rise to part of its current organisation. A new centre, the Centre for Human and Social Sciences (*Centro de Ciencias Humanas y Sociales*, CCHS) was created to house the seven SSH institutes located in Madrid. The centre was the place of work for 74% of SSH staff and about 65% of its researchers. The remainder were distributed into ten other institutes throughout the rest of Spain (CSIC, 2008, 2012).

The creation of the CCHS included the renaming of five of its institutes located in Madrid and the redefinition of its scientific programs according to the Strategic Action Plan of the SSH area (2006-2009). The list of institutes brought together in the CCHS is the following:

- Institute of History (IH).
- Institute of Philosophy (IFS).
- Institute of Language, Literature and Anthropology (ILLA), which predecessor was the Institute of the Spanish Language (ILE).
- Institute of the Language and Cultures of the Mediterranean and Near East (ILC), which predecessor was the Institute of Philology (IFL).
- Institute of Economics, Geography and Demographics (IEGD), which predecessor was the Institute of Economics, Geography (IEG).

- The Institute of Policy and Public Goods (IPP), which predecessor was the Unit for Comparative Politics and Policies (UPC).
- The Institute of Documentary Studies on Science and Technology (IEDCYT), which predecessor was the Scientific Information and Documentation Centre (CINDOC).

Other than the seven research institutes, the CCHS encompasses a large network of horizontal research support and service units including nine laboratories and, from 2008, the biggest library[39] in Spain (*Tomás Navarro Tomás*, TNT library) regarding humanities and social sciences disciplines. This library resulted from the fusion of the eight CSIC libraries specialized in philosophy, philology, history, sociology, politics, geography, economics, etc., that CSIC held in Madrid.

Other than the seven institutes housed in the CCHS, ten research institutes are located throughout the Spanish territory. Four of these belong exclusively to the CSIC, six are joint research institutes of CSIC, universities and government institutes. These ten institutes are:

- Milá and Fontanals Institution (IMF), located in Barcelona.
- School of Hispano-American Studies (EEHA), located in Seville.
- School of Arabic Studies (EEA), located in Granada.
- Institute of Islamic and Near Eastern Studies (IEIOP), located in Zaragoza, a joint institute created from a collaborative agreement between the CSIC, the *Cortes de Aragón* (regional government) and the University of Zaragoza (UNIZAR).
- López Piñero Institute of the History of Medicine and Science (IHCD), located in Valencia, a joint institute of the CSIC and the University of Valencia (UV).
- Padre Sarmiento Galician Studies Institute (IEGPS), located in Santiago, a joint institute of CSIC and *Xunta de Galicia* (regional government) since 2000.

[39] TNT library contains a million volumes, 11,000 journals, 700,000 monographs, and occupies 21km of shelves (CSIC, 2008).

- Mérida Institute of Archaeology (IAM), located in Mérida, a joint institute of CSIC, *Junta de Extremadura* (public regional government) and *Consorcio de la Ciudad Monumental de Mérida* (public local consortium).
- Institute for Economic Analysis (IAE), located in Barcelona.
- Institute for Advanced Social Studies (IESA), located in Córdoba, a joint institute created from a collaborative agreement between the CSIC and the *Junta de Andalucía* (regional government) in 1995.
- Institute of Innovation and Knowledge Management (INGENIO), located in Valencia, a joint institute of the CSIC and the Polytechnic University of Valencia (UPV).

A summary of the 17 institutes[40] of the SSH is presented in Table 4.2, and complemented by the Table 7.1 (Study 3) in which the main fields of research covered by the SSH institutes are provided.

[40] The Rome School of History and Archaeology (EEHAR) located in Rome has not been included in the list of institutes considered because it has not its own permanent CSIC researchers.

Table 4.2: Social sciences and humanities institutes of the CSIC

Acronym	Name of the institutes	Area	Year of foundation	Location	Nature of the institutes
IH	Institute of History	H	1910	Madrid (CCHS)	C
IMF	Milá and Fontanals Institution	H	1968	Cataluña (Barcelona)	C
ILLA (*ILE*)	Institute of Language, Literature and Anthropology (*Institute of the Spanish Language*)	H	1999	Madrid (CCHS)	C
ILC (*IFL*)	Institute of Languages and Cultures of the Mediterranean and the Near East (*Institute of Philology*)	H	1985	Madrid (CCHS)	C
IFS	Institute of Philosophy	H	1986	Madrid (CCHS)	C
EEHA	School of Hispano-American Studies	H	1942	Andalucía (Sevilla)	C
EEA	School of Arabic Studies	H	1932	Andalucía (Granada)	C
IEIOP	Institute of Islamic and Near Eastern Studies	H	2000	Árágón (Zaragoza)	J (*Cortes de Aragón*)
IHCD	López Piñero Institute of the History of Medicine and Science	H	1985	Comunidad Valenciana (Valencia)	J (UV)
IEGPS	Padre Sarmiento Galician Studies Institute	H	1943	Galicia (Santiago)	J (*Xunta de Galicia* since 2000)
IAM	Mérida Institute of Archaeology	H	2001	Extremadura (Mérida)	J (*Junta de Extremadura* and *Consorcio de la Ciudad Monumental de Mérida*)
IEGD (*IEG*)	Institute of Economics, Geography and Demography (*before Institute of Economics, Geography*)	SS	1986	Madrid (CCHS)	C
IEDCYT (*CINDOC*)	Institute of Documentary Studies on Science and Technology (*Scientific Information and Documentation Centre*)	SS	1953	Madrid (CCHS)	C
IPP (*UPC*)	Institute of Public Goods and Policies (*Unit for Comparative Politics and Policies*)	SS	1999	Madrid (CCHS)	C
IAE	Institute for Economic Analysis	SS	1985	Cataluña (Barcelona)	C
IESA	Institute for Advanced Social Studies	SS	1992	Andalucía (Córdoba)	J(*Junta de Andalucia*) since 1995
INGENIO	Institute of Innovation and Knowledge Management	SS	1999	Comunidad Valenciana (Valencia)	J (UPV)

Source: own elaboration based on SSH Action Plan 2006-2009 (CSIC, 2006).
H: Humanities; SS: Social Sciences
C: CSIC institute; J: Joint institute

Our three empirical studies are based on the SSH area and addresses different level of the organisation such as the researcher (Study 1), the research institute (Study 2) and the research group (Study 3). Since the studies took place at various points between 2006 and 2011, this section provides some figures that give a broad overview of how SSH has evolved in the period analysed and its weight within to whole CSIC (see Table 4.3).

The proportion of tenured SSH researchers within the CSIC is 10%. This weighting is slightly inferior when comparing the total staff working in the area. Indeed, despite the increase of SSH over the period, its relative share of CSIC human resources has fallen slightly. However, data indicate that the figure has remained substantially constant in term of human resources and institute structure over the period analysed.

On the other hand, although contracts between SSH researchers and external companies and organisations have increased over the period, the proportion of this contracts compared to the total number of CSIC contracts has dropped from 7% to 3%. Moreover, despite an increase in the number of contracts, there has been a significant decline in the funding coming from these contracts. Indeed, the average value of a contract has fallen considerably from 82,000€ in 2006 to 18,000€ in 2011.

Scientific productivity measured in terms of articles, books and patents is very biased by fields. In fact, the rate of SSH researchers' publications in indexed journals is very low compared to the whole CSIC. Patents in SSH are very rare.[41] However, the SSH field has produced more than half of the books within the CSIC and its publications in non-indexed journals often represents more than a quarter of the CSIC, reaching 39% in 2010.

[41] See for an exception the patent belonging to the Institute of History entitled "System for determining ambient acidity and method for using same" (2010). Reference ES2373138.

Table 4.3: Main indicators of the SSH field and its weight within the CSIC (2006-2011)

	2006	2007	2008	2009	2010	2011
SSH Institutes	17 (15%)	17 (14%)	17 (13%)	17 (13%)	17 (13%)	17 (13%)
CSIC institutes	11 (15%)	11 (15%)	11 (14%)	11 (14%)	11 (15%)	11 (15%)
CSIC joint institutes	6 (15%)	6 (12%)	6 (12%)	6 (12%)	6 (11%)	6 (11%)
Human resources: total staff*	852 (8%)	854 (7%)	1,057 (9%)	1,073 (8%)	1,116(8%)	1,024 (7%)
Tenured researchers (civil servants)	253 (10%)	268 (10%)	305 (10%)	314 (10%)	318 (10%)	316 (10%)
Contract and agreements with companies and organisations						
Number	91 (7%)	71 (5%)	114 (8%)	71 (6%)	137 (4%)	137 (3%)
Funding (k€)	7,458 (14%)	5,045 (8%)	6,357 (10%)	5,551 (9%)	5,637(7%)	2,495(4%)
Scientific Productivity						
Articles in SCI/SSCI-listed journals	146 (2%)	182 (2%)	237 (3%)	331 (3%)	333 (3%)	601 (5%)
Articles in non SCI/SSCI-listed journals	368 (23%)	497 (29%)	456 (26%)	476 (24%)	415 (39%)	359 (27%)
Books	143 (55%)	187 (54%)	168 (54%)	198 (54%)	152 (56%)	223 (59%)
Doctoral thesis	38 (7%)	37 (6%)	46 (7%)	49 (6%)	46 (6%)	74 (8%)
Spanish patents	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (0.6%)	0 (0%)

Source: Own elaboration based on CSIC annual reports from 2006 to 2011 (CSIC, 2007, 2008, 2009, 2010, 2011, 2012).
In brackets the weight of each SSH value compared to the total value of the CSIC.
*The table only provides data regarding tenured researchers since annual reports do not contain detailed information on SSH human resources.

The Studies

Study 1: Are 'STEM from Mars and SSH from Venus'? Challenging disciplinary stereotypes of research's social value

Study 2: Informal collaborations between Social Sciences and Humanities researchers and non-academic partners

Study 3: Knowledge transfer activities in Social Sciences and Humanities: explaining the interactions of research groups with non-academic agents

CHAPTER 5

STUDY 1:[42]

ARE 'STEM FROM MARS AND SSH FROM VENUS'? CHALLENGING DISCIPLINARY STEREOTYPES OF RESEARCH'S SOCIAL VALUE

Abstract

There is a reasonably settled consensus within the innovation community that science, technology, engineering and mathematics (STEM) research is more 'useful' to societies than other kinds of research notably social sciences and humanities (SSH). Our paper questions this assumption, and seeks to empirically test whether STEM researchers' practices make their research more useful than SSH researchers. A critical reading of the discussion around SSH supports developing a taxonomy of differences: this is tested using a database covering 1,583 researchers from the Spanish Council for Scientific Research (CSIC). Results do not support that SSH research is less useful than STEM research, even if there are differences found in the nature of both transfer practices and their research users. The assumption that STEM research is more useful than SSH research needs revision if research policy is to properly focus on research useful for society.

Keywords: research policy, user engagement, knowledge transfer, research utilisation, social sciences and humanities.

---

[42] Developed with Elena Castro Martínez and Paul Benneworth.

5.1. Introduction

Is science, technology, engineering and mathematics (STEM) research more useful to society than other kinds of research, notably social sciences and humanities (SSH)? A recent provocation in *Nature* suggested that social science researchers were primarily concerned with disciplinary disagreements rather than contributing to solving contemporary societal problems (Van Langenhove 2012). Research policy discourse of late certainly seems to assume that is true (Nightingale and Scott 2007). Indeed, in observing the policy discussion, one gets the sense that there is almost a belief that STEM is made from some kind of superior stuff, that STEM is from the hard useful Mars whilst SSH is a soft Venusian luxury (*cf.* Gray 1992). In this paper we explore the extent to which this assumption is valid. And regardless of which side of the debate you find yourself on, we believe that this policy assumption is something that needs empirical testing.

We begin by contending that debate has been too constrained by indicators: problems in finding suitable indicators have been used to draw the inference that this means the SSH research has no impact. However, inspired by other research (e.g. Bate 2011; Hughes et al. 2011) we note the well-documented existence of engagement practices by SSH researchers, which imply relationships with 'users', and 'users' imply utility. We therefore see here a potential contradiction, as if SSH research were less useful than STEM, then one would expect that there would be material differences in researchers' practices in ways that made that research less useful.

Our paper starts from the widely noted position that good indicators for measuring the impact of arts and humanities research are missing (*cf.* AWT 2007; British Academy 2008; Crossick 2009; Algra et al. 2011; Bate 2011) and that over-simplistic indicators for social sciences and humanities might cause an important damage in these areas (Donovan 2005; British Academy 2008). This is not to say that indicators do not exist, but that they do not fulfil Van Vught and Westerheijden's definition of allowing transparency and comparability between disciplines (2010). And this is where we see the problem in the debate –a failure to find appropriate 'transparent' impact indicators has become an assumption that SSH research does not have an impact, and is not socially useful or relevant (Hessels et al*.* 2009).

As a result, governments focusing on research that can drive economic growth (Kaiser and Prange-Gstöhl 2010; DG RESEARCH 2011) are regarding SSH as not worthy of investment. As argued more generally by O´Neill (2011: v) '*some held that in straitened times all public funding should go to research in science, technology, engineering and medicine.'* When combined with Van Langenhove's argument that social science research makes no useful contribution, this adds up to a powerful prescription to slash funding to social sciences fields. But if this were based on a fallacy, then this policy would be wrong-headed, and therefore we argue that good science policy making demands addressing the question of whether SSH is less useful than STEM.

We argue that this is not an issue which can be determined *a priori:* in this paper, we develop a set of empirical criteria which allow us to determine whether SSH research is less societally useful than STEM research. We then test this criteria set in a single empirical case, the Spanish Council for Scientific Research (CSIC). Our argument is that if the policy assumption holds, that STEM is more useful than SSH, then that will be visible in the comparative user engagement practices of STEM and SSH researchers. We argue that a 'user engagement practice' necessarily implies the existence of relationships with users, and the existence of 'users' implies that the research is useful to someone, itself a pre-condition for wider societal value. Thus, our framework offers a set of criteria that allow it to be empirically established whether SSH research is less useful or differently useful. This in turn allows a contribution to be made to the urgent policy debate of whether SSH are *a priori* less useful and therefore less worthy of funding than STEM.

The structure of the paper is as follows. In section 5.2 we classify disciplinary differences distinguishing those that affect social utility of their research from those that do not. In section 5.3 we identify some stylized facts regarding SSH research differences which might account for –from the theory– why this systematic disadvantage and bias afflicts social sciences and humanities. We then formulate hypotheses which are suitable to experimental testing. In section 5.4 we present an overview of the data and methodology for this study and we set out the variables used to test the hypotheses and their descriptive statistics. On the basis of the results about differences presented in section 5.5, in section 5.6 we provide a discussion of them and offer some implications and policy recommendations.

5.2. Social Sciences and Humanities context in the science system

Our starting point is that there is a policy problematic in assuming that SSH's lack of economic impacts means that it is less socially useful. Policy-makers seek macro-scale benefits, and economic outputs give them a way to claim these benefits. Policy-makers have internalised this message and sought to increase and concentrate funding on areas that bring the greatest narrowly-economic returns (*cf.* Kaiser and Prange-Gstöhl 2010; Leisyte and Horta 2011). But this mistakenly suggests that total societal returns to public investments in research are higher for STEM subjects. Spin-offs and patent licensing income have never been more than suggestive of a much wider and only partly economically-calculable set of social benefits that research brings (Pavitt 1991; Nightingale and Scott 2007). We therefore ask whether, taking a much wider reading of utility:

> "Is social science and humanities research different to science, technology, engineering and mathematics research in ways that make it systematically less useful to society?"

There is extensive research suggesting that SSH does have real and broad impacts: for brevity's sake, we restrict our discussion to Spanish and British examples. In Spain, the SIAMPI project identified extensive impacts where clear public benefits were created, including culture and heritage, neatly illustrated through examples from road and public safety. Public prosecutors worked with philosophy researchers at CSIC to provide deep understandings of the roots of driver behaviour in designing their strategies for dealing with traffic offenders. Work between police forensics research laboratories and a linguistic research group of CSIC contributed to increasing arrest and prosecution rates (Molas-Gallart et al.

2010). However, a SIAMPI report noted that whilst the preservation of the cultural heritage is a valuable impact, assessments considering its economic value depend on the extent to which popular demand for these cultural goods can be considered to be a crucial element in the impact assessment (Molas-Gallart et al. 2010).

In the UK context, there is a wealth of evidence that humanities research produces societally useful outputs (Hughes et al. 2011). Jonathan Bate's edited collection "The public value of the humanities" assembled 22 case studies of how particular research projects led to public outputs. In many cases the authors could enumerate these benefits: a vivid example was a piece of film research that led to a 3 hour TV series watched by over a million viewers (Toulmin 2011). More generally, the UK's (statutory) Higher Education Business and Community Interaction Survey (HEBCIS) collects a suite of engagement activities counting attendances at lectures, exhibitions and museums run by universities.

SSH clearly produces benefits in terms of things that users value, although not always in ways that permit a simple traceability of macro-economic impacts. How can we interpret the fact that, although SSH research creates social impacts, as eminent a public scientist as Van Langenhove can criticise their generic lack of utility? We ascribe this to a notion of difference, that STEM is somehow different from SSH. We therefore see that the problematic in the public policy debate can be stylised as a disagreement about the nature of this difference, corresponding to two positions:

- STEM research produces different kinds of outputs to SSH research (more easily traceable to macro-economic impacts, *cf.* Nightingale and Scott 2007; Hessels et al. 2009)

- STEM research produces more useful outputs than SSH research (more people find their output more useful, *cf.* Van Langehoven 2012)

We argue that the current policy debate has, for reasons of inadequate indicators, disregarded this issue of SSH being differently useful to STEM. We argue that these two positions can be regarded as two contradictory hypotheses which are empirically resolvable. And this is the issue that we test in this paper, whether SSH is less useful than STEM, or differently useful. To operationalize this idea of usefulness beyond narrow economic or monetary terms (which however imperfect and restricted, at least gives a comparable measure of economic use), we are drawn into wider debates about the social value of research.

There are not good frameworks for comparing how publics value intangible benefits in non-economic ways, and therefore we restrict ourselves to seek only to take a first step. We use researcher practices engaging with 'users' as a proxy for usefulness. If STEM was really more useful to society than SSH, then we would expect to find that STEM researchers' practices were more oriented towards users than SSH researchers' and Hughes et al*.* (2011) suggest that this is not the case. 'Users' we here define as agents with whom researchers interact in the process of their knowledge flowing into society.

To sharpen that intuitive definition, in this paper we draw on Spaapen *et al.*'s idea of productive interactions as representations that research is useful to 'users': they define three types, namely personal contacts directly interacted with, audiences interacted with via artefacts, and customers engaged with through contracts with third parties (Molas-Gallart and Tang 2011; Spaapen and Van Drooge 2011). In this paper, for methodological reasons, we make a distinction between 'visible' users (i.e. direct contacts and contract partners) and 'invisible' audiences, based on the distinction of whether the researcher has a direct contact with that person receiving the knowledge.

5.3. Differences in the research and transfer practices

This then raises the issue of how would practices differ between STEM and SSH researchers? To do this, we explore the different kinds of 'claims' which various writers have made about differences between STEM and SSH, and seek to draw them into a typology from which to derive hypotheses. These 'claims' are different kinds of entity – some are backed by more or less robust evidence, whilst some are policy narratives which have assumed the form of 'common sense'. Because we are dealing with claims made by actors in a policy discussion, we do not here have a single model of how research produces impact: rather, these relate to differences in practices that might reduce a SSH researcher's likelihood of doing research that at some point has some kind of societal value.

In contrast to Olmos-Peñuela et al. (2012), and following our preceding argument, we classify these 'claims for difference in practices' by making a simple distinction of whether they imply that STEM is more useful, or simply differently useful:

- There are differences in practices which imply that STEM is more useful than SSH research: differences in practices here support the hypothesis that STEM is more useful than SSH.

- There are differences in practices which imply that STEM has a different way of making a societally beneficial contribution to SSH research: differences here support the hypothesis that STEM is differently useful to SSH.

We classify the eight claims about difference that are made as the first four suggesting that STEM is more useful to SSH, and the last four that STEM is differently useful to SSH. For each we give a brief explanation of the claim made, and derive a hypothesis in each case that SSH researcher practices is different to STEM researcher practices.

M1. SSH is more oriented towards national / regional audiences.
M2. SSH research tends to be less universal and to have smaller audiences.
M3. SSH research cannot give answers but only insights into problems.
M4. Lack of visibility of the contribution SSH makes to social development.
D1. SSH research does not need to try to be useful to be useful.
D2. SSH researchers collaborate less with business users who are a visible group.
D3. SSH researchers collaborate with government agencies rather than firms.
D4. SSH researchers collaborate with community users rather than firms.

SSH tends to be more oriented to national / regional audiences

In science policy contexts it is assumed that SSH are far more particular and specific than STEM, the latter producing universal laws and explanations. SSH and arts activities are especially important at closer geographical levels (British Academy 2004) and highly oriented towards regional or specific cultural communities. As noted by Edgar and Pattison (2006: 97-98):

> *'The humanities still speak to specific communities, unlike the natural sciences that at least aspire to speak to a universal humanity... [humanities] still appear to speak in the voice of particular communities and about issues that concern particular communities'.*

The SSH research is very often strongly context-oriented and not easily extrapolated to other regions or communities. A critical reading of Bate's book (2011) "The public value of the humanities" demonstrates a broad spectrum of research topics, each one confined to a very specific research and specific audience. Conversely, STEM knowledge can be used in generating knowledge '*rooted in discovering increasingly and predictive universally applicable insights*' (Bakhshi et al. 2008: 15). According to this, we posit:

Hypothesis 1. The rate of involvement with national users compared to international users is higher for SSH researchers than for STEM researchers.

SSH to be less generalizable and to have smaller potential audiences

The second claim made about SSH and arts research is that individual pieces of research are not easily scalable; so a research project produces an exhibition that attracts a number of visitors but then the public life of that knowledge ends (Bakhshi et al. 2008) compared to STEM research. Here the claim is that SSH and arts research is intrinsically less useful because there are fewer potential users, meaning smaller impacts and users or audiences than for STEM research with its universalist possibilities (Bakhshi et al. 2008). Indeed, Hughes et al. (2011) find that UK arts and humanities researchers reported more often that their research was irrelevant for external organisations. Likewise, the SIAMPI project illustrates this characteristic through the example of the discovery, translation and publication of Spanish 16th century music and the limited type of audience interested on it (Molas-Gallart et al. 2010). Hence our hypothesis is that SSH researchers feel that few non-academic entities are interested in their specific research, that is:

Hypothesis 2. SSH researchers experience a lower demand for their research than is correspondingly the case for STEM researchers.

SSH does not give concrete answers but insights into problems

One of the key problems is that different SSH disciplines purport to be able to talk authoritatively about the same subjects but different fields have quite different ways of looking at those subjects. The great example is economics, where one's theoretical perspective produces wildly differing interpretations of similar events, a very confusing message for policy makers, and clearly contrasting with STEM research's clear laws and universals. Some subjects use hermeneutic, inductive approaches, as noted by Bakhshi et al. (2009: 110): '*the arts and humanities develop and re-evaluate earlier ideas and sources of evidence, viewing them from new perspectives and new contexts.'* For the public, the STEM disciplines give hard answers to questions without this grey area for interpretation and are regarded as authorities in their fields. Conversely, SSH researchers become one voice amongst many in a crowded global marketplace of ideas, with opinions as equal to those of think-tanks or lobbyists.

Therefore the claim is that SSH disciplines talk less authoritatively about the world, reducing the utility of their knowledge by being contingent and disputed rather than universal and established. Of course, it could also be claimed that SSH's subject domain is more complex and less knowable, and a diversity of approaches provides depth in understanding the issues and problems. But there is still circulating a set of claims that SSH is more akin to interpretations whilst STEM research is more authoritative. We would expect SSH researchers to feel more threatened by having to test the validity of their research compared to STEM. Thus, we suggest the following hypothesis:

Hypothesis 3. SSH researchers have less interest in checking the validity and applicability of their research than STEM researchers.

The lack of visibility of SSH's contribution to social development

The last difference claim that implies that STEM research is more useful than SSH research is the lack of visibility of SSH research that leads to its under-utilisation: SSH disciplines are too often too far from their eventual users which reduces the visibility of their research output. This claim is a version of the argument that SSH research is more theoretical and relates more exclusively to solving theoretical rather than practical problems. Based on Frascati Manual classification of basic/applied research (OECD 2002), Gulbrandsen and Kyvik (2010) found in Norwegian universities that a larger proportion of humanities academics compared to other fields classified their activities as 'basic'.

An alternative categorisation is the Stokes Quadrant Model (1997)[43] that classifies research along two dimensions: theoretical excellence and practical relevance, and used in previous studies (Abreu et al. 2009; Hughes et al. 2011). Hughes et al. (2011) find that academics from arts and humanities describe their research as basic, with a higher orientation to the pursuit of fundamental understanding (Bohr Quadrant) compared to the rest of the areas. Then, we would expect to find STEM researchers located in the Edison or Pasteur Quadrants, if they are more concerned with considerations of use and relevance whilst SSH researchers to be more oriented to basic and excellent research which corresponds to the Bohr Quadrant. We therefore posit the following hypothesis:

Hypothesis 4. SSH researchers are more concerned with the pursuit of fundamental understanding whereas STEM researchers are more focused on considerations of use.

There is of course here a counter-claim, namely that SSH do not readily fit into to a simple STEM-derived technology transfer or knowledge transfer model (Hartley

[43] According to the quadrants proposed by Stokes (1997): Bohr´s Quadrant represents research concerned solely with the pursuit of fundamental understanding; Edison´s Quadrant represents research solely interested in considerations of use and Pasteur´s Quadrant represents the combination of both fundamental understanding and considerations of use.

and Cunningham 2001; Bakhshi et al. 2009; Jaaniste 2009). The dominant model focuses on narrow indicators only counting formalised and transactional activities, that is to say contractual relationships between an academic unit and a non-academic agent in a way that creates a legal entity that can easily be counted – such as a contract, patent license, non-disclosure agreement or co-operative Heads of Agreement. However, these institutionalized knowledge transfer activities (Geuna and Muscio 2009) only represent a fraction of universities' full suite of interactions with and impacts upon society (D'Este and Patel 2007; Perkmann and Walsh 2007) and ignore more informal collaborations. Tacit knowledge plays a more prominent role in SSH and arts than it does in STEM (AHRC 2009: 15) hence, SSH are characterised by a lower codified research (Pilegaard et al. 2010) and a higher relevance of personal contacts between researchers and users (British Academy 2008). Indeed, SSH is dominated by informal collaborations that do not leave an audit trail (Castro-Martínez et al. 2011). Conversely, STEM research gives tangible products or technologies that require formal intellectual property recognition protection. Indeed, a recent study conducted in the UK context (Abreu and Grinevich 2013) show lower levels of engagement of SSH researchers in formal commercial activities compared to other sciences and engineering disciplines. Therefore, in a context where science's contribution is measured through narrow transactional indicators –SSH is dominated by informal collaborations and STEM researchers are more likely to use formalised interactions–, we propose the following hypothesis:

Hypothesis 5. SSH researchers use a lower proportion of formal pathways to interact with non-academic actors compared to STEM researchers.

SSH's usefulness is delivered by SSH not trying to be useful

One claim often made by SSH's advocates is that unlike STEM disciplines, social sciences and the humanities are claimed to have a higher purpose beyond the direct and visible application to economic growth. They provide a lens enabling society to understand about generic and fundamental questions about the past, the present and the future, and about the ethical and cultural values that shape society (*cf.* Bigelow 1998, cited in Bullen et al. 2004; British Academy 2004). SSH researchers are '*opinion-makers and are called upon everyday media as experts*' (Stannage and Gare 2001: 111) to address issues such the crisis, unemployment, immigration, and other social problems (Kyvik 1994; 2005; Bentley and Kyvik 2011). Conversely, STEM research is more weakly linked to current events or to understanding a contemporary social phenomenon: consider the recent discovery of the Higgs Boson –the event was its discovery and all media engagement depended on when it was found. According to previous studies, SSH researchers would be more engaged in popularisation activities such as radio, television, press and conference activities whereas STEM researchers would be more represented in institutional activities such as open door events (Jensen and Croissant 2007: 4). Consequently we posit:

Hypothesis 6. SSH researchers spend more time in popularisation activities than STEM researchers.

Business users are a more visible group than government or community

Another claim that arises about differences between areas is related to the non-academic agents with whom researchers collaborate. STEM tends to have a greater common form of engagement, via firms, whilst the contributions of SSH are more diverse, coming through different kinds of contributions through the public and voluntary sectors as well as direct with publics through engagement. Our argument is that SSH appears to be less useful because of having a less singular form of engagement, with diverse groups, whilst STEM subjects benefit from having collaboration activities with firms which are a collective more amenable to aggregation by policy makers. Hence, the hypotheses proposed are:

Hypothesis 7a. SSH researchers collaborate less with firms than STEM researchers.

Hypothesis 7b. SSH researchers use fewer pathways collaborating with firms than STEM researchers.

SSH research users tend to be government agencies

A simple way of expressing this claim is the frequently evoked image of the humanities as an ivory tower, and SSH as disconnected from society. There being no interaction between academics and non-academics in these disciplines, and then SSH disciplines make no socio-economic contribution. However, that is an assumption apparently deriving from technology transfer and knowledge transfer studies, primarily focused on university-industry relationships rather than a wider set of users (Hughes et al. 2011). The range of potential users of academic research can be expanded to all science-society interactions including government agencies (see British Academy 2008 for further details on SSH contribution to the public policy). Indeed, in the Australian context government department and agencies are the most frequently cited clients of SSH and arts (Gascoigne and Metcalfe 2005), and in the British context, arts and humanities are more involved with the public sector (38%) than with the private sector (30%) (Hughes et al. 2011). From this literature, we posit:

Hypothesis 8a. The frequency of collaborations with government agencies compared to firms is higher for SSH researchers than for STEM researchers.

Hypothesis 8b. SSH researchers use more pathways collaborating with government agencies than STEM researchers.

SSH research users tend to be community users

As indicated in the previous claim, we can find a very diverse 'set' of users of SSH research if we consider science-society interactions rather than science-industry interactions. By expanding this approach, we identify a variety of users varying in terms of their economic power, their ability to engage academics, and their motivation to work with them. Other than the public sector (previously presented), SSH is closely linked to community users such as non-profit organisations, as showed in the Spanish context (Castro-Martínez et al. 2011). Moreover, in the British context, arts and humanities academics are highly engaged with the charitable sector (46%) (Hughes et al. 2011). Based on previous studies, we suggest the following hypotheses:

Hypothesis 9a. The frequency of collaborations with non-profit organisations compared to firms is higher for SSH researchers than for STEM researchers.

Hypothesis 9b. SSH researchers use more pathways collaborating with non-profit organisations than STEM researchers.

Our argument is that these claims are clearly overlapping and provide a means to identify whether SSH researchers' practices do differ from that of STEM researchers and in which areas. Therefore, although some of the hypotheses might seem obvious, what is important is the composition of the ways in which differences in practices in aggregate varies between the two groups. A full summary of these nine hypotheses is presented at Appendix Table 5.A.1. The hypotheses are tested using a database of researchers working at the Spanish Council for Scientific Research (CSIC). In order to better frame the testing process, we now provide an explanation of the variable construction and the dataset.

5.4. Data and methodology

5.4.1. Population and data collection

The empirical study is focused on the CSIC, the largest public research organisation in Spain and the third largest in Europe. CSIC emerged in 1939 after the civil war, and was built on the remnants of the research centres of the dissolved *Junta de Ampliación de estudios* (created in 1907). The mission of this organisation is to develop and promote research through its institutes in the interest of the scientific and technological progress. In 2011, CSIC had 126 research institutes distributed throughout Spain and it had 14,050 employees distributed as civil servants (41.9%), contract workers (50.3%) and research fellows (7.8%). The organisation is distributed around eight main areas of knowledge[44]. In economic terms, CSIC resources in 2011 came from direct transfers from the government budget (60%) and external resources (40%) coming from regional, national, and international competitive R&D programmes and contracts with companies and organisations (CSIC 2012). Compared to Spanish universities, CSIC is the better performed institution in contracting with public and private entities, in the number of patents registered and internationalized and in technology licensing. Furthermore, CSIC generates 20% of the Spanish scientific production with an amount of personnel that represent 6% of the total staff engaged in R&D in Spain.

We use a recent database assembled by two institutes[45] from the CSIC in the framework of the IMPACTO project, commissioned by the CSIC. The project aims to empirically determine the nature and characteristics of CSIC researchers' relationships with firms, government agencies and other social agents as well as the factors affecting them. We consider that this database is suitable to conduct an exploratory analysis to test differences between SSH and STEM since it directly tackles the aspects addressed through our hypotheses and since data allows comparison by area of knowledge. More specifically, the database contains the answers from scientific researchers (civil servants[46] or researchers contracted through *JAE-Doc*, *Juan de la Cierva*, *Ramón y Cajal* or similar post-doc programs) with a doctoral degree and the right to act as principal researchers and enter into contracts with other entities. The CSIC Human Resources Department identified, at 30th November 2010, a total of 4,240 researchers meeting these requirements.

A questionnaire was developed from a literature review on the effects of public research, built on conceptual foundations analysing the role of public research in business R&D and innovation processes, with a special emphasis on those studies

---

[44] CSIC is divided into eight scientific areas, namely 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; Natural Resources. These last seven scientific areas belong to STEM.

[45] The research institutes from CSIC involved in the IMPACTO project were INGENIO (Institute of Innovation and Knowledge Management) and IESA (Institute for Advanced Social Studies).

[46] Following CSIC's organisational level, scientific civil servants can hold the categories of tenured scientist, scientific researcher and research professor. Teachers and professors from universities which are attached to CSIC have been included in the category of tenured scientist and research professor, respectively.

that reflect different transfer mechanisms and their impacts (Bonaccorsi and Piccaluga 1994; Cohen et al. 2002; Schartinger et al. 2002; Azagra-Caro 2007; D'Este and Patel 2007). Following the theoretical and empirical review, five main conceptual dimensions were identified and included in the questionnaire, namely researchers’ profile and their research activity; researchers’ relationships with non-academic agents; barriers to establishing relationships; engagement in dissemination activities; and results of researchers’ relationships with its socio-economic environment (see Appendix Table 5.A.2 for further details on the questionnaire structure).

Two contextual conditions would suggest the questionnaire was well understood by its respondents. Firstly, the questionnaire is addressed to the academic community, who share the same language to address topics related to research and collaborative practices. Second, the implementation of the CSIC Institutional Action Plan (2006-2009) has sensitised the researchers to the questionnaire’s concepts and terminology. We also conducted a pre-test of the questionnaire on forty five CSIC researchers of the different scientific areas of knowledge in which the CSIC is structured, to ensure that all the questions were well understood by respondents. Researchers firstly completed the test questionnaire and then participated in a telephone interview in which they provided their opinion about the questionnaire.

Societal usefulness is a relevant topic in the policy agenda of the institution and the implementation of instruments to measure engagement may mean that CSIC researchers tend to report an overly positive attitude towards this agenda in their responses to the questionnaire. However, we are confident that this has not been the case for the following reasons. Firstly, the historical mission of the CSIC of conducting useful research and contributing to the societal development is not new; therefore, researchers have always had these values embedded in their practices to some extent. Second, the autonomy of individual researchers based on both their tenured positions and their independent access to national and international competitive research funding may also reduce researchers’ sense of obligation to provide an answer compatible with current research governance regarding the usefulness agenda. Finally, sixteen pilot interviews conducted at the beginning of the project reflected that researchers were adopting a critical position on the discourse of usefulness and engagement, which is likely to have reduced any undue positive biased in the answers reported.

Data collection took place between 7th April 2011 and 24th May 2011 through the population e-mails provided by the CSIC Human Resources Department. The type of strategy conducted for data collection was multi-method; combining online questionnaires with telephone follow-up to ensure a final sample proportionally distributed by areas of knowledge and professional categories. Given the relevance of multiple contacts with the respondents to maximise responses to email surveys (Dillman 2007), an invitation email was sent from the Presidency to all the population, followed by the on line questionnaire, two reminder emails to the population who did not respond and a final follow-up by telephone. The final response rate was 37%, corresponding to a sample covering 1,583 researchers. Population and sample distribution by area of knowledge is reported in Table 5.1. Chi Square tests confirm that there are no statistical differences between the population and sample distribution by scientific area of knowledge (nor within SSH for its fields), except for agricultural sciences which is slightly overrepresented in the sample.

Table 5.1: Population and sample distribution by area of knowledge

	Population (N)	Population (%)	Sample (N)	Sample (%)	% Differences χ^2 test (*)
STEM	**3,838**	**90.5%**	**1,466**	**92.6%**	**2.1%**
Biology and Biomedicine	771	18.2%	244	15.4%	-2.8%
Food Science and Technology	285	6.7%	128	8.1%	1.4%
Materials Science and Technology	562	13.3%	201	12.7%	-0.6%
Physical Science and Technology	569	13.4%	204	12.9%	-0.5%
Chemical Science and Technology	480	11.3%	209	13.2%	1.9%
Agricultural Sciences	412	9.7%	203	12.8%	3.1%*
Natural Resources	759	1.,9%	277	17.5%	-0.4%
SSH	**402**	**9.5%**	**117**	**7.4%**	**-2.1%**
Social Sciences	127	3.0%	40	2.5%	-0.5%
Humanities	275	6.5%	77	4.9%	-1.6%
TOTAL	**4,240**		**1,583**		

Source: adapted from the IMPACTO project.
Note: χ^2 test has been used to assess whether there are differences between the population and the sample distribution for each area of knowledge.
(*) indicates statistical differences at 5%. Agricultural sciences are statistically overrepresented in the sample.

Of course, using this database does bring impose some limitations on the validity of our findings and for the sake of completeness we explicate these shortcomings. Firstly, the database includes exclusively CSIC researchers, with university researchers not being included. But focusing on CSIC allows obtaining a homogenous population similarly affected by the same contextual conditions, which is preferable to explore the validity of our hypotheses. Secondly, all scientific fields are not equally represented in CSIC, but this is a common feature in academic organisations in which some areas of knowledge have a higher weight than other. In this sense, the sample obtained is a version of the reality as its composition reflects CSIC's structure by scientific area of knowledge. Thirdly, we are using an existing database in which the questions predated our paper. This limitation is partly (and we believe sufficiently) mitigated by the adequacy of the questionnaire from which the database is constructed: it is exclusively restricted to two kinds of users, partners and customers (i.e. direct interactions) rather than audiences engaged with at a distance (*cf.* Spaapen and Van Drooge 2011). Nevertheless, the questionnaire covers researchers' practices and researchers' collaborations with non-academic agents, which are the aspects addressed in all the hypotheses proposed. Moreover, all scientific fields are covered in the database, which allow for conducting comparisons between STEM and SSH. On balance, we consider that despite these limitations, it is still reasonable to propose using the CSIC database as the foundation for our exploratory analysis. In the following section we present the variables used from the questionnaire to test the hypotheses proposed.

5.4.2. *Variables and test considerations*

To test the hypotheses proposed, we use a number of variables constructed from the CSIC questionnaire. In constructing each variable we have taken the nine hypotheses and sought to identify from the questionnaire a question which allows us to see practices relevant to that hypothesis. We argue that each variable represents one practice within the set of all practices that might correspond to each hypothesis, but not necessarily that it is the best variable. We justify this on the grounds of this being a piece of exploratory research seeking to understand whether differences in practice do exist, and if so, then what their apparent ramifications are. We would not advocate using these variables as a complete measure of user engagement practices, and we would not, at this stage, recommend adopting them more widely as ‘indicators’ for social value. The detailed variable definition is presented in Table 5.2.

Table 5.2: Definitions of variables

		Measure	Method (Range)
Continuous variables			
National Orientation	•	The number of different types of national entities divided by the number of different types of international entities with whom the researcher has collaborated over the last 3 years. This variable is constructed following three-step procedure. Firstly, we codified in binary variables 5 assertions regarding the researcher’s collaborations with different national entities and international entities. Therefore, we coded ‘1’ each variable if the researcher indicated that he/she has collaborated with at least one of the following entities: firms located in Spain; government agencies; non-profit organisation; firms located outside of Spain; and international organisation, over the last 3 years; and ‘0’ otherwise. Secondly, three of these binary variables are used to construct a three-item variety index ranging between 0 and 3 (national entities) regarding whether or not a researcher has collaborated over the last 3 years with the following national entities: 1) firms located in Spain; 2) government organisation; 3) non-profit organisation. The two remaining entities named firms located outside of Spain and international organisation are used to construct a two-item variety index ranging between 0 and 2 (international entities) regarding whether or not a researcher has collaborated over the last 3 years with these two international entities. Thirdly, the variable [National Orientation] is then constructed as a percentage by using the following formula: [National Orientation]= (national entities) / (international entities) * 100	Ratio
Formality	•	The percentage of the formal pathways used by a researcher to collaborate with non-academics related to the total pathways used over the last three years. This variable is constructed following three-step procedure. Firstly, we codified in binary variables 14 assertions regarding the researcher’s collaborations activities with different entities. Therefore, we coded ‘1’ each variable if the researcher indicated that he/she has collaborated with at least one of the following entities: firms, government agencies, international organisations or non-profit organisations, over the last 3 years; and ‘0’ otherwise. Secondly, eight of these binary variables are used to construct an eight-item variety index ranging between 0 and 8 (formal pathways) regarding whether or not a researcher has developed the following collaborative activities with firms, government agencies, international organisations or non-profit organisations over the last 3 years: ➔ Contract research *(original research project totally sponsored by the contracting entity)* ➔ Collaborative research funded by a Spanish public program ➔ Collaborative research funded by international programs *(Framework Programme or similar)* ➔ Courses and specialized training activities taught by the CSIC ➔ Use of CSIC´ infrastructures or equipment by this entity ➔ License of patents *(or other types of Intellectual Property Protection)* ➔ Creation of a new firm in partnership ➔ Participation in the creation of a new centre or joint unit of R&D The six remaining binary variables are used to construct a six-item variety index ranging between 0 and 6 (informal pathways) regarding whether or not a researcher has developed the following collaborative activities with firms, government agencies, international organisations or non-profit organisations over the last 3 years: ➔ Occasionally contacts or consultations *(not formalised through a contract or an agreement)* ➔ Technical services, technical reports or technological support ➔ Temporal stay of a person of your team outside the academia ➔ Training of postgraduates outside the academic *(including PhD Thesis)* ➔ Consultancy through committees and expert meetings ➔ Participation in diffusion activities in professional environment *(congress or professional conferences, trade fairs)* Thirdly, the variable [Formality] is then constructed as a percentage by using the following formula: [Formality]= (formal pathways) / (formal pathways + informal pathways) * 100	Ratio

Table 5.2 (Continued): Definitions of variables

	Measure	Method (Range)
Continuous variables		
Popularisation	• Measured as the percentage of time spent by the researcher on popularisation activities (e.g. publications of articles in newspapers or in textbooks, participation in radio or television programs, in "science weeks, etc.).	Ratio
Government Agencies	• Measured as the frequency of collaborations with government agencies divided by the frequency of collaborations with firms located in Spain over the last 3 years. The frequency of these collaborations are both measured using a 4-point Likert scale ranging from '1'= *Zero times* to '4'= *Seven or more times.*	Ratio
NPO	• Measured as the frequency of collaborations with non-profit organisations divided by the frequency of collaborations with firms located in Spain over the last 3 years. The frequency of these collaborations are both measured using a 4-point Likert scale ranging from '1'= *Zero times* to '4'= *Seven or more times.*	Ratio
Diversity of pathways of interactions with: a)Firms b)Government agencies c) NPO	• Measured using a fourteen-item variety index regarding whether or not the researcher has collaborate in different activities with a) firms; b) government agencies; c) non-profit organisations; over the last 3 years. The activities included are the fourteen items previously used in the definition of the variable [Formality].	Sum (0-14)
Categorical Variables		
User Demand	• Measured using a 4-point Likert scale ranging from '1'= *Not at all* to '4'= *Often* to indicate the answer of the researcher to the following question: 'To what extent the little interest of other entities about your research is an obstacle to establish relationships with other entities?'	Ordinal (the scale ranges between 1 and 4)
Check Validity	• Measured using a 4-point Likert scale ranging from '1'= *Not important* to '4'= *Very important* to indicate the degree of importance for the researchers of the following assertion: 'the motivation to establish relationships with other entities is to check the validity or practical application of the research developed.'	Ordinal (the scale ranges between 1 and 4)
Stokes Quadrant	• Categorical variable coded '1' if the researcher's research is classified in the Linnaeus Quadrant; '2' in the Edison´s Quadrant; '3' in the Bohr´s Quadrant and '4' in the Pasteur´s Quadrant (more details at Appendix Table 5.A.2). The variable [Stokes Quadrant] is operationalized by using two variables: 1). the extent to which scientific activity is inspired by making contributions to fundamental understanding; and 2). the extent to which researcher activity is inspired by considerations of use. The construction of the categorical variable [Stokes Quadrant] used in this paper is based on these two variables and was derived in a two-step process. First, we codified both variables ('fundamental understanding' and 'considerations of use') into '1' (high) if the researcher has answered 'a lot' and '0' (low) otherwise. Second, the four configurations of scientific research orientation were characterized by combining the two variables in the following manner: - *Linnaeus Quadrant*: low fundamental understanding and low consideration of use - *Edison Quadrant*: low fundamental understanding and high consideration of use - *Bohr Quadrant*: high fundamental understanding and low consideration of use - *Pasteur Quadrant*: high fundamental understanding and high consideration of use	Nominal
Firms	• Measured using a 4-point Likert scale ranging from '1'= *Zero times* to '4'= *Seven or more times* to indicate the frequency with which a researcher has collaborated with firms located in Spain over the last 3 years.	Ordinal (the scale ranges between 1 and 4)
Area	Dichotomous variable: • coded '1' if the researcher belongs to the SSH area and '0' if the researcher belongs to the STEM area. STEM area encompasses the following sub-areas: 1) Biology and Biomedicine; 2) Food Science and Technology; 3) Materials Science and Technology; 4) Physical Science and Technology; 5) Chemical Science and Technology; 6) Agricultural Sciences; 7) Natural Resources.	Binary

All the variables used to test the hypotheses are ordinal or continuous variables except for the variable referred to the Stokes Quadrant. Therefore, for ordinal and continuous variables (distributions not matching with a normal distribution) we use the Mann Whitney test (U) to statistically assess whether there are differences in the sampling distribution of the different variables for SSH and STEM areas. For the categorical variable [Stokes Quadrant] we use the independency Chi Square test (χ^2) to assess whether there are similarities between SSH and STEM researchers in their distribution between the four categories proposed by Stokes (1997): Linnaeus[47], Edison, Bohr and Pasteur.

5.5. Empirical results

5.5.1. Descriptive statistics

The descriptive statistics of the variables used in this study corresponding to *all* areas are reported in Table 5.3. The weight of SSH researchers in the whole sample is 7.4%. More than half of the researchers reported to be positioned in the Bohr Quadrant (research highly inspired by fundamental understanding and lowly by consideration of use), followed by the Pasteur Quadrant with 22.2% and Edison Quadrant with 9.7%. The average percentage of time spent by researchers on popularisation activities is 4.04%.

More than 80% of the respondents declare that checking the validity or practical application of the research developed is an *important* or *very important* motivation to establish relationships with other entities. Likewise, more than half researchers report as *quite* or *a lot* the extent to which the little interest of other entities about their research is an obstacle to establish relationships with them.

In their relationships with non-academic entities, 43% of the pathways of collaboration used by researchers are formal. The average ratio of research collaborations with national entities, in comparison with international entities is 72%. Slightly less than one quarter of the respondents do not collaborate with

[47] Alrøe and Kristensen (2002).

firms over the last three years whereas almost 15% do it seven times or more. Indeed, the most frequent case is to collaborate with firms one to three times in the considered period. Moreover, on average, the respondents score 2.60 of a possible maximum of 14 on the variety index of collaborative activities with firms.

Related to the rate of collaborations with agents other than firms, we find on average that the ratio of researchers´ collaborations with government agencies and NPO, in comparison with firms, is respectively 1.18 and 0.84. Focusing on the diversity of researchers' pathways of collaborations, results indicate that respondents score 4.15 and 0.78 of a possible maximum of 14 on the variety index of collaborative activities with government agencies and NPO, respectively.

Table 5.3: Descriptive statistics

Continuous Variables	Type of variables	Mean	Standard deviation
National Orientation	Continuous: number	72.11	21.918
Formality	Continuous: number	43.31	17.944
Popularisation	Continuous: number	4.04	6.635
Government Agencies	Continuous: number	1.21	0.731
NPO	Continuous: number	0.86	0.533
Firms_pathways	Index: 14 items	2.60	2.519
Government_pathways	Index: 14 items	4.15	3.024
NPO_pathways	Index: 14 items	0.78	1.564
Categorical Variables		**Distribution**	**Median**
User Demand	• *Not at all*	*14.4%*	
	• *A little*	*31.3 %*	
	• *Quite*	*35.3 %*	*Quite*
	• *A lot*	*19.0 %*	
Check Validity	• *Not important*	*2.7 %*	
	• *Some important*	*15.7%*	
	• *Important*	*48.8 %*	*Important*
	• *Very important*	*32.8 %*	
Stokes Quadrant	• *Linnaeus*	*10.0 %*	
	• *Edison*	*9.7 %*	
	• *Bohr*	*58.1 %*	
	• *Pasteur*	*22.2 %*	
Firms	• *0 times*	*23.8 %*	
	• *1-3 times*	*42.4 %*	*1-3 times*
	• *4-6 times*	*18.9 %*	
	• *7 or more times*	*14.9 %*	
Area	• *SSH*	*7.4%*	
	• *STEM*	*92.6%*	

Note that these descriptive statistics are referred to the whole sample (SSH and STEM together).

5.5.2. Statistical tests

To empirically test the hypotheses formulated, we apply the independence Chi Square test (χ^2) to assess the hypothesis 4, that is, the independence or not between SSH researchers and STEM researchers in their position in the Stokes Quadrant. The null hypothesis here is that there is independency between the two groups and is rejected if the *p-value* < .05. A Mann Whitney test (U) is applied for hypotheses 1 to 3 and 5 to 9 to know whether there are statistical significant differences between SSH and STEM. Note that for these hypotheses the null hypothesis is that there are no differences between SSH and STEM and is rejected if the *p-value* < .05. Results are presented in Table 5.4.

Are STEM disciplines more useful than SSH disciplines?

The first set of hypotheses tested is related to whether STEM research is more useful than SSH research. For the variable [National Orientation] there is evidence that there are differences in favour of the national orientation of SSH research: we reject the null hypothesis (H1) about the regional or national orientation of SSH as the *p-value* is 0.00. This is the only piece of evidence that suggests that SSH research might be less useful than STEM, by being more oriented to primarily national users compared to international users. For the remaining three utility indicators, there is no evidence to reject the hypotheses that SSH and STEM researchers' practices are similar.

For the variable [User Demand] measuring researchers' perception of the interest of users about their research, we cannot reject the null hypothesis (H2) as the *p-value* is 0.35. The literature predicted that SSH researchers would feel less interest or demand from users than STEM researchers in their research (*cf.* Hughes et al. 2011); nevertheless, this is not supported by our evidence and we have to move towards rejecting this hypothesis.

For hypothesis H3 [Check Validity] we cannot reject the null hypothesis as we obtain a *p-value* of 0.57. From our review, our starting hypothesis was that SSH researchers would be less interested in validating their research with users than STEM researchers. As SSH researchers conduct research regarded as less authoritative, we expected that they would be less interested than STEM researchers in checking the applicability of their research; however, our data does not support this assumption.

The result of the χ^2 test corresponding to the variable [Stokes Quadrant] indicates that we cannot reject the null hypothesis about independence in the research orientation (H4) as the *p-value* is 0.62. Thus, there are no differences between SSH and STEM regarding the distribution of the researchers within the Stokes Quadrant. Previous studies found differences between humanities and STEM, the former being more oriented toward fundamental understanding (Gulbrandsen and Kyvik 2010) and the latter more concerned with the use and relevance of the research (Hughes et al. 2011). However, contrary to what was expected, our data do not support differences in the way in which researchers orientate their research. Indeed, based on this result, we cannot assert that the lack of visibility of SSH research is due to differences in the way they conduct or orientate their research. Differences from previous studies could potentially be due to the fact that our analysis includes also social science disciplines (excluding arts disciplines). Nevertheless our data results move us to rejecting the idea of a difference between SSH and STEM in terms of research orientation.

Are SSH disciplines differently useful to STEM disciplines?

For the variables suggesting that STEM research is differently useful to SSH research, the following results are found. We analyse the variable [Formality] to test H5, whether SSH and STEM researchers use similar nature of pathways to engage with users. Our data supports the view that SSH researchers tend to use few formalised activities to collaborate with non-academic agents (Castro-Martínez et al. 2011). This is unsurprising: SSH research often does not need to subscribe contracts to agree to the confidentiality, protection and exclusivity of the research since this knowledge does not lose value when it is shared. Conversely, it is more usual the use of formal agreement to protect STEM research output though patent because their results may lose market value if they are disseminated before their protection.

The result of testing H6 [Popularisation] indicates that we can reject the null hypothesis (*p-value* = 0.00) and that SSH researchers spend significantly more time in these type of activities than STEM researchers. This result is in line with what the literature predicts and some previous studies (Kyvik 1994; 2005), implying that SSH researchers are willing to disseminate their research beyond the academia and to integrate it into public life because they have always considered contributing to the culture of society as part of their core activities, whilst for STEM, engagement in these activities is a more recent phenomenon.

Finally, we focus on the set of agents with whom researchers collaborate, that is, to the null hypotheses related to differences in the type of users. We propose that there would be statistically differences in both the intensity to which researchers are engaged with a specific user, and the diversity of pathways through which these collaborations take place. We test the intensity of these collaborations through the following hypotheses: H7a [Firms], H8a [Government Agencies] and H9a [NPO]; and the diversity of the pathways used to collaborate through the hypotheses H7b [Firms_pathways], H8b [Government_pathways] and H9b [NPO_pathways]. Mann Whitney test results indicate that for all six hypotheses, we can reject the null hypotheses as the *p-values* are lower than 1%.

The literature predicts that SSH researchers collaborate less with firms, and more with public bodies and non-profit organisations compared to STEM researchers, which is confirmed by our empirical data – as indicated by the means for SSH and STEM presented in Table 5.4 for these variables. Of course these results should be nuanced in the context of the knowledge economy, where SSH is highly involved in corporate development, for example through research around the concepts of organisational learning, organisational management and human resources, essential in the knowledge based economy. Likewise art and humanities is also increasingly important in the emerging cultural and creative sectors (European Commission 2010).

Our findings have been compared to a similar study conducted by Hughes et al. (2011) in the UK (see the last two columns of Table 5.4). The comparability of these studies is somewhat reduced by the fact that, unlike comparing SSH and

STEM, Hughes et al. (2011) compare arts and humanities with all other areas (including social sciences as well as STEM). Moreover, our analysis goes one step beyond a descriptive study through our use of inferential statistical analysis. Taken these considerations into account, we find that Hughes et al. (2011) results point in the same direction than ours except for two variables: [Stokes Quadrant] and [Government Agencies]. Overall, our results confirm those found in the British context and add richness to the study since we statistically test hypotheses to assess whether different usefulness can be inferred from researchers' practices.

Table 5.4: Results of statistical tests (U and χ^2)

	Null Hypotheses tested	Differences between SSH and STEM	Mean[a] SSH	Mean[a] STEM	Findings in Hughes et al. (2011)	Agree or Disagree
H1	$[\text{National Orientation}]_{SSH} = [\text{National Orientation}]_{STEM}$	**SSH** > STEM***	**76.95**	71.71	Cannot be compared.	n/a
H2	$[\text{User Demand}]_{SSH} = [\text{User Demand}]_{STEM}$	SSH = STEM	2.50	2.60	More A&H academics report that their research is of no relevance for external organisations (27%) compared to other academics (11%).	Agree
H3	$[\text{Check Validity}]_{SSH} = [\text{Check Validity}]_{STEM}$	SSH = STEM	3.09	3.12	A&H academics report the lowest score among all the disciplines to assess 'to test the practical application of their research' as a motivation or objective to interact with external organisations.	Agree
H4[b]	$[\text{Stokes Quadrant}]_{SSH} = [\text{Stokes Quadrant}]_{STEM}$	SSH = STEM	–	–	A&H academics are more likely to describe their research in the Bohr Quadrant (50%) and less likely in the Edison Quadrant (25%) and Pasteur Quadrant (25%) than other academics (27%, 46% and 31%, respectively). Exception: academics in health sciences are less user-inspired (Edison Quadrant) than A&H academics.	Do not agree
H5	$[\text{Formality}]_{SSH} = [\text{Formality}]_{STEM}$	SSH < **STEM*****	38.27	**43.72**	Cannot be compared.	n/a
H6	$[\text{Popularisation}]_{SSH} = [\text{Popularisation}]_{STEM}$	**SSH** > STEM***	**6.68**	3.83	A&H academics are more likely to be involved in outreach activities (44%) than other researchers (34%)	Agree
H7a	$[\text{Firms}]_{SSH} = [\text{Firms}]_{STEM}$	SSH < **STEM*****	1.96	**2.27**	A&H academics are less engaged with the private sector (30%) than other academics (43%).	Agree
H7b	$[\text{Firms\_pathways}]_{SSH} = [\text{Firms\_pathways}]_{STEM}$	SSH < **STEM*****	1.50	**2.69**	Cannot be compared.	n/a
H8a	$[\text{Government Agencies}]_{SSH} = [\text{Government Agencies}]_{STEM}$	**SSH** > STEM***	**1.71**	1.17	A&H academics' engagement with the public sector (38%) compared to private sector (30%) is lower than for other academics (56% and 43%, respectively).	Do not agree
H8b	$[\text{Government pathways}]_{SSH} = [\text{Government pathways}]_{STEM}$	**SSH** > STEM***	**4.90**	4.09	Cannot be compared.	n/a
H9a	$[\text{NPO}]_{SSH} = [\text{NPO}]_{STEM}$	**SSH** > STEM***	**1.38**	0.81	A&H academics' engagement with the charitable sector (46%) compared to the private sector (30%) is higher than other academics. (44% and 43%, respectively)	Agree
H9b	$[\text{NPO\_pathways}]_{SSH} = [\text{NPO\_pathways}]_{STEM}$	**SSH** > STEM***	**1.74**	0.71	Cannot be compared.	n/a

*** indicates that the coefficient is significant at the 1% threshold. n/a is used for not applicable. A&H is used for Arts and Humanities.

[a] Means are provided for ordinal variables for practical purposes: they indicate the direction of the differences between STEM and SSH.

[b] H4 has been tested with a χ^2 test.

5.6. Conclusions

The results as presented above –with the necessary caveats that they are at best exploratory– give an interesting insight into the nature of the differential utility of SSH and STEM research. The first point is that the evidence does not support the claim that SSH researchers' practices make them less useful to societal users than STEM researchers. They feel as much demand from direct users, they are willing to work with users around testing the validity of their findings, and they are certainly not more blue sky when measured in terms of the Stokes classification. They have a much higher orientation towards national (and regional) visible users than do STEM researchers, but that does not conclusively demonstrate that SSH research has less use because of the other indications that suggest that although more oriented to national communities, they are just as user-oriented.[48] Indeed, one then conceivably argue that SSH research does more to create national impact, something increasingly important in times of crisis. The conclusion of this would be that it would make sense for policy-makers to invest more in SSH research than in STEM research to drive recovery because that investment would be more likely to create national benefits. Of course, we would draw back from making that argument because of our research's exploratory nature, but we do believe that this counter intuitive finding is suggestive of more research being needed in this area more generally.

The second finding relates to where the material differences between STEM and SSH research do lie: clearly, STEM and SSH are characterised by different kinds of usability. SSH researchers tend to use less formal pathways to engage with visible users, and it is formal pathways that are more easily tracked and measured. SSH researchers are far more likely to get involved in popularisation activities than STEM researchers, participate in reach-out activities for a mass public audience. STEM researchers work with visible users that are relatively homogenous in terms of the kinds of things they seek –process inputs creating economic growth– whilst SSH researchers work with visible users who have a much more diverse range of uses for knowledge.

[48] One could conceive, for example, that some STEM subjects are more locally oriented, such as agriculture, and some SSH are more universally oriented, for example philosophy. This would therefore an emergent disciplinary property than related to the societal usefulness of that research.

Returning to our opening question, these results provide a clear answer. The question we originally posed was:

> "Is social science and humanities research different to science, technology, engineering and mathematics research in ways that make it systematically less useful to society?"

Our findings suggest that SSH research is different to STEM research, but not in ways that make it systematically less useful to society, thus corroborating Nightingale and Scott's (2007) contention. This likewise contradicts Van Langenhove's perception that social sciences scholars idealise themselves as living in ivory towers: whilst scholars may themselves say that that is what they think they do, this question was not asked in the survey. When we look concretely to what researchers reported doing, SSH researchers surveyed were not involved in practices that were less useful than STEM researchers: there were visible users for SSH research just as there were visible users for STEM research. The existence of visible users in turn suggests a group of entities that find CSIC SSH research useful.

More research is needed to replicate the work in other national contexts. An important issue to address here is the importance of differing demand and environmental conditions between SSH and STEM research. It is not clear that conceptualising the way social value of SSH arises within an innovation system framework makes sense. The fragmented, diffuse and indirect relationships between actors and the relatively limited roles that individual knowledge producers play in the eventual incorporation of SSH knowledge appear to shape practices in a deep-seated way allowing relatively comparable usability of the emerging knowledge.

Likewise, our findings suggest that SSH research does differ from STEM research in the way that it creates social value, so not directly by working with businesses but less visibly, creating content for the media and working with government and NPOs to contribute to improving quality of life. These findings are not surprising, because they are suggested claims in the literature (e.g. Bate 2011) but our research contributes by substantiating these points with the finding that the fact that they do not always provide direct economic utility is not accompanied by a lower practical orientation towards utility. Literature provides good explanations of why these differences might exist.

However, the fact that they exist suggests that new and better ways need to be found to understand how SSH research creates social value, and to re-embed these understandings in conceptual frameworks for research valorisation more generally.

This finding raises the interesting question of why this discursive distortion fallacy has emerged in the policy discourse, and there are a number of potential explanations that warrant further investigation. The first would be that there has been a change, and SSH used to be less useful than STEM, but has changed and the policy discourse will over time itself evolve to reflect this change. The second would be that it is a result of differential availability of statistics, and a general stronger trust and acceptance of statistics based on economic criteria. The third would be that it is an irrational belief that has become embedded in discourses and is sufficiently attractive to persist despite the contradictions that it raises. We therefore see that research is also needed into policy-makers behaviour to understand if they are adapting to this message, and how these new and better ways of understanding value can become implemented in policy-making and science instruments.

5.7. References

Abreu, M. and Grinevich, V. (2013) 'The nature of academic entrepreneurship in the UK: Widening the focus on entrepreneurial activities', *Research Policy*, 42/2: 408-22.

Abreu, M., Grinevich, V., Hughes, A. and Kitson, M. (2009) 'Knowledge exchange between academics and the business, public and third sectors', Cambridge: Centre for Business Research and UK-IRC, <http://www.cbr.cam.ac.uk/pdf/AcademicSurveyReport.pdf> accessed 15 November 2011.

AHRC (2009) 'Leading the World. The economic impact of UK arts and humanities research', Arts and Humanities Research Council, <http://www.ahrc.ac.uk/About/Policy/Documents/leadingtheworld.pdf> accessed 15 November 2011.

Algra, K., Bennis, H., van Henten, J.W., Kemperink, K., Mijnhardt, W., Rutten, P., Spaapen, J., Hilberdink, K. and Pen, M. (2011) 'Quality indicators for research in the humanities', Amsterdam: KNAW, <http://www.knaw.nl/Content/Internet_KNAW/publicaties/pdf/20111024.pdf> accessed 11 July 2012.

Alrøe, H.F. and Kristensen, E.S. (2002) 'Towards a systemic research methodology in agriculture: Rethinking the role of values in science', *Agriculture and Human Values*, 19/1: 3-23.

AWT (2007), Alfa en Gamma stralen. Valorisatiebeleid voor de Alfa- en Gammawetenschappen, Rijswijk: Adviesraad voor Wetenschaps- en Technologiebeleid.

Azagra-Caro, J. M. (2007) 'What type of faculty member interacts with what type of firm? Some reasons for the delocalisation of university-industry interaction', *Technovation*, 27/11: 704-15.

Bakhshi, H., Schneider, P. and Walker, C. (2008) 'Arts and humanities research and innovation', London: Arts and Humanities Research Council and NESTA, <http://www.nesta.org.uk/library/documents/arts-humanities-innovation-report.pdf> accessed 15 November 2011.

Bakhshi, H., Schneider, P. and Walker, C. (2009) 'Arts and Humanities Research in the Innovation System: The UK Example', *Cultural Science,* 2/1: 1-23.

Bate, J. (2011) *The public value of the humanities.* London: Bloomsbury.

Bigelow, J. (1998) 'Valuing humanities research'. In: Australian Academy of the Humanities (ed.) *Knowing ourselves and others: the humanities in Australia into the 21st century*, Vol. 3, Reflective Essays, pp. 37-58. Canberra: Commonwealth of Australia.

Bonaccorsi, A. and Piccaluga, A. (1994) 'A Theoretical Framework for the Evaluation of University-Industry Relationships', *R & D Management*, 24/3: 229-47.

British Academy (2004) 'That Full Complement of Riches': The Contributions of the Arts, Humanities and Social Sciences to the Nation's Wealth', London: The British Academy, <http://www.britac.ac.uk/templates/asset-relay.cfm?frmAssetFileID=6386> accessed 15 November 2011.

British Academy (2008) 'Punching our weight: the humanities and social sciences in public policy making', London: The British Academy, <http://www.allea.org/Content/ALLEA/WG%20Evaluating/Punching_our_weight.pdf> accessed 15 November 2011.

Bullen, E., Robb, S. and Kenway, J. (2004) ''Creative destruction': knowledge economy policy and the future of the arts and humanities in the academy', *Journal of Education Policy,* 19/1: 3-22.

Castro-Martínez, E., Molas-Gallart, J. and Olmos-Peñuela, J. (2011) 'Knowledge transfer in the Social Sciences and the Humanities: informal links in a Public Research Organization', paper presented at Atlanta Conference on Science and Innovation Policy, held Atlanta, United States, 15-17 September 2011.

Cohen, W. M., Nelson, R. R. and Walsh, J. P. (2002) 'Links and impacts: the influence of public research on industrial R&D', *Management Science,* 48/1: 1-23.

Crossick, G. (2009) 'So who now believes in the transfer of widgets?' talk given at the Knowledge Futures Conference, held Goldsmiths, University of London, 16-17 October 2009, <http://jupiter.gold.ac.uk/media/transfer-of-widgets.pdf> accessed 20 September 2011.

CSIC (2012) 'Memoria anual del CSIC 2011', Madrid: Consejo Superior de Investigaciones Científicas (CSIC), <http://documenta.wi.csic.es/alfresco/downloadpublic/direct/workspace/SpacesStore/81d3f71c-819c-4787-9147-8c18b2d64fcb/CSIC_MEMORIA_2011_alta.pdf> accessed 9 July 2012.

D'Este, P. and Patel, P. (2007) 'University-industry linkages in the UK: what are the factors underlying the variety of interactions with industry?', *Research Policy,* 36/9: 1295-313.

DG RESEARCH (2011) 'Innovation Union Competitiveness Report 2011', Brussels: DG RESEARCH, <http://ec.europa.eu/research/innovation-union/index_en.cfm?section=competitiveness-report&year=2011> accessed 14 July 2011.

Dillman, D. A. (2007) 'Survey Implementation'. In: Dillman D.A. (ed.) *Mail and internet surveys: The Tailored Design Method*, pp. 150-93. New Jersey: John Wiley & Sons.

Donovan, C. (2005) 'The governance of social science and everyday epistemology' *Public Administration,* 83/3: 597-615.

Edgar, A. and Pattison, S. (2006) 'Need humanities be so useless? Justifying the place and role of humanities as a critical resource for performance and practice', *Medical humanities,* 32/2: 92-98.

European Commission (2010) 'Unlocking the potential of cultural and creative industries', Green Paper, COM (2010) 183, Brussels: European Commission, <http://ec.europa.eu/culture/documents/greenpaper_creative_industries_en.pdf> accessed 3 October 2011.

Gascoigne, T. and Metcalfe, J. (2005) 'Commercialisation of research activities in the humanities, arts and social sciences in Australia', Australia: CHASS Occasional Papers №1, Council for Humanities, Arts and Social Sciences (CHASS), <http://www.chass.org.au/papers/pdf/PAP20050501TG.pdf> accessed 15 November 2011.

Geuna, A. and Muscio, A. (2009) 'The governance of university knowledge transfer: a critical review of the literature', *Minerva,* 47/1: 93-114.

Gray, J. (1992) *Men are from Mars, women are from Venus.* London: HarperCollins.

Gulbrandsen, M. and Kyvik, S. (2010) 'Are the concepts basic research, applied research and experimental development still useful? An empirical investigation among Norwegian academics', *Science and Public Policy*, 37/5:343-53.

Hartley, J. and Cunningham, S. (2001) 'Creative Industries: from Blue Poles to fat pipes', paper presented at National Humanities and Social Sciences Summit July 2001, pp. 16-26. Canberra: Commonwealth of Australia.

Hessels, L., van Lente, H. and Smits, R. (2009) 'In search of relevance: the changing contract between science and society', *Science and Public Policy*, 36/5: 387-401.

Hughes, A., Kitson, M., Probert, J., Bullock, A. and Milner, I. (2011) 'Hidden Connections: Knowledge exchange between the arts and humanities and the private, public and third sectors', Cambridge: Arts and Humanities Research Council and Centre for Business Research, <http://www.ahrc.ac.uk/About/Publications/Documents/hiddenconnectionsCBRreport.pdf> accessed 4 January 2012.

Jaaniste, L. (2009) 'Placing the creative sector within innovation: The full gamut', *Innovation: management, policy & practice,* 11/2: 215-29.

Jensen, P. and Croissant, Y. (2007) 'CNRS researchers' popularization activities: a progress report', *Journal of Science Communication,* 6/3: 1-13.

Kaiser, R. and Prange-Gstöhl, H. (2010) 'A paradigm shift in European R&D policy? The EU Budget Review and the economic crisis', *Science and Public Policy*, 37/4: 253-65.

Kyvik, S. (1994) 'Popular Science Publishing', *Scientometrics*, 31/2: 143-53.

Kyvik, S. (2005) 'Popular science publishing and contributions to public discourse among university faculty', *Science Communication,* 26/3: 288-311.

Leisyte, L. and Horta, H. (2011) 'Introduction to a special issue: Academic knowledge production, diffusion and commercialization: policies, practices and perspectives', *Science and Public Policy*, 38/6: 422-24.

Molas-Gallart, J., Tang, P. and Castro-Martínez, E. (2010) 'Social impact assessment in the Social Sciences and Humanities: an application of the SIAMPI approach', SIAMPI Project, Workpackage 6 Report.

Molas-Gallart, J. and Tang, P. (2011) 'Tracing 'productive interactions' to identify social impacts: an example from the social sciences', *Research Evaluation*, 20/3: 219-26.

Nightingale, P. and Scott, A. (2007) 'Peer review and the relevance gap: ten suggestions for policy-makers', *Science and Public Policy*, 34/8: 543-53.

O´Neill, O. (2011) 'Foreword'. In: Bate, J. (ed.) *The Public Value of the Humanities*, pp. v-viii. London: Bloomsbury Academic.

OECD (2002) 'The Measurement of Scientific and Technological Activities', Frascati Manual 2002: Proposed Standard Practice for Surveys on Research and Experimental Development, Paris: OECD.

Olmos-Peñuela, J., Benneworth, P. and Castro-Martínez, E. (2012) 'Are STEM from Mars and SSH from Venus? A comparison of research and transfer activities in the hard and soft disciplines', working paper presented at Center for Higher Education and Policy Studies, Enschede, The Netherlands, 18 January 2012.

Pavitt, K. (1991) 'What makes basic research economically useful?', *Research Policy*, 20/2: 109-19.

Perkmann, M. and Walsh, K. (2007) 'University-industry relationships and open innovation: towards a research agenda', *International Journal of Management Reviews,* 9/4: 259-80.

Pilegaard, M., Moroz, P. W. and Neergaard, H. (2010) 'An auto-ethnographic perspective on academic entrepreneurship: Implications for research in the social sciences and humanities', *Academy of Management Perspectives,* 24/1: 46-61.

Schartinger, D., Rammer, C., Fischer, M. M. and Frohlich, J. (2002) 'Knowledge interactions between universities and industry in Austria: sectoral patterns and determinants', *Research Policy,* 31/3: 303-28.

Spaapen, J. and van Drooge, L. (2011) 'Introducing 'productive interactions' in social impact assessment', *Research Evaluation*, 20/3: 211-18.

Stannage, T. and Gare, D. (2001) 'Partnerships and collaborations: The importance to humanities, social sciences and creative arts', paper presented at National Humanities and Social Sciences Summit July 2001, pp. 105-14. Canberra: Commonwealth of Australia.

Stokes, D. E. (1997) *Pasteur's quadrant: basic science and technological innovation.* Washington, D.C.: Brookings Institution Press.

Toulmin, V. (2011) 'This is a local film. The cultural and social impact of the Mitchell & Kenyon film collection'. In: Bate, J. (ed.) *The public value of the humanities*, pp. 87-102. London: Bloomsbury Academic.

Van Langenhove, L. (2012) 'Global issues: Make social sciences relevant', *Nature*, 484/7395: 442-42.

Van Vught, F.A. and Westerheijden, D.F. (2010) 'Multidimensional ranking: a new transparency tool for higher education and research', *Higher Education Management and Policy*, 22/3:1-26.

5.8. Appendix

Table 5.A.1: Summary of the hypotheses

STEM is more useful than SSH	H1. The rate of involvement with national users compared to international users is higher for SSH researchers than for STEM researchers. H2. SSH researchers experience a lower demand for their research than is correspondingly the case for STEM researchers. H3. SSH researchers have less interest in checking the validity and applicability of their research than STEM researchers. H4. SSH researchers are more concerned with the pursuit of fundamental understanding whereas STEM researchers are more focused on considerations of use.
STEM is differently useful to SSH	H5. SSH researchers use a lower proportion of formal pathways to interact with non-academic actors compared to STEM researchers. H6. SSH researchers spend more time in popularisation activities than STEM researchers. H7a. SSH researchers collaborate less with firms than STEM researchers. H7b. SSH researchers use fewer pathways collaborating with firms than STEM researchers. H8a. The frequency of collaborations with government agencies compared to firms is higher for SSH researchers than for STEM researchers. H8b. SSH researchers use more pathways collaborating with government agencies than STEM researchers. H9a. The frequency of collaborations with non-profit organisations compared to firms is higher for SSH researchers than for STEM researchers. H9b. SSH researchers use more pathways collaborating with non-profit organisations than STEM researchers.

Table 5.A.2: Structure of the questionnaire

CONCEPTUAL DIMENSIONS	DESCRIPTION	NUMBER OF QUESTIONS
Researchers' profile and research activity	Includes questions related to researchers' opinions and attitude towards their work and their relationships with other entities. It also addresses their sources of research funds, as well as the characteristics of their academic activities.	Characteristics of the research activity: 5 questions Researchers' profile: 8 questions
Relationships with other entities in the socio-economic environment	Collects information about the frequency and type of relationships in which researchers engage with different public / private entities (e.g. firms, government agencies, international organisations, non-profit organisations). It also addresses researchers' perceptions of the interest of these entities in their research; researchers' motivations to establish these relationships and how these were initiated.	Relationships with other entities of the socio-economic environment: 6 questions
Obstacles and aspects that influence in the development of relationships with other entities	Contains information regarding the obstacles found by researchers to establishing relationships with other entities as well as the institutional support received to initiate and manage these relationships.	Obstacles and aspects that influence the relationships: 7 questions
Outreach	Includes activities related to dissemination and social communication of the researchers' scientific activities. Questions address researchers' frequency of engagement in these activities, as well as the relevance and influence for their scientific work.	Activities related to diffusion and social use of science: 3 questions
Results of relationships with the socio-economic environment	Collects information about the influence and the results for researchers from their relationships with other entities. It also addresses benefits for the entities with which researchers have established relationships.	Results of relationships with the socio-economic environment: 4 questions

Source: IMPACTO project report.

CHAPTER 6

STUDY 2:[49]

INFORMAL COLLABORATIONS BETWEEN SOCIAL SCIENCES AND HUMANITIES RESEARCHERS AND NON-ACADEMIC PARTNERS

Abstract

The analysis of how research contributes to society typically focuses on the study of those transactions that are mediated through formal legal instruments (research contracts, patent licensing and creation of companies). Research has shown, however, that informal means of technology transfer are also important. This paper explores the importance of informal collaborations and provides evidence of the extent to which informal collaborations between researchers and non-academic partners' take place informally in the Social Sciences and Humanities (SSH). Data is obtained from two studies on knowledge exchange involving researchers working in the SSH area of the Spanish Council for Scientific Research (CSIC). We show that informal collaborations not officially recorded by the organisation are much more common than formal agreements and that many collaborations stay informal over time. We explore the causes of such prevalence of informality and discuss its policy implications.

Keywords: informality, collaborations, knowledge exchange, social sciences, humanities, public research organisation.

---

[49] Developed with Elena Castro Martínez and Jordi Molas Gallart.

6.1. Introduction

Knowledge generated in academic contexts can be applied to the solution of technical or social problems in many different ways. Typically, such application will not be carried out by the academics themselves and will therefore require some collaboration between academics and other societal groups. These collaborations often leave a trail in the form of official documents, when this happens we can say the collaboration has been formalised. For instance, contracts may be written to frame the terms of a research collaboration, academics may protect their IP through patenting and then license the use of such patents, and academics may participate in the creation of firms to exploit the knowledge they have generated. These activities generate documentary evidence that can then be used to generate data. As monitoring and evaluation of the use of research results is becoming widespread, these data are increasingly important: the extent to which they provide a fair reflection of the collaborations that academics establish with potential non-academic beneficiaries of their research becomes an important question both from a policy and analytical perspective.

Turning our attention towards the extant literature on the use and impact of academic research, we note that it has traditionally focused on a limited range of these documented or formal activities; this is explained by their higher visibility and traceability compared to other activities that do not embody a legal contractual instrument. This is problematic since those studies that have addressed informal collaborations have found that both firms and researchers rank them highly among the wide range of knowledge exchange and transfer activities (Abreu et al. 2009; Agrawal and Henderson 2002; Cohen et al. 2002; Meyer-Krahmer and Schmoch 1998). Therefore, ignoring informal links and focusing only on formal mechanisms could be too narrow an approach to provide a balanced and comprehensive perspective on knowledge exchange processes. Yet, informal collaborations are hard to capture and quantify, and careful field research needs to be conducted to generate data (Amara et al. 2013; Grimpe and Fier 2010; Link et al. 2007).

Our interest in informality was triggered when, during a project to assist in the development of CSIC's social scientists collaborative links with non-academic users and beneficiaries of its research, we realized that many existing collaborations were not reported in the organisation's database of contracts and collaboration agreements. This moved us to analyse the issue in more detail and to study the nature of such informal collaborations.

The purpose of this paper is to contribute to the literature on knowledge exchange by exploring the extent of informal collaborations in the Social Sciences and Humanities (SSH), and the context in which informality emerges. To this aim, we will first identify all the non-academic partners with whom SSH scientists in a large research organisation (the Spanish Council for Scientific Research, CSIC) collaborate. We will then quantify the presence of informal collaborations in this population, and finally we will assess qualitatively the conditions under which such informal collaborations have emerged.

The remainder of the paper is structured as follows. The next section reviews the literature on University-Industry relations focusing on studies addressing informality whether directly as the main concern of the work, or only as an issue that emerged among others. Section 6.3 provides a description of the context of the study. Section 6.4 uses two complementary studies to develop empirical evidence on the extent and nature of the informal collaborations between CSIC's SSH researchers and non-academic parties. Finally, section 6.5 draws conclusions and policy implications.

6.2. Literature Review

Much of the extant literature in the broad fields of research impact, University-Industry relations, and technology transfer usually relies on the analysis of data derived from the formal documents underpinning the relationships across institutional boundaries. For instance, an abundant body of research on University-Industry relations draws on the analysis of patent licenses, spin-off companies, and research contract revenues. The focus on documented evidence is often justifiable: the transfer to industry of research results for their further development and application typically entails a commercial transaction revolving around the purchase of rights to the use of Intellectual Property (IP). In this context, technology commercialization becomes a cornerstone of the efforts to apply the knowledge generated in academic environments.

Yet, the relations between academia and other societal partners involve other activities like collaborative research, conferences, informal contacts or the temporary exchange of researchers, which are not necessarily reflected in written documents or legal agreements (Meyer-Krahmer and Schmoch 1998: 52). With the growth of interest in the variety of knowledge exchange processes, a problem has, however, emerged: their visibility is variable. An exchange of knowledge conducted through a series of informal conversations cannot easily be identified, monitored and 'counted'; in comparison the techniques to use patents and patent licensing data to analyse technology transfer are increasingly sophisticated and the quality, coverage and availability of the data sets is improving. Therefore, while the interest in the variety of 'knowledge exchange' processes has increased, quantitative analysis has naturally revolved around activities that can be more easily quantified.

The activities that leave traces that can be aggregated in large databases are typically linked to commercial transactions: licenses and royalty agreements, research contracts, and the property rights on which these need to be based. Analysts have made a distinction between such 'formal technology transfer mechanisms' embodying or directly resulting 'in a legal instrumentality' revolving around the allocation of property rights and obligations, and informal means of transfer and exchange "facilitating the flow of technological knowledge through informal communication processes, such as technical assistance, consulting, and collaborative research" (Link et al. 2007: 642). Examples of informal transfer include "sending technical reports to knowledge users outside the scholarly milieu, giving presentations in a technical seminar organized by firms or other types of organisations, participating in industry expert groups or expert committees that are involved in efforts to directly apply research knowledge, etc." (Landry et al. 2010: 1389). A broader definition of, in this case, informal University-Industry relations extends to "exchanges between firms and individuals inside the university, without any formal agreement involving the university itself. Typical examples are consultancy contracts with professors or information exchange meetings organised in an informal way" (Bonaccorsi and Piccaluga 1994: 239).[50] Note that Bonaccorsi and Piccaluga´s definition of informality does not exclude all exchanges using a 'legal instrumentality': a university lecturer can sign a contract with a firm as an

[50] We can easily broaden this definition to include all academic research organisations.

individual without informing the university, such collaboration will not however be visible to the university and it is therefore classed as informal. From this perspective informal collaborations can also be understood as those taking place 'under the radar' of the university or research centre: they are not directly visible to management.

This is not an isolated event; several studies have observed that academics do not disclose all their knowledge transfer and exchange activities to administrators (Landry et al. 2010), and that, even when inventions are formally disclosed, firms will try to conclude informal arrangements with the scientists instead of going through the formal organisational channels (Siegel et al. 2003: 43). In fact, some evidence has been obtained suggesting that university scientists bypass their institutions to sell or license their discoveries privately (Markman et al. 2008). Individual academics may not inform their employers when they enter into individual contracts with clients and partners and, naturally, they are not required to inform their administrators every time they engage in a conversation with individuals from outside academia.

While commercialization activities formalised in legal documents leave clear traces that can be used as indicators of activity, performance and economic impact, academics trying to analyse knowledge exchange between researchers and other non-academic partners will find informal collaborations more difficult to identify and track (Hagedoorn et al. 2000). Indeed, most of these informal collaborations will not necessarily appear ''on the books'' of university administration (Boardman and Ponomariov 2009: 142). Is this a serious problem? Is it possible that an analysis focusing on formal collaborations may not present a fair view of the collaborations between academia and industry and society? This remains a debated matter.

Based on an analysis of 2,000 German manufacturing firms, Grimpe and Hussinger conclude that formal and informal means of technology transfer are complementary (Grimpe and Hussinger 2008). Amara and his colleagues reach a compatible conclusion when they show that academics tend to engage simultaneously in paid and unpaid consulting (Amara et al. 2013), and argue that informal transfer activities are key in the establishment of a "virtuous circle among the different knowledge transfer activities" (Landry et al. 2010: 1399). This should not come as a surprise: research suggests that formal collaborations are typically built on initially informal contacts, which improve the quality of a formal relationship (Grimpe and Hussinger 2008). Once a contract has been fulfilled it is likely to be followed by further informal exchanges; that is, relations that do not take place within the provisions of the legal agreement. Formal and informal collaborations are thus complementary and can even be difficult to tell apart.

However, we cannot assume that this complementarity will exist under all conditions. A recent study covering more than 22,000 UK researchers across disciplines found that "academics tend to use either formal or informal channels for engagement, but rarely both" (Abreu and Grinevich 2013: 8). This result suggests that collaborations between researchers and non-academic partners may be conducted exclusively through informal channels without recourse to any legal instrument. If this were the case, recorded collaborations would hardly represent the actual extent of the collaboration between researchers and non-academic partners. The possibility that the variety of linkages may be such that it may not be adequately conveyed by data derived from formal agreements has analytical implications. Quantitative analyses addressing aspects of informality have had to collect data through questionnaires trying to approximate informal transfer activities and collaborations that are not gathered through official data (Amara et al. 2013; Grimpe and Fier 2010; Link et al. 2007). We follow on this literature strand by examining the extent to which the collaborations between academics and non-academic partners have remained exclusively informal and the conditions under which this occurs in a field, the SSH, where informal activities are particularly common (Abreu and Grinevich 2013; Castro-Martínez et al. 2008; Hughes et al. 2011).

For the purpose of this study, similarly to Bonaccorsi and Piccaluga (1994), we characterize informality by the absence of any legal agreement of any form underpinning a collaboration between an academic institution (public research organisation or university) and a non-academic partner (firms, government agencies, non-profit organisations, etc.). In contrast with previous studies, however, we establish a mutually exclusive differentiation between formal and informal collaborations: we define a collaboration between a researcher and a partner as informal when this has not been formalised at all through any legal instrument of any type or form involving the academic organisation. In other words no aspect of the collaboration is or has been visible to the administrators in the academic organisation. The very demanding conditions that this definition imposes can help us identify a type of collaboration that has not been emphasized in the literature. Research has so far suggested that informal activities can be a precursor to more formal engagement (Abreu et al. 2009; Druilhe and Garnsey 2004), or that there is complementarity between formal and informal transfer activities (Grimpe and Hussinger 2008), with academics engaging simultaneously in both of them (Amara et al. 2013). In contrast, by defining a collaboration as informal only when it has not been formalised at all, in the cases of informality we identify there is no evidence of complementarity with formal mechanisms, or of an evolution towards formality as the collaboration matures.

6.3. The context: Social Sciences and Humanities at CSIC

The Spanish Council for Scientific Research (CSIC) is the largest public research organisation in Spain employing more than 7,000 researchers. The studies that provide the empirical basis for this paper were conducted between 2007 and 2010. Table 6.1 presents some general data for the organisation in this period. It is a large public research establishment with a staff of over 12,000 arranged into research institutes, and characterised by the important role of core public funding and a large number of tenured researchers who constitute the core of the organisation. At the time the study was carried out, CSIC research activities were conducted by a large number of research groups (some formally established, others operating *de facto* without formal recognition) organised in research institutes, which constituted the administrative units.

Table 6.1: CSIC in figures

	2007	2010
Total number of CSIC Institutes	125	128
Total staff	**12,885**	**14,144**
Tenured researchers and technicians (civil servants)	4,541 (35%)	5,111 (36%)
Contracted researchers, technicians and grant holders	6,750 (53%)	7,508 (53%)
Administration and other	1,594 (12%)	1,525 (11%)
Sources of funding		
Core funding from Government	68%	54%
External Resources"*"	32%	46%
Contracts and agreements with private and public sector organisations and firms		
Number	1,314	3,099
Funding (k€)	63,149	78,600

Source: own elaboration based on CSIC annual reports of 2008 and 2011 (CSIC 2008; 2011).
"*"External resources include funds from regional, national and international competitive R&D programmes, contracts with companies and organisations and funds from the European Social Fund and the European Regional Development Fund.

CSIC is organised into eight scientific areas, one of which is Humanities and Social Sciences.[51] Humanities and Social Sciences was one of the three original areas established when CSIC was created in 1939 and the support that some fields like American history received at this early stage still explains today the weight of the humanities within the area. Later, during the Spanish democratic transition, new social science institutes were created, slightly increasing the weight of the social sciences, although the humanities continued to dominate (Fernández-Esquinas et al. 2009).

The SSH area is composed of 17 research institutes: 6 in social sciences and 11 in humanities. Three of these institutes are joint research institutes of CSIC and universities (IEIOP, IHCD, INGENIO), and a further three belong to CSIC and regional governments (IEGPS, IAM, IESA). In the case of joint CSIC-University institutes,

[51] The remaining areas are biology and biomedicine; food science and technology; materials science and technology; physical sciences and technology; chemical sciences and technology; agricultural sciences; and natural resources.

contracts and agreements can be channelled either through the university or through the CSIC[52] (see Appendix Table 6.A.1 for further details on the SSH institutes).

At first sight, the legal context within which CSIC researchers work does not seem conducive to informal collaborations. While in many universities of different countries professors are allowed to earn supplementary money working for a percentage of their time on their own account (Göransson et al. 2009), CSIC researchers are civil servants prevented by law[53] from taking on additional remunerated work, with a few exceptions, including paid teaching or lecturing assignments, up to a limit of 75 hours per year, remunerated contributions to examination and evaluation boards, and, under certain conditions, they can also receive income derived from copyrights.[54] This limited set of activities can legally be conducted by CSIC researchers without the need for a formal contract between the partner and CSIC. Therefore, the current legal framework and accepted practices allow for a range of informal activities, from lectures, seminars or other teaching activities, to publications and media appearances, and participation in a range of advisory committees and working groups. Also, any activity carried out for free is implicitly approved and often, although not always, informal. It should be noted that CSIC researchers enjoy substantial latitude in the definition of their activities. Because the salaries of tenured researcher are covered by the organisation´s operational budget, any advisory or research activity requiring no other resources than the work of the researcher, could be conducted at no cost to the partner.

6.4. Informal collaborations in the SSH: an analysis

6.4.1. Introduction

The empirical evidence we present here is structured into two main complementary studies. The first, conducted in 2007, is a quantitative analysis of CSIC research groups in the SSH institutes focusing on the extent to which they engage in formal or informal

[52] This has implications for our analysis since we have had to consider contracts channelled through the relevant universities in addition to those channelled through CSIC.

[53] Act 53/1984, 26 December 1984, on "*Incompatibilidades del personal al servicio de las Administraciones Públicas*" published in the *Boletín Oficial del Estado*, 4 January 1985.

[54] Note that for all other activities, channelled through formal contracts between CSIC and its clients, the researchers are entitled to receive up to 18% of the total contract value as a 'productivity bonus'.

collaborations with non-academic partners.[55] The second is a qualitative analysis of a selected sample of SSH researchers and their partners to study in detail the characteristics of the collaborations they have undertaken overtime. This qualitative analysis allows us to enquire into the factors that can help explain the preeminence of informal collaborations found in the first part of the study.

6.4.2. Quantitative study

6.4.2.1. Data and methodology

Our study population is constituted by all the 97 SSH research groups at CSIC. Data were collected from:

- CSIC and university databases[56] listing collaborations established through formal agreements (including contracts and other legal forms) between CSIC institutes and partners. We considered all the agreements in force at some point during the period 2002-2007 and we built a list of all the external partners with at least one formal agreement with a SSH research institute during that period.

- Semi-structured face-to-face interviews with representatives from all 97 research groups in all the SSH institutes. Groups were identified through institutes' web pages and the institute directors identified contact people in the groups. Groups were mainly small: more than half of them had less than 5 researchers holding a PhD degree. Interviews were held in 2007. The interviews established the groups' research activities and priorities and analysed their collaborations with partners. We built lists of all partners identified by interviewees, with whom the groups had established collaborations in the period 2002 to 2007. Interview transcripts were sent to interviewees for validation. Group information was aggregated by institute to make it comparable with the data from the CSIC and university databases.

[55] In the following, we use the term partners as shorthand for non-academic partners collaborating with researchers.

[56] Relevant university databases were analysed for the three joint CSIC-University institutes, for which we will also considered the contracts and agreements channelled through the universities.

Therefore, the outputs of this process included two lists of non-academic organisations and a few non-affiliated individuals with whom researchers had established collaborations: one, derived from CSIC and university databases, included all partners who had entered contracts or other legal agreements, and the other, included *all* the organisations and individuals that researchers mentioned as partners during the interviews.

We found a broad variety of individuals or organisations outside the academia with an interest in SSH research: CSIC SSH research groups had established collaborations with 574 different partners during the 2002-2007 period. We then checked whether the partner identified during the interviews also appeared in the CSIC and University databases: if they did not, that specific partner was classed as having an exclusively 'informal collaboration' with the CSIC institute; that is, the connection was taking place without any type of formal agreement. Therefore, for each institute the partners felt into two groups:

- *Formal collaborations* which included all partners with at least one legal agreement with CSIC or relevant University during the 2002-2007 period.
- *Informal collaborations* which included partners with relationships with CSIC researchers but who had not entered into any legal agreement of any sort during the period 2002-2007 with the researchers' organisations.

Therefore, we are neither analysing patterns of formal and informal collaborations nor their intensity or frequency. Our focus is only on those collaborations that remain *exclusively* informal and we have used a very restrictive definition of 'informal collaboration' to identify them. If a researcher and a partner had entered at least one agreement (a contract, a Memorandum of Understanding…) during that period, the collaboration was classed as formalised even if most of the collaborations were still being carried informally. We are interested in the 'partner-institute' binomial regardless of the number of collaborations undertaken. Note that since we are comparing data at the institute level, a determined partner could collaborate with different SSH institutes leading to different 'partner-institute' binomials; therefore, the number of total collaborations can be higher than the number of total partners identified over the period 2002-2007.

Finally, we considered the types of partners with whom collaborations had been established: (i) government organisations; (ii) non-profit organisations, including foundations, NGOs, industry and commercial associations, and technology centres; (iii) public and private firms; and 4) individuals entering relationships on their own behalf (see Table 6.2 for further details).

6.4.2.2. Results

During the 2002-2007 period, CSIC researchers in the SSH area established collaborations with 574 different partners. More than three quarters of these partners were government (39.3%) and non-profit organisations (36.2%). This figure is completed by public and private firms (23.5%) and a few individuals (1%) usually owners of properties with historical or cultural interest, who required specialist services and advice for their upkeep and preservation. A detail of the different groups of partners is presented in Table 6.2 below. We observe a broad diversity of activities among partners but a dominance of public sector and non-profit organisations.

Table 6.2: Partners collaborating with SSH institutes during the period 2002-2007

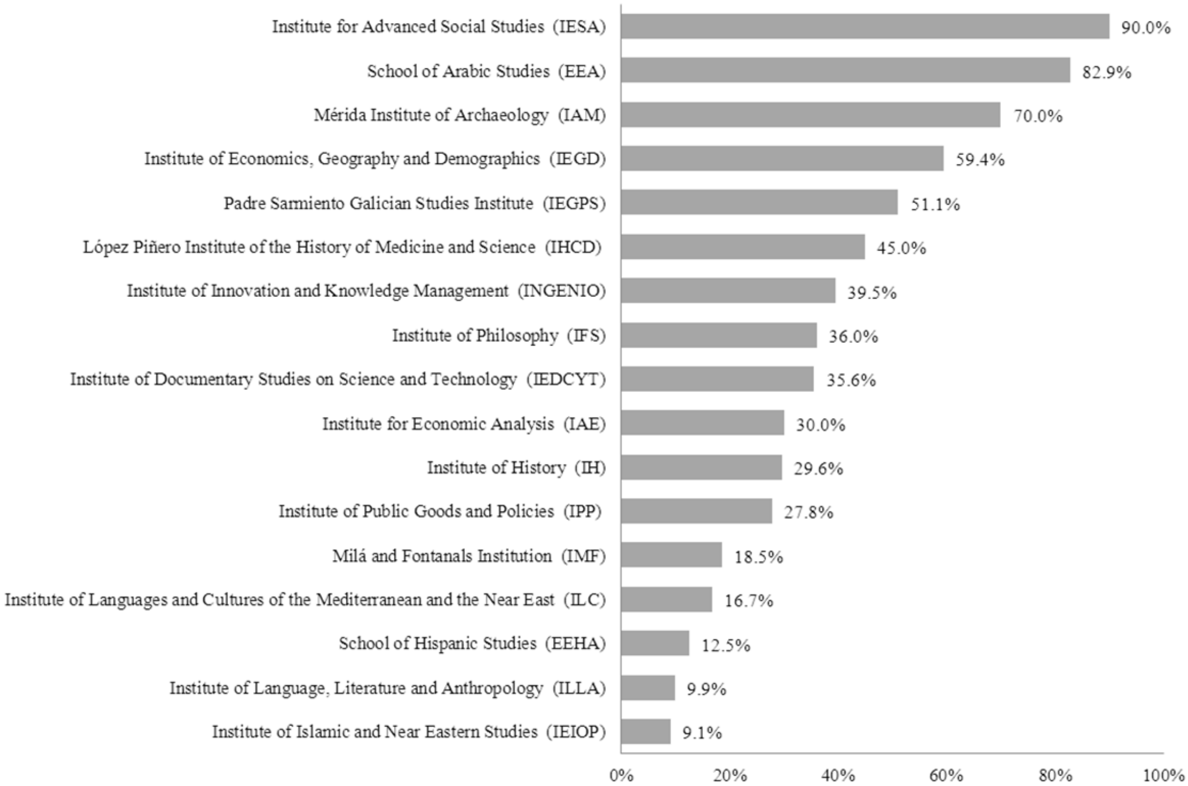
Type of partner	N (%)	Examples
Government organisations	**226 (39.3%)**	
• International organisations and foreign governments	37 (6.4%)	Foreign museums, embassies, international organisations in areas of culture and education (e.g. European Commission, United Nations).
• Central	57 (9.9%)	National museums, archives and libraries. Government departments in the areas of economic affairs and treasury, social affairs, culture, fine arts and heritage, tourism, education, health, migration, foreign affairs, labour affairs, justice, security, science and technology, environment, rural and marine affairs, agriculture, fisheries and food.
• Regional	76 (13.2%)	Libraries, regional museums and regional government departments responsible for social affairs and welfare, culture, economy and finance, tourism, education, sports, health, governance, public works and transport, science and technology, industry, environment, regional land planning and public works, agriculture and fisheries.
• Local	56 (9.8%)	Local museums, local government departments responsible for economy and local development, social affairs, and culture.
Non-profit organisations	**208 (36.2%)**	Private and public foundations and associations, trade unions, museums and churches.
Firms	**135 (23.5%)**	Firms operating in the following sectors: publishing and media, cinema, tourism, culture, management consulting, communication and information technologies, archaeology, architecture, public works and building, gas and electricity suppliers, mining.
Individual	**5 (1.0%)**	Owners of heritage buildings and sites.

Most of the collaborations with these partners are exclusively informal: from 662 collaborations identified between 2002-2007, 402 (61%) were classified as informal. Conversely, we labelled 260 collaborations (39%) as formal since we find traces of these relationships in the corporate databases. The percentage of informal collaborations we have found is very high, particularly if we take into account that, according to our definition, once a group has formalised a collaboration with a partner through, for instance, a contract or a Memorandum of Understanding, all the collaborations between any researcher in that group and the partner organisation, preceding or following such formalisation, are no longer considered informal.

Disaggregating this information by research institutes, we found a slightly higher percentage of informal collaborations for the institutes working in the humanities: informal collaborations amounted to 65% of the total collaborations for the humanities institutes and to 53% for the social sciences.[57] Exclusively informal collaborations are predominant for 12 out of 17 SSH institutes; that is, for 12 institutes, more than half the partners that had established collaborations with members of the institute had not entered into any sort of legal agreement. Exclusively informal collaborations were particularly dominant at Institute of Islamic and Near Eastern Studies (IEIOP) and the Institute of Language, Literature and Anthropology (ILLA), where more than 90% were classed as informal collaborations. For a few institutes, however, most collaborations were classed as formal: Institute for Advanced Social Studies (IESA, 90%) and the School of Arabic Studies (EEA, 82.9%) (see Figure 6.1).

[57] If we had considered the CSIC SSH institutes to be a sample of a broader population, this difference would not have been considered statistically significant. The Student's t-test indicates that the mean of the percentage of partners with informal collaborations is not significantly different between social sciences and humanities institutes (*p-value*= 0.339).

Figure 6.1: Percentage of formal collaborations over total number of partners involved in collaborations with each SSH institute over the period 2002-2007



Source: own elaboration.

Some telling differences emerge when we compare informal and formal collaborations according to the types of partners with which researchers established collaborations. Although in aggregate terms, government organisations (39.3%) are the most common partners and firms account only for 23.5%, this difference is even more marked if we restrict our analysis to formal collaborations. Almost 50% of formal collaborations are established with government organisations, while 31% are with non-profits organisations, and only 19% are with firms. Conversely, if we focus on informal collaborations, non-profit organisations emerge as the most frequent type of partner, accounting for almost 40% of all the agents with whom the CSIC SSH institutes established informally collaborations, followed by government agencies (35%) and firms (25%).

To summarize, the quantitative study highlights a prevalence of informal collaborations and a marked variety in their prevalence across institutes and across the type of partners. This suggests that a more detailed analysis is required to understand the way in which these collaborations (formal and informal) emerge, the reasons why and the contexts where informality persists. The following section addresses these issues by analysing a sample of cases illustrating collaborations between SSH researchers and its partners.

6.4.3. Exploring informality: a qualitative study

6.4.3.1. Data and methodology

The second stage of this analysis consists of an in-depth study of examples of collaboration between selected CSIC SSH research groups and non-academic partners. The data was gathered as part of a large project funded by the European Commission under the 7th Framework Programme to develop methodologies to assess the socio-economic impact of research (www.siampi.eu). The method revolved around the identification of 'productive interactions' (Spaapen and van Drooge 2011) between researchers and research stakeholders. The aim of the method was to trace in detail the type of collaborations that researchers and their partners established, their context, how they developed overtime and what did they entail in terms of knowledge exchanges and eventual social impact. Here we focus on how the collaborations were organised and how they were affected by market and other contextual conditions. Our goal is to explore the conditions under which collaboration are formalised as well as the reasons underlying the prevalence of informal collaborations in the SSH.

Using information on partners obtained through the first phase of the study, we selected 12 cases intended to be illustrative of the variety of collaborative situations and partners we had identified. The cases selected covered instances of formal and informal collaborations across all main SSH research fields, with partners from very different social spheres and in different geographical locations. Therefore, the selection was not random but rather intended to provide a window on the wide variety of collaborations established with partners and to illustrate in this way the different contexts within which collaborations emerged.

For all the cases analysed we interviewed the group leader (typically an experienced, tenured researcher) and, for ten of the cases, at least one non-academic partner involved in the collaboration under study (see Table 6.3 below). We conducted a total of

24 in-depth interviews. The programme of interviews was conducted during 2010 using a semi-structured questionnaire organised into three sections: the context of the research and its application environment; the direct contacts established between researchers and partners (the 'productive interactions'),[58] and their outcomes.

6.4.3.2. The cases: the nature of the collaborations

The cases analysed provide evidence on the varied nature of the collaborations established and the conditions underlying them. Table 6.3 provides a summary of the groups interviewed and the collaborations analysed; these include both collaborations underpinned by contracts and agreements and those that were not. The table is arranged listing first those collaborations that were not covered by formal agreements.

[58] Note that we address direct collaborations –in which the researcher can easily identify the partner and user of its research– and we do not consider indirect and diffuse ways of knowledge exchange such as publications or exhibitions.

Table 6.3: Cases analysed

SSH institutes and research groups	Partners	Nature of the collaboration and aim
ILLA: Linguistic geography and sociology (*Linguistics*)	Scientific Police- forensic laboratory (national government)	Informal and personal collaborations to support specific analysis or voice recordings. The research group provided advice about the creation of the acoustic forensic laboratory.
ILC: Iberian Jewish culture (*Jewish Culture*)	Association Casa Sefard-Israel (non-profit organisation)	Personal and occasional assistance in dissemination events on the history of Spanish Jews.
IMF: Musicology (*Music*)	Record Producer (small firm)	Informal and personal collaborations aimed to recover music scores from the XVIth Century and transcribe them into modern notation to be played and recorded.
ILLA: Spanish theatre (*Theatre*)	National Classical Theatre Company (public theatre company)	Informal and personal collaborations with researchers advising a theatre company on the performance of baroque theatre.
ILLA: Heritage, memory and identity (*Identity*)	Association of Aluche-Carabanchel prison * (non-profit organisation)	Informal and personal collaboration with a neighbourhood association dealing with problems associated with the management of large derelict former prison (Carabanchel) in the neighbourhood.
IFS: Philosophy after the Holocaust (*Philosophy*)	Road safety prosecutor (national government)	Informal and personal collaborations to analyse the attitudes of road users towards road safety.
IEGPS: Archaeology and heritage (*Archaeology*)	Galician government (regional government)	Formal agreement to provide advice and technical support on archaeological sites valorisation.
	Wind Energy company (large firm)	Contracts to carry out archaeological impact studies previous to engineering and construction works.
	Archaeology company (small firm)	Contracts to carry out archaeological impact studies previous to engineering and construction works.
IEDCYT: Scientometrics, knowledge production and transfer in health and biotechnology (*Scientometrics*)	Genoma España (non-profit organisation)	R&D contracts to produce bibliometric analysis of Spanish biotechnology research.
IH: Contemporary international relations (*International Relations*)	Casa Asia (non-profit organisation)	Annual formal agreements for the organisation of bilateral Spain-Philippines fora and the organisation of seminars, courses and research project on the Philippines.
IESA: Social studies on immigration (*Immigration*)	Directorate General for immigration (regional government)	Formal agreements to build and manage a Permament Andalusian Observatory of Migrations. The collaboration includes the elaboration of reports.
IEGD: Economic geography and urban development (*Geography*)	Madrid City Hall * (local government)	Formal agreement for the development of the Industrial Observatory of Madrid. The collaboration includes the elaboration of annual reports and monographies.
ILC: Written heritage of the Ancient Near East (*Manuscripts*)	Foundation Montserrat Abbey and Compañia de Jesús (non-profit organisation)	Formal agreement (without commitment of financial resources) to allow researchers' access to Coptic manuscript collections held at the Monastery of Montserrat. Researchers contribute to the identification and conservation of the collection.

* Partners not interviewed.

A first observation is that our interviews with partners tended to be more emphatic about the contribution of the researchers than the views offered by the researchers themselves. The researchers were not able to appreciate fully the impact of their contributions.

Informal collaborations revolved around personal contacts and were open-ended: the partner would draw on the help and assistance of the researchers as needs emerged and usually for very specific and recurrent tasks: several lectures, a string of queries. These requests for help were underpinned by long-term personal acquaintance and bonds of trust; the partner would typically call the researchers with a specific request (for a lecture, a query or request for help) and the researcher would agree to provide help. The small magnitude of each specific request and the economic context of the relationship obviated the need for any contractual agreement and economic compensation. For instance, a linguist[59] would give, from time to time, his opinion on forensic work; a historian was available to participate in conferences and lectures to promote the awareness of the Sephardic legacy and the reality of Jewish communities in Spain and Israel. These collaborations were occasional, recursive and did not require additional research exploiting, instead, the accumulated expertise of the researchers.

Informal collaborations could also be more structured. The poetic music research group has developed a long-term collaboration with a specialised record producer company with the objective of recovering and recording music scores from the Spanish XVIth Century.[60] Part of this task involves transcribing the old music score into modern notation and to work with performing musicians; in so doing, the research have adapted their research objectives to the need of this specific community of research users. Overtime they have developed strong personal links, and the collaboration has evolved and strengthened without any formal agreement.[61] In this case, one reason for the absence of formal contracts is the limited economic monetary worth of the outcomes of this collaboration: Spanish XVIth Century music has a very small audience and therefore

[59] The linguistic group also helped in the consolidation of the forensic laboratory at the time of its creation, in the design of the techniques and methodologies used in the laboratory and in the professionalization of its technicians (without any agreement).

[60] See Castro-Martínez et al. (2013) for more details on the musicology case.

[61] There is an agreement between the CSIC and the record producer for the edition of each music CD but not for the collaborative activity between the research group and the record producer.

the potential income that can be derived from this activity is very small. The need for additional resources to carry out the research and collaborative work, in addition to the time of the individuals involved, is also very small. No economic exchange is required and, under these circumstances, there is no need to formalise the collaboration. The collaboration has proved to be open-ended, but more intense than in the case of recurrent small collaborations.

A similar relationship has been developed between researchers in classic Spanish theatre and the National Classical Theatre Company. Again, over the years, the Director has drawn on the advice of the researchers, but such collaboration has not required additional financial commitments by both parties. The advice provided has helped changing the way Spanish Classical theatre is performed, changing all aspects of the performance, from props to diction. The collaboration is more involved than the mere provision of arms-length advice, but has also remained open-ended and based on personal links.

Sometimes the collaboration revolved around a specific, sizeable problem. A group of anthropologists working in a group researching ‘heritage, memory and identity’ at the Institute of Language, Literature and Anthropology (ILLA) helped a neighbourhood association to deal with a large, iconic, abandoned prison in their neighbourhood. Although the work required research, the neighbours did not have economic resources to contribute to it, and the researchers used their core funding and capabilities to work with the association, again without any formal agreement. The researchers designed a programme of action research and help the neighbourhood to deal with the variety of problems caused by having an ‘undesired’ heritage like a large abandoned prison in their midst. Therefore, the researchers benefitted by obtaining access to a study case: pecuniary compensation was not an important consideration in their view. A similar case, where researchers obtained access to research subjects or situations, can be found in the collaboration between a group of philosophers and the road safety prosecutor. The problems the prosecutor brought to the table influenced the research strategy of the group: the road safety prosecutor contacted the group to work together in the study of driver behaviour leading to road accidents. Both parties have been working together and have organised joint seminars, workshops and other events involving additional stakeholders. Outputs of this collaboration include scientific publications and prosecutor reports to Congress on road safety campaigns and school. Again, the collaboration did not involve any financial exchange and was conducted without any formal agreement or contract. In these cases, the researchers typically did not require resources other than their own work to provide the services involved in the collaboration and were moved by an interest to see their research applied (*Linguistics, Jewish Culture, Music, Theatre, Identity,* and *Philosophy* cases in Table 6.3).

Formal contracts were present when the exchange was mainly driven by pecuniary objectives (like in the *Archaeology* group provision of consultancy services) or when additional resources were needed to carry out the work. The latter cases called for formal contracts and agreements to channel the funds and establish the basis on which an exchange of money for services is conducted. Markets for research services are better established in some areas than others. A perhaps surprising area where a large commercial market exists is archaeology: in Spain archaeological audits are required by law before starting any major civil engineering or building project. This has opened a market for specialised audits, where CSIC archaeologists have been active. The *Archaeology* research group[62] we studied carried out archaeological impact assessment audits for wind energy companies, civil engineering and construction firms, and naturally all this work was carried out under contract.

Contractual research had also been carried out, among others, in the field of scientometrics with the foundation '*Genoma España*'. The goal here is the production of bibliometric studies on Spanish biotechnology. This is a continuous collaboration (7 years working together) based on a string successive R&D contracts. The work here requires the access to data that is typically generated by commercial organisations and is, therefore, costly to access.

Other formal agreements ('*convenios*') are signed with government departments and other public sector organisations to frame research collaborations involving a transfer of economic resources to the research group. We identified several of these formal collaborations: archaeologists working with the Galician regional government in a variety of projects, *International Relations* scholars working with a public sector consortium ('*Casa Asia*') to organise activities to promote links between Spain and the

[62] See Parga-Dans et al. (2012) for more details on the archeological case.

Philippines, *Immigration* researchers establishing an Andalusian Observatory of Migration for the regional Directorate for Immigration Policy, and the *Geography* group establishing the Industrial Observatory of Madrid for the Madrid City Hall.

In all these cases the researchers are moved, at least in part, by a need for resources or pecuniary interest and deal with an organisation with the capacity to make an economic contribution. Yet, agreements can also be signed in situation where there are no direct financial exchanges but a complex relationship that needs to be backed by some sort of legal document. An example is the agreement between the written heritage of the Ancient Near East group at CSIC, a Catalan university, Montserrat Abbey and the Jesuit order (‘*Compañía de Jesús*’) to catalogue old manuscript collections held by the religious organisations. The agreement was signed to establish the conditions under which the researchers gained access to the unique Greek and Coptic manuscript collections in exchange for help in cataloguing and maintaining it, and to establish the responsibilities of the researchers in relation to the handling of the collection. Additionally, the researchers were sometimes offered free lodging at the monasteries holding the collections.

Formalisation has therefore emerged when there is a financial exchange involving both, researcher organisation and partner, and when there is a need to formalise the conditions under which a specific work is carried out, because, for instance, access is being granted to valuable collections. This naturally occurs in the SSHs, but what the study above shows is that there is a wide set of situations under which it does not. These are discussed in the following section.

6.5. Discussion and conclusions

Despite using a very stringent definition of informality, we have found that informal collaborations with partners are very common among CSIC SSH research groups. This differs from a finding stressed in much of the literature that sees informal and formal links as complementary. This makes intuitive sense: the application of knowledge generated in academia calls for an understanding of both the context of knowledge generation and the context of application. In this situation it is normal for a formal collaboration (covered by a ‘legal instrumentality’) to follow initial informal exchanges in which the parties to the transaction learn about each other and their contexts. The use of a formal instrument (for instance, a research contract) will typically be agreed upon when a collaboration requires the use of resources that both sides consider significant. Yet, once a formal instrument has been established, it is not necessarily the case that all collaborative activities between the partners take place under such agreement. On the contrary, the partners can take advantage of the possibilities open through the new formalised collaboration to explore new ideas and themes for further work. Formal and informal collaborations can co-exist and strengthen each other.

The existence of such complementarity will however depend on the context. First, it is not always the case that the existence of a formal agreement encourages further informal collaborations: legal and commercial departments in firms and research centres linked through research and IP exploitation contracts are often concerned about the implications of loose talk among scientists and engineers (Tang and Molas-Gallart 2009). When the economic stakes are high, the boundaries set up by the legal instruments may define the limits of the collaboration in its entirety. If important investments in equipment are required and the technologies or services under development have substantial commercial potential, firms seeking research collaboration will be looking for exclusivity in the use of the research results and will aim to impose confidentiality conditions on the researchers. Academic organisations and individuals will also seek commercial agreements that will allow them to capture part of this value. In these situations the degree of complementarity between informal and formal collaboration could depend on the maturity of a collaborative link. Some sort of informal collaboration may be needed to establish the elements of trust required to develop a deeper formalised relationship, but once this is established the collaboration is channelled through the formal instruments that have been set up. Our study has not addressed this situation, but suggests that the dynamic relationship between formal and informal collaboration requires more attention. Be that as it may, in a situation where informal links lead to formal collaboration, the documents underpinning it can still provide good indicators of the extent of the collaboration. This is not the situation we have found in our study.

Our results suggest that there are situations in which informal and formal collaboration may not be complementary at any point in the life of the relationship: that instead of informal contacts leading to formal agreements and living alongside them, collaborations may persist in their original informality for long periods of time. This has implications for our understanding of the nature of the relationships between science and society, for our approaches to data collection, and for policy. We will address them in turn.

Our main conclusion is that there are contexts in which informality is persistent. Our qualitative analysis suggests that informal collaborations are maintained overtime under conditions related to the characteristics of the partners, the researchers and the type of collaborative activity. Informality, in the narrow sense we have defined it here, can emerge when the researcher is not moved by pecuniary motives and is able to collaborate with partners who have no economic resources to contribute towards the costs of his or her work. Two economic conditions have to be fulfilled for this to happen: (i) the activity must not involve substantial additional costs above the direct costs of the work of the researchers' involved; and (ii) the work must be covered by 'core' research funding or other projects. Additional costs will be low or non-existent when collaborations are based on the accumulated knowledge of the researcher (like in the cases of *Theatre*, *Jewish Culture*, *Linguistic* in Table 6.3); in other words, when original research is not involved. In our cases, however, there were situations where informality existed in collaborations involving research activities. In these cases, for resources to be invested informally in these research activities, there is a need for core research funding and for researchers to have the freedom to apply such core funding to the activities they choose (see *Music*, *Identity, Philosophy* in Table 6.3). In contexts where research is funded mainly through projects rather than core funding, resources are usually linked directly with paying projects and informality is unlikely to emerge with the regularity we have seen in our study. If the conditions for persistently informal collaboration are fulfilled, we find a variety of non-pecuniary reasons that explain the involvement of researchers in informal collaboration: the opportunities it offers to access data and information, to apply knowledge in areas the academic finds interesting and valuable, and to make valuable contributions to society. As Schiller argues (Schiller 2010), one of the dimensions of informality is the existence of a set of intangible rewards.

Therefore, when non-pecuniary motivations exist, and the economic conditions allow it, it is not unusual to find collaborations that remain informal overtime. Formalising a research activity could still have some advantages, even under these conditions: it could help determine the responsibilities of the partners, and could give legal cover in case disputes arise about the nature of the advice given or the use of partner resources. We can hypothesize that partners who fulfil the conditions to enter an informal collaboration will gauge the costs and advantages of formalisation. The higher the costs of a formal engagement the more likely it is that the collaboration will remain informal. In a system like the Spanish that is highly bureaucratic and where administrative conditions and practices are very burdensome, we should expect informality to appear more frequently. Further, when collaboration revolves around a string of small engagements (like recurrent consultations) related to a specific question or problem, and when the needs emerge suddenly, formalisation is likely to be too slow and afford few, if any, benefits to the collaboration partners (like in the case of *Linguistics*).

This paper has focused on a specific field (the social sciences and humanities) within a very specific institutional context (a large Spanish research organisation). It has proposed a way to analyse informal collaborations and pointed out a specific context in which persistent informality occurs. The conditions that enable and facilitate the emergence of collaborations that remain informal overtime are not unique to our context, but obviously they are not reproduced everywhere. Further researcher is needed to provide a systematic, general view of the conditions under which informality persists and to be able to establish different propensities to formalise collaborations across institutional settings and fields of knowledge.

Our results have also implications for the kinds of indicators that should be used in analytical work. If informal collaborations thrive under specific contextual conditions, indicators based on formal legal documents (like, for instance, research or license contracts) will capture a varying proportion of the collaborations established between academics and non-academics depending on their contextual conditions. Therefore, the use of these indicators cannot be indiscriminate; in particular, care should be exercised when using them for comparative purposes or for the aggregate analysis of areas of knowledge where the propensity to formalise collaborations may be different. This is not to mean that indicators cannot be developed to analyse informal collaborations; they do leave trails: partners linked through an informal collaboration will still exchange emails, may co-author articles and reports, and their participation in the organisation of, for instance, cultural events and exhibitions is likely to be acknowledged. But such indicators of collaboration are difficult to assemble, and even more difficult to be constructed in such a way that could enable the researcher to use them as aggregate measurements. This is an area where further work is needed. Typically, scholars have developed and implemented bespoke questionnaires to capture informal collaborations, but these can also face problems. Written questionnaires might not be able to capture the extent of informal collaborations. Researchers could be reluctant to compromising on paper collaborations not officially entered, or may think that small collaborations are irrelevant. If informal links are important, responses to questionnaires will be very sensitive to the ways questions are posed and the forms in which the research design tries to capture informality.

From a policy perspective, informal collaborations remain invisible to the management processes of the research organisations within which they take place. Again, any data derived from such management sources is likely to be incomplete and biased (since the situations that lead to informality do not appear equally in all research disciplines and research management contexts). This has to be taken into account when considering the management of science and technology policies: the lack of visibility of many instances of collaboration in the SSHs has important implications for policy implementation. First, informal activities are difficult to include in institutional and individual assessments. In the Spanish context, where assessments are based exclusively on activities that can be audited, informal collaborations are not, for instance, taken into account when considering individual academics for promotion. This is likely to have been a disincentive to the development of these forms of interaction; finding that there is no reward or recognition for these activities some researchers may try to avoid them. Yet, trying to recognize them for evaluation and assessment purposes is not a straightforward endeavour. Attempts to identify and 'count' them may lead to increased bureaucratization and the feeling among researchers of a growth in the 'audit culture' and to react against it, either by keeping the activities 'underground' or by ceasing to engage in them. Attempts at formally recognizing more forms of collaboration in, say, promotion decisions, may lead researchers to focus only on those activities that are 'counted'. How to develop management and incentive systems that cover formal as well as informal means of collaboration remains an open challenge for research policy.

As research organisations and their funding departments accept the need to increase the value academic researchers provide directly to society, policies to develop technology transfer, knowledge exchange and research impact are becoming more widespread. Yet, many of them still focus on the commercialization of research outputs and the management of IP for the generation of commercial gains, and leave unaddressed the forms of knowledge exchange in the SSH we have identified in this paper. Support to knowledge exchange in these fields requires a broader set of instruments that should go beyond commercialization support. The need to facilitate social engagement and to build social networks between academic researchers and potential partners of their research should be included in the mix of policy instruments if the objective is to improve the contribution of SSH researchers to societal development. Such policies are, however, unlikely to generate economic returns and should, besides, stay clear from attempts at formalising the collaborations that have been established, lest this attempt become a disincentive for the same activities they aim to promote. Under these conditions assessing the effectiveness of such broadly-based knowledge-exchange support activities becomes particularly difficult.

6.6. References

Abreu, M. and Grinevich, V. (2013) ‘The nature of academic entrepreneurship in the UK: Widening the focus on entrepreneurial activities’, *Research Policy*, 42/2: 408-22.

Abreu, M., Grinevich, V., Hughes, A. and Kitson, M. (2009) ‘Knowledge exchange between academics and the business, public and third sectors’, Cambridge: Centre for Business Research and UK-IRC, <http://www.cbr.cam.ac.uk/pdf/AcademicSurveyReport.pdf> accessed 15 November 2011.

Agrawal, A. and Henderson, R. (2002) ‘Putting patents in context: Exploring knowledge transfer from MIT’, *Management Science,* 48/1: 44-60.

Amara, N., Landry, R. and Halilem, N. (2013) ‘Faculty consulting in natural sciences and engineering: between formal and informal knowledge transfer’, *Higher Education*, 65/3: 359-84.

Boardman, P. C. and Ponomariov, B. L. (2009) ‘University researchers working with private companies’, *Technovation,* 29/8: 142-53.

Bonaccorsi, A. and Piccaluga, A. (1994) ‘A theoretical framework for the evaluation of university-industry relationships’, *R&D Management,* 24/3: 229-47.

Castro-Martínez, E., Recasens, A. and Jiménez Sáez, F. (2013) ‘Innovation systems in motion: an early music case’, *Management Decision,* 51/6: Forthcoming.

Castro-Martínez, E., Fernández-de-Lucio, I., Pérez-Marín, M. and Criado-Boado, F. (2008) ‘La transferencia de conocimientos desde las Humanidades: posibilidades y características’, *Arbor,* 184/732: 619-36.

Cohen, W. M., Nelson, R. R. and Walsh, J. P. (2002) ‘Links and impacts: the influence of public research on industrial R&D’, *Management Science,* 48/1: 1-23.

CSIC (2008) ‘Annual report 2007’, Madrid: Consejo Superior de Investigaciones Científicas (CSIC).

CSIC (2011) ‘Annual report 2010’, Madrid: Consejo Superior de Investigaciones Científicas (CSIC).

Druilhe, C. and Garnsey, E. (2004) ‘Do academic spin-outs differ and does it matter?’, *The Journal of technology transfer,* 29/3: 269-85.

Fernández-Esquinas, M., Sebastian, J., López-Facal, J. and Tortosa-Martorell, E. (2009) ‘Growth rings in the tree of science. The institutional evolution of the Spanish Council for Scientific Research’, *Revista Internacional de Sociología,* 67/2: 251-84.

Göransson, B., Maharajh, R. and Schmoch, U. (2009) ‘New activities of universities in transfer and extension: multiple requirements and manifold solutions’, *Science and Public Policy,* 36/2: 157-64.

Grimpe, C. and Hussinger, K. (2008) 'Formal and informal technology transfer from academia to industry: complementarity effects and innovation performance', ZEW-Centre for European Economic Research, Discussion Paper No. 08-080. <ftp://ftp.zew.de/pub/zew-docs/dp/dp08080.pdf> accessed 17 October 2011.

Grimpe, C. and Fier, H. (2010) 'Informal university technology transfer: a comparison between the United States and Germany', *The Journal of Technology Transfer,* 35/6: 637-50.

Hagedoorn, J., Link, A. N. and Vonortas, N. S. (2000) 'Research partnerships', *Research Policy,* 29/4: 567-86.

Hughes, A., Kitson, M., Probert, J., Bullock, A. and Milner, I. (2011) 'Hidden Connections: Knowledge exchange between the arts and humanities and the private, public and third sectors', Cambridge: Arts and Humanities Research Council and Centre for Business Research. <http://www.ahrc.ac.uk/About/Publications/Documents/hiddenconnectionsCBRreport.pdf> accessed 4 January 2012.

Landry, R., Saïhi, M., Amara, N. and Ouimet, M. (2010) 'Evidence on how academics manage their portfolio of knowledge transfer activities', *Research Policy,* 39/10: 1387-403.

Link, A. N., Siegel, D. S. and Bozeman, B. (2007) 'An empirical analysis of the propensity of academics to engage in informal university technology transfer', *Industrial and Corporate Change,* 16/4: 641-55.

Markman, G. D., Gianiodis, P. T. and Phan, P. H. (2008) 'Full-Time Faculty or Part-Time Entrepreneurs', *Engineering Management, IEEE Transactions on,* 55/1: 29-36.

Meyer-Krahmer, F. and Schmoch, U. (1998) 'Science-based technologies: university-industry interactions in four fields', *Research Policy,* 27/8: 835-51.

Parga-Dans, E., Castro-Martínez, E. and Fernández-de-Lucio, I. (2012) 'La arqueología comercial en España: ¿un sistema sectorial de innovación?', *Cuadernos de Gestión,* 12/2: 139-56.

Schiller, D. (2010) 'Institutional Reconfiguration within the German Science Sector and its Implications for Cross-Sector Collaboration: Designing Formal Organisations or Stimulating Informal Practice?', paper presented at *Workshop on Cross-Sector Collaboration (CSC) in National Innovation Systems: Understanding the Impact on Policy and Practice*, 15-16 April. Córdoba.

Siegel, D. S., Waldman, D. and Link, A. (2003) 'Assessing the impact of organizational practices on the relative productivity of university technology transfer offices: an exploratory study', *Research Policy,* 32/1: 27-48.

Spaapen, J. and van Drooge, L. (2011) 'Productive interactions in the assessment of social impact of research', *Research Evaluation,* 20/3: 211-18.

Tang, P. and Molas-Gallart, J. (2009) 'Intellectual Property in collaborative projects: navigating the maze', *International Journal of Technology Management*, 47/ 4: 371-91.

6.7. Appendix

Table 6.A.1: Social sciences and humanities institutes of the CSIC

Area	Nature of the institute	Acronym	Name of the institute
H	C	IH	Institute of History
H	C	IMF	Milá and Fontanals Institution
H	C	ILLA	Institute of Language, Literature and Anthropology
H	C	ILC	Institute of Languages and Cultures of the Mediterranean and the Near East
H	C	IFS	Institute of Philosophy
H	C	EEHA	School of Hispanic Studies
H	C	EEA	School of Arabic Studies
H	J	IEIOP	Institute of Islamic and Near Eastern Studies
H	J	IHCD	López Piñero Institute of the History of Medicine and Science
H	J	IEGPS	Padre Sarmiento Galician Studies Institute
H	J	IAM	Mérida Institute of Archaeology
SS	C	IEGD	Institute of Economics, Geography and Demographics
SS	C	IEDCYT	Institute of Documentary Studies on Science and Technology
SS	C	IPP	Institute of Public Goods and Policies
SS	C	IAE	Institute for Economic Analysis
SS	J	IESA	Institute for Advanced Social Studies
SS	J	INGENIO	Institute of Innovation and Knowledge Management

H: Humanities; SS: Social Sciences
C: CSIC institute; J: Joint institute

CHAPTER 7

STUDY 3:[63]

KNOWLEDGE TRANSFER ACTIVITIES IN SOCIAL SCIENCES AND HUMANITIES: EXPLAINING THE INTERACTIONS OF RESEARCH GROUPS WITH NON-ACADEMIC AGENTS

Abstract

This study is framed within the discussion around the contribution of research in the social sciences and humanities (SSH) to society. Our aim is to contribute to the debate on SSH knowledge transfer (KT) using a unit of analysis that has received relatively less attention in the literature despite increasing exploitation of its organisational form in the science system, the research group. The paper addresses two main questions. First, the extent to which SSH research groups engage in KT and the types of KT activities they use to interact with non-academic communities. Second, the factors related to research groups' characteristics and the profiles of their leaders, which direct the engagement of research groups towards a specific KT activity. Our empirical analysis is based on data from a questionnaire study of SSH research groups of the Spanish Council for Scientific Research (CSIC). We find that SSH research groups engage with non-academic communities through a diversity of KT activities. Different characteristics of research groups and individuals (leaders) are related to the likelihood of research groups to be involved in a particular KT activity. We discuss the implications of these findings for research and management.

[63] Developed with Elena Castro Martínez and Pablo D'Este.

Keywords: knowledge transfer activities, social sciences, humanities, research groups, science-society interactions.

7.1. Introduction

The relevance given to knowledge for the development of modern society, and the rise of the knowledge based economy, have increased the visibility of institutions creating and disseminating knowledge (Geuna and Muscio, 2009). In this context, universities and public research organisations are under increasing pressure to demonstrate the societal value of their research since they are responsible to their funding entities and also to the wide range of taxpayers supporting public research. Policy efforts focus on promoting and measuring universities' technology transfer and its engagement with non-academic communities. The activities selected to account for these measures are restricted mostly to commercial activities (i.e. intellectual property licensing and spin-off creation) as reflected in a large literature (e.g. Friedman and Silberman, 2003; Jensen et al., 2003; Link et al., 2003; Shane, 2004). Unfortunately, social sciences and humanities (SSH) research does not completely fit with the prevailing technology transfer model constructed for science and technology (Crossick, 2009), which tends to leave these disciplines 'out of the picture' in policy and academic discussions on knowledge transfer (KT).

Indeed, many authors agree about the problems involved in evaluating and measuring the impact of SSH research because of its less tangible and measurable results (Ibarra et al., 2006; Moed et al., 2002; Molas-Gallart et al., 2000; Nederhof, 2006). Lack of visibility of the social value of SSH research along with the common belief that these disciplines have fewer links with third parties, have led to concerted attempts to demonstrate its public value (see Bate (2011) for a collection of detailed case studies in the humanities). Recent studies show that SSH is engaged with a wide range of partners (firms, government agencies, non-profit organisations) through a broad spectrum of KT activities that do not take the form of technology transfer (Castro-Martínez et al., 2008; Hughes et al., 2011). Our paper seeks to contribute by addressing some unexplored aspects of the literature related to the heterogeneity of university-industry interactions and KT in the context of SSH (for further details see Gulbrandsen et al., 2011).

This paper makes two specific contributions to extend our understanding of KT activities undertaken in the SSH. First, an abundance of empirical studies on KT restrict their analyses to the natural sciences and engineering disciplines (e.g. Bishop et al., 2011; D'Este and Perkmann, 2011; Haeussler and Colyvas, 2011; Landry et al., 2010, among others). The first contribution is to shed light on KT activities in SSH, since this is an area of study that traditionally has received scarce attention in the empirical literature. In connection to this, the first question we address is: To what extent do SSH research groups engage in KT with non-academic communities, and what forms of KT activities are the most frequent? More specifically, we focus on mechanisms involving direct (personal) interaction between researchers and users or stakeholders, but not the indirect ones, such as books, manuals, guides, etc., which do not require the direct interaction with researchers.

Second, KT and science-society interactions have been studied mostly at the university-level and more recently from a lower level of analysis, such as the researcher or the university department. The academic research group is rarely used as the unit of analysis. This is unfortunate since research groups –defined as a team of researchers working on a common research area within larger institutions and recognized as an entity by their colleagues or partners (Laredo and Mustar, 2000) –are important units of organisation within the science system as producers of knowledge (Braam and van den Besselaar, 2010; Hernández et al., 2009; Rey-Rocha et al., 2008; Wuchty et al., 2007). Thus, the second contribution of this paper is to focus on the research group as the unit of analysis since KT studies at this level of aggregation are rare (for a few exceptions see Bercovitz and Feldman, 2011; Ramos-Vielba et al., 2010, 2012), by addressing the following question: What are the factors that shape engagement of SSH research groups in different forms of KT activities?

The paper is structured as follows. Section 7.2 discusses some particular aspects related to the SSH research context. Section 7.3 reviews the main KT activities engaged in by academics. Section 7.4 addresses research groups' determinants of KT activities. Section 7.5 offers a description of the data, methodology, variables and descriptive results. Section 7.6 presents the empirical analysis and section 7.7 provides a discussion of the results and outlines the emerging conclusions and their implications for managerial practice and further academic research.

7.2. The context of the social sciences and humanities

7.2.1. The social sciences and humanities debate

SSH traditionally have been in the background in science and policy debates, which have been dominated by discourse focused on technology transfer and commercialization activities. National research policies mostly consider technological needs, and SSH research is relatively marginalized when policies are formulated (Cassity and Ang, 2006). The valorisation[64] of academic results has been limited mostly to the economic contribution of universities through patents licensing, spin-off creation and technology transfer activities, mainly linked to the results from the hard sciences. Indeed, as noted by Benneworth and Jongbloed (2010), the emergent restrictive definition of universities' societal impact is worrying since it runs the risk of overlooking the potential of the arts, humanities and social sciences.

However, increasing concern over the contribution of SSH to society is reflected in a growing body of literature that tries to show evidence of its societal impact. For example, in the British context, several efforts have been made to analyse the economic impact and the contribution of SSH research to the culture, the innovation system and the policy sphere (AHRC, 2009a; Bakhshi et al., 2008; British Academy, 2004, 2008). In the Danish context, the report elaborated by the Danish Business Academy entitled 'When Social Sciences and Humanities research generates profit' identifies the main research themes relevant for the business sector, to be covered by SSH disciplines (DEA, 2007). Likewise, the European project HERAVALUE[65] addresses the problem of identifying the societal impacts of research conducted within the arts and the humanities. Moreover, coinciding with the European Commission's future framework for research and innovation (Horizon 2020), the debate on the SSH contribution has been brought to the supranational domain. Claims for better support for SSH research are at the centre of debate about the future configuration of European research. A recent position paper from the Danish Business Academy discusses how and why SSH can play

[64] Valorisation is understood as making the results from academic research accessible to increase the likelihood of them being used outside the academia as well as the co-production of knowledge (Bryson, 2000).

[65] http://www.utwente.nl/mb/cheps/research/current_projects/heravalue/, accessed on 3 September 2012.

an important role in realizing the Innovation Union and in contributing to solving Grand Societal Challenges. The message conveyed by the authors of this document, which coincide with previous messages, is clear: ‘The complexity of the Grand Societal Challenges demand alternative solutions and new ways to exploit our academic competences in the best and broadest way possible. This is not done by losing the Social Sciences and Humanities, but by using it’ (DEA, 2011: 22).

This section highlights that the contribution of SSH research to society is currently a ‘hot’ topic in academic and policy debates. The following section discuss in further details some characteristics of SSH research and the way that SSH research is used by non-academic communities.

7.2.2. Social sciences and humanities research characteristics

Understanding the place of SSH in the KT debate requires some understanding of the characteristics of the knowledge being transferred. It is well known that SSH research primarily is concerned with the study of the human condition, the way in which individuals relate and behave, and how societies are organised. As Gibbons et al. (1994) note, research in the context of application and reflexivity are inherent characteristic of these disciplines. These features are not unique to SSH since they correspond also to other fields within the paradigm of new production of knowledge (Gibbons et al., 1994). However, differences between SSH and other fields reside in the nature of the knowledge produced and its potential use, as well as the type of outputs generated.

SSH can help us to cope better with a special class of societal needs that cannot be satisfied in any other way (Janik, 2010: 2). SSH research is often based on a constant interrogation of the past to understand the present (reflexivity) and it contributes to produce meaning as well as lens through which to understand current social phenomena. Therefore, SSH researchers are closely engaged with the public, allowing them to direct research to the generation of knowledge covering societal interest and needs in the context of application. Overall, the contribution of the SSH extends to society as a whole through the provision of content, self-reflection, critical and conceptual thinking (European Commission, 2007: 9), rather than provision of technologies and new artefacts more typical of disciplines such as engineering and the experimental sciences. Conversely, primary outputs of non-SSH disciplines are mainly oriented to the industry, and take the form of tangible artefacts which are simpler to identify and measure than SSH outputs. These differences in the types of users and outputs across areas of knowledge have important implications regarding the uses and the prevalent modes of interactions with non-academic stakeholders.

Difference may stem also from the objectives of potential users of the research. According to Pelz (1978), research can be used in a direct way to solve a specific problem (instrumental use), but may also be used more indirectly to generate enlightenment (conceptual use) or to sustain a legitimate idea or position (symbolic use). The balance between these types of uses can differ across areas since different disciplines have diverse patterns of collaboration with different types of users. SSH researchers are strongly engaged with government agencies, often dominated by conceptual and symbolic uses (Amara et al., 2004). On the other side, the patterns of collaboration among non-SSH researchers are linked comparatively more to industry, with firms the primary users of research outputs to solve technical specific problems or to develop innovative products and processes (instrumental use).

The nature of the research output might impinge upon the type of KT activities used. For instance, since SSH research outputs rarely take the form of technology or artefacts, its uptake by socio-economic agents is rarely captured using traditional indicators that mainly account for transactional and commercial activities such as spin off creation and intellectual property rights licences. Therefore, we turn in the following section to address more collaborative activities (such as consultancy or contract and joint research) as opposed to commercial activities.

7.3. Knowledge transfer activities in social sciences and humanities

To what extent do SSH research groups engage in KT with non-academic communities and what forms of KT activities are the most frequent? This section frames these research questions through a review of the variety of KT activities addressed in the literature and identification of those that best suit the specificities of SSH.

Several conceptual frameworks have been developed to identify and classify the broad variety of university-industry forms of interactions. Bonaccorsi and Piccaluga (1994) proposed a taxonomy for university-industry relationships based on the degree of formalisation of collaborations, its length and the organisational resources provided by the university. Molas-Gallart et al. (2002) identify 12 third stream activities involving academic and non-academic communities which they classify into university capabilities and university activities. Abreu et al. (2008) conceptualize university-business knowledge exchange using a taxonomy that groups a wide range of modes of interactions into four categories: educating people, stock of codified useful knowledge, problem solving activities, and public space. Similarly, a recent study conducted by Abreu et al. (2009) categorizes 23 types of interactions between academics and external organisations into 3 broad activities -people based activities, community based activities, problem solving activities, and a fourth narrower category of commercialization activities. Finally, the UK Arts and Humanities Research Council (AHRC) conducted a research project about cultural engagement and KT that led to the aggregation of transfer activities into eight transfer channels (e.g., performances, exhibitions, consultations, e-engagement, etc.) for measuring outcomes from KT in the sphere of cultural engagement (AHRC, 2009b). This brief review informs about the several conceptual efforts undertaken to identify, define and classify the wide spectrum of activities for science-society interactions.

Empirical studies related to non-technology transfer provide some insight into the dominant forms of collaboration in SSH. For example, in the study conducted by Schartinger et al. (2002) in the Austrian context, the authors show that joint research activities are used predominantly by natural and technical sciences (engineering, chemistry, physics) but of minor relevance in economics and social sciences (Schartinger et al., 2002: 317). In fact, their study indicates that personnel mobility and training courses are the most important KT activities in the field of economics, while training courses for firms, and lectures delivered to firm members are prevalent in the fields of economic and social sciences. A study focused on the Australian context (Gascoigne and Metcalfe, 2005) found that consultancy (39%) and contract research (16%) were the most common activities among SSH and arts researchers. In the UK context, a study of 3,500 arts and humanities academics showed low levels of engagement in commercialization activities and interactions dominated by other forms of activity such as participation in networks (61%), providing lectures for the community (56%) and consultancy activities (37%) (Hughes et al., 2011).

Overall KT activities are encapsulated by the five types described below. Academic *consultancy*, defined as technical advice services work commissioned by non-academic agents that do not necessary involve original academic research, but the use of their accumulated knowledge (Perkmann and Walsh, 2008). *Contract research* is understood as research activities carried out by academics and commissioned by non-academic organisations, as opposed to *joint research*, involving formal collaborative arrangements to conduct research oriented to fundamental understanding and undertaken by both parties (D'Este and Patel, 2007). *Training* refers to learning activities, such as courses, offered by the academic community (or demanded by non-academics) which are tailored to socio-economic agents' needs (business, government, professional groups); they are usually short term and targeted to deal with a limited range of issues. This activity is separate from traditional and formalised courses such as degree or masters courses (Molas-Gallart et al., 2002). Finally, *personnel mobility* refers to the flow of academics to other social environment (e.g. secondments to firms or to public agencies), as a way to further develop the expertise generated in the academic sphere to solve societal or economic problems as well as to learn from the context of application (Schartinger et al., 2002).

According to Abreu et al.'s (2009) taxonomy, consultancy, contract research and joint research are classified as problem solving activities while training and personnel mobility are considered people-based activities. Both contract and joint research are activities aimed at the generation of new knowledge and original research, and strongly associated with high levels of funding.[66] Consultancy, training and personnel mobility are comparatively more directed towards solving problems and meet specific demands compared to contract and joint research (Manjarrés-Henríquez et al., 2008, 2009). In line with the studies reviewed, the present paper aims to examine to what extent the SSH are engaged in these five types of KT activities and what factors shape involvement in these activities.

[66] However, depending on the field of research, the amounts of funding required can vary considerably. For instance philosophers' activities require fewer resources (books, internet) than those of archaeologists, who may need to do excavations and have access to specialized laboratories to conduct their research.

7.4. Determinants of knowledge transfer activities by research groups

Academic researchers increasingly are organised in research groups to conduct their scientific activities; therefore, the study of the characteristics of groups is of great importance to understand research practices (Rey-Rocha et al., 2002). For instance, some studies combine the analysis of individual and collective (organisational) characteristics to explain individual research productivity (Carayol and Matt, 2006) or collective scientific productivity (Carayol and Matt, 2004). In the KT literature, we find studies combining organisational and individual characteristics to explain researchers' interaction with industry (Boardman and Corley, 2008; Landry et al., 2010; Ponomariov, 2008), but rarely addressing interactions at the research group level. Additionally, the role of certain actors within an organisation may exert a critical influence to the organisational behaviour of a scientific collective; for instance, Bercovitz and Feldman (2008) show the influence of the departments' chair on the behaviour of other departments' members. Likewise, leaders of research groups might play a relevant role in orientating the practices of the groups and shaping their engagement with other non-academic communities. Bearing this in mind, we focus on research group-level and the individual-level characteristics to address our second research question: What are the factors that shape the engagement of SSH research groups in different forms of KT activities?

In addressing this question we explore the links between the characteristics of research groups and individuals (i.e. group leaders), and the engagement of research groups in KT activities. Given the variety of KT activities (and their particular characteristics), different determinants could be diversely related to each form of interaction. There are very few empirical studies on research groups that investigate the determinants of KT at these two levels of aggregation (for an exception see Ramos-Vielba et al., 2012). In the present study, we adapt to this unit of analysis (i.e. the research group) those organisational and individual factors reported in the literature as significant for shaping university–industry interactions.

7.4.1. Research group characteristics

Research groups can differ in composition, size and degree of heterogeneity. Differences in these characteristics may be associated with the extent and way that research groups engage in diverse forms of KT activities. Based on the literature review, we consider research group size, degree of multidisciplinarity and orientations toward users' needs might be closely related to how SSH research groups engage with non-academic communities. A review of the empirical studies that consider these characteristics is provided below.

Research group size

The scale of resources (research personnel) is a necessary condition to attract and collaborate with non-academic stakeholders because larger research units will have more resources to participate in a range of activities in addition to traditional research and publication. Some studies analyse the influence of department size (measured as numbers of academic staff) on academics' interactions with industrial partners. Schartinger et al. (2001) find a positive relationship between department size and the likelihood of engaging in joint research and personnel mobility. Schartinger et al. (2002) show that size significantly explains higher levels of science-industry interactions in the form of contract research, joint research, personnel mobility and training activities. Landry et al. (2010), in a study of 1,554 Canadian researchers, find that research unit size positively influences researchers' engagement in consulting activities. Thus we would expect:

Hypothesis 1: Larger research groups will be more likely to engage in KT activities.

Research group multidisciplinarity

According to Gibbons et al. (1994), the production of knowledge in the humanities is characterized by higher permeability of disciplinary frontiers. Educational diversity may affect the range and depth of the ability of the group to manage knowledge (Dahlin et al., 2005) and to tackle the research challenges within an increasingly complex society. This points to argue that collaboration involving different disciplines produces good research by allowing different approaches and solutions to particular problems. To our knowledge, the relationship between multidisciplinarity and engagement in KT activities has not been widely considered in the KT literature although SSH researchers believe that multidisciplinarity facilitates higher levels of KT (Castro-Martínez et al., 2008). In this sense, more heterogeneous research groups (based on the diversity of the educational backgrounds of their members) would be better equipped to tackle research problems from a broader perspective and to have more tools to provide interdisciplinary based solutions to socio-economic problems (Bercovitz and Feldman, 2011). This is more relevant in the SSH, where human and social phenomena needs to be approached from a wide spectrum of disciplines, each with its own theories and methodologies, leading to a broader search for solutions. In this context, we could expect multidisciplinary research groups to have a greater capacity to respond to socio-economic needs since they will have a more diversified and richer knowledge background with which to address societal challenges. The inclusion of a measure of multidisciplinarity in this study should shed some new light on the effect of background diversity in research groups' involvement in KT activities. Therefore, we would expect that:

Hypothesis 2: More multidisciplinary research groups will be more likely to engage in KT activities.

Focus on users' needs

The way that research groups conduct their research and include users' considerations in the implementation of research projects is an important aspect influencing interactions between both parties. The literature on knowledge utilization makes several suggestions as to the factors influencing the degree of research uptake outside the academic sphere. The two communities explanation (Caplan, 1979) highlights the lack of understanding between academic and non-academic communities. The gap between these two communities leads to under-utilization of academic research and lower levels of interaction between them since they work according to different norms, values, languages and objectives. Alternatively, the organisational interest explanation supports the hypothesis that the exploitation of university research by non-academics is improved if the research project focuses on the needs of users in addition to scholarly advancement (Amara et al., 2004; Landry et al., 2003). According to this explanation, conducting research that considers both users' needs and the social relevance of research results would help to bring these communities together and would promote uptake of academic results. Findings from empirical studies analysing knowledge exchange between social science researchers and government agencies, provide evidence that the two communities explanation does not describe the actual behaviour of social science scholars (Landry et al., 2001), and that the research focus on users' needs is positively related to the uptake of university research by government agencies (Amara et al., 2004). Similar results have been found for the natural sciences and engineering fields (Landry et al., 2007). According to the above explanations and the evidence from empirical studies, we would expect that:

> **Hypothesis 3:** Research groups conducting research focused on users' needs will be more likely to engage in KT activities.

7.4.2. Individual characteristics of the research group' leaders

Several studies analyse the influence of researchers' characteristics on their decisions to participate in different KT activities (Boardman and Ponomariov, 2009; D'Este and Patel, 2007; Landry et al., 2010, among other). In a collective such as a research group, individuals play an important role in its final practices. Therefore, a focus on the leader is relevant since he/she is a powerful source of influence on employees' work behaviour (Yukl, 2002). In the context of research groups, we contend that the leader can be a direct trigger of the behaviour of research group members (De Jong and Den Hartog, 2007) through decisions that establish research priorities, guide the work of members towards achievement of the research objectives, and mobilize group members' commitment. Results from individual-level studies of researchers' characteristics (such as academic status and research impact) provide indirect evidence that underpin the formulation of the hypotheses below.

Academic status

The reward system in academia is traditionally associated with scientific publication in peer-reviewed journals. Other activities, such as commercialization and collaborative

KT, may be considered as not contributing directly to the advancement of academic careers. According to the theory of time allocation (Rosen, 1974), investing time in KT activities might be perceived as more costly for academics not at the top of their academic careers (Braxton and Del Favero, 2002; Diamond, 1993), who would prefer to concentrate their efforts in more highly valued (by the academic reward system) activities that allow them to achieve promotion. Compared with early career researchers, more established scientists in tenured positions may not have the same pressure to publish, may enjoy greater social capital and may be less motivated by traditional academic incentives and, therefore, more willing to participate in commercial activities (Louis et al., 1989). Abreu et al. (2009) find that position matters, and that professors are more heavily engaged in commercialization activities than readers, senior lecturers or lecturers. D'Este and Perkmann (2011) provide evidence that higher academic status is positively related to the frequency of researchers' interactions with firms through consultancy, contract and joint research activities. From the literature review we would expect that:

Hypothesis 4: Research groups whose leaders hold high academic status are more likely to engage in KT activities.

Star scientists

Scientific reputation of researchers can affect engagement in interaction activities. Previous research has highlighted that star scientists (i.e., academics who publish more, and produce papers with greater impact) are more likely to show successful commercialization of research results. Empirical work relating research quality and engagement in commercial activities has been conducted at the university (Di Gregorio and Shane, 2003; O'Shea et al., 2005; Perkmann et al., 2011) and at the individual (Lowe and Gonzalez-Brambila, 2007; Zucker and Darby, 1996) levels. These studies generally show a positive relationship between scholarly success and commercial success. Having a star scientist in the position of group leader may attract the attention of non-academic agents who are more interested in collaborating with groups that include scientists with high academic reputation or high research impact. Some empirical studies include variables for number of publications to explain the university-industry relationship. Schartinger et al. (2001, 2002), who measure the quality of the department by analysing the number of international publications per researcher, find that publication is positively related to a higher engagement of the department in joint research activity, but not in activities such as contract research or personnel mobility. Lowe and Gonzalez-Brambila (2007) conduct an individual-level study that measures researchers' productivity as the number of journal articles published per year; they conclude that faculty entrepreneurs are more productive than their peers. Finally, Landry et al. (2010) analyse possible complementarities among different activities and show that academic publication and consulting are positively related. Therefore, taking presence of a star scientist as a measure of academic research impact, we would expect that:

Hypothesis 5: Research groups whose leaders are star scientists are more likely to engage in KT activities.

7.5. Data, main variables and descriptive statistics

7.5.1. Study context

The empirical study conducted in 2007 analyses the Spanish Council for Scientific Research (CSIC), the largest public research organisation in Spain and the third largest in Europe. CSIC is part of the Ministry responsible for research and its primary objective is to develop and promote research in the interest of scientific and technological progress. In 2007, CSIC employed 12,885 scientists, technicians and administrators included as civil servants (41%), fix term contract personnel (37%) and doctoral and post-doctoral researchers (22%). Tenured researchers are civil servants and accounted for 1,830 scientists (CSIC, 2008). CSIC scientists are spread over 125 research institutes distributed throughout Spain, accounting for 6% of total personnel dedicated to publicly funded R&D in Spain and generating 20% of Spanish scientific production.

CSIC's activity ranges from basic research to technological development. It is organised around eight scientific and technical areas covering a wide range of disciplines, namely: (1) biology and biomedicine; (2) food science and technology; (3) materials science and technology; (4) physical science and technology; (5) chemical science and technology; (6) agricultural sciences; (7) natural resources; and (8) humanities and social sciences. The research institute constitutes the administrative unit and each institute is composed of research groups. Research activities are mainly articulated around these research groups.

In 2007, SSH accounted for some 10% of total CSIC employees, and included 268 tenured researchers and more than 250 doctoral and contract researchers working in 17 research institutes and 97 research groups. The area is composed of multidisciplinary institutes varying by field, size and number of research groups: an institute can either host several research groups or be constituted by a unique research group (see Table 7.1 for further details). In general, CSIC SSH research groups are not large: more than half include fewer than five tenured researchers.

Table 7.1: Population and sample distribution by institutes and fields

Area	Acronym	Institutes	Main fields covered	Population Research Groups (N)	Population Researchers* (N)	Sample Research Groups (N)	Sample Researchers* (N)
H	IH	Institute of History	Prehistory, ancient history, medieval history modern history, comparative history, history of art, Greco-Latin and biblical heritage studies, historiography.	22	125	17	102
H	IMF	Milá and Fontanals Institution	Archaeology, anthropology, ethnography, medieval studies, history of science, musicology	10	56	10	56
H	ILLA	Institute of Language, Literature, and Anthropology	Language, literature, anthropology	10	42	9	37
H	ILC	Institute of Languages and Cultures of the Mediterranean and the Near East	Philology, lexicography, lexicology, palaeography, historical studies	9	48	9	48
H	IFS	Institute of Philosophy	Philosophy, ethics, history of science	4	27	3	24
H	IEIOP	Institute of Islamic and Near Eastern Studies	Ancient history, medieval history, epigraphy, philology, historiography	4	20	3	18
H	IHCD	López Piñero Institute for the History of Medicine and Science	Historical studies on science, technology and society, contemporary medicine studies, sociology of science	4	19	3	16
H	EEHA	School of Hispano-American Studies	Modern history , contemporary history, historical geography, cultural anthropology	3	20	3	20
H	EEA	School of Arabic Studies	Architectural history, historiography, epigraphy, philology, medieval history	3	9	3	9
H	IEGPS	Padre Sarmiento Institute for Galician Studies	Archaeology, architectural history, heritage studies	2	13	2	13
H	IAM	Mérida Institute of Archaeology	Archaeology, history of art, architectural history, historical geography	1	7	1	7
SS	IEGD	Institute of Economics, Geography and Demography	Economics, geography, demography	11	40	8	35
SS	IEDCYT	Institute of Documentary Studies on Science and Technology	Information sciences, science policy, history of science	7	18	6	17
SS	IPP	Institute of Public Goods and Policies	Political sciences, sociology	4	25	3	19
SS	IAE	Institute for Economic Analysis	Economics	1	23	1	23
SS	IESA	Institute for Advanced Social Studies	Sociology	1	15	1	15
SS	INGENIO	Institute of Innovation and Knowledge Management	Economics, political sciences, sociology	1	13	1	13
		TOTAL (%)		**97**	**520**	**83 (85.6%)**	**472 (90.6%)**

* It includes researchers from other institutions linked to CSIC through agreements. H: Humanities; SS: Social Sciences.

7.5.2. Sample and data collection

The population for the present study consists of all 97 SSH research groups in CSIC. Research groups were identified through institute web pages and consultation with research institute directors. Data were gathered in two phases. The first phase took place in 2007 and used two questionnaires to collect data. Both questionnaires were answered by the contact persons in each of the research groups, which often corresponded to the research group leader who provided information on research group members and their characteristics. The first questionnaire was administered face-to-face and collected information on the identification and description of the research group, its components (members), their status and their study background. The results were sent to interviewees for validation. The second (checklist) questionnaire was distributed to the contact persons who completed them and returned them by postal mail. This postal questionnaire comprised a checklist of items to be scored on a four point likert scale, referring mostly to the previous two years. The questionnaire was constructed based on the literature review on technology transfer conducted by Bozeman (2000) which we adapted to the research group to organise the information related to knowledge transfer dimensions: agent, recipient, media, object and demand environment. Although Bozeman's work is not at the research group level of analysis, we considered his literature review useful to identify and synthesize the main dimensions of the knowledge transfer process from which we build the structure of the questionnaire.

We obtained 94 validated questionnaires from the face-to-face interviews and 86 completed checklist questionnaires. The information from both sources related to 83 research groups, representing around 86% of the population and covering more than 90% of SSH researchers (Table 1). A second phase of data collection was conducted in September 2010. Information on academic production and impact of research group leaders (publications and citations) was gathered from Thomson Reuters' ISI Web of Science (WoS), and especially from the Social Science Citations Index (SSCI) and Arts & Humanities Citation Index (A&HCI). We used lifetime citations data (Linmans, 2010) to collect data on citations received by the papers published by research group leaders up to 2007. The final sample for the study is composed of the 83 research groups for which we have information at both, group and individual (i.e. the group leader) levels.

7.5.3. Main variables

We consider the following five binary dependent variables, one for each specific type of KT activity: consultancy; contract research; joint research; training; and personnel mobility. Each dependent binary variable takes the value 1 if the research group has engaged in this specific KT activity with non-academic agents during the period 2005-2007, and 0 otherwise.

The two independent continuous variables included in our analysis, size and degree of multidisciplinarity, refer to the characteristics of research groups. Research group size is measured as the number of full time equivalent research personnel in the group, excluding administrative, support staff and non-PhD staff. We used probability plots[67] to determine whether the variable size distribution matched the normal distribution. The observations were not clustered around the straight line corresponding to a normal distribution so we matched the variable size with a normal distribution using a logarithmic transformation.

The degree of multidisciplinarity is measured considering both variety (number of different disciplines) and balance (evenness of the distribution) of PhD degrees among group members. Disciplines are classified according to the UNESCO nomenclature with 4 digit of disaggregation[68]. Shannon's diversity index is computed for each research group to obtain an index capturing research group multidisciplinarity because it reflects simultaneously the variety of disciplines and how evenly they are distributed within the research group.

$$\text{Shannon diversity index} = -\sum_{i=1}^{N} p_i \log p_i$$

[67] We used the Q-Q plots procedure which plots the quintiles of the distribution of the variables against the quintiles of a normal distribution.

[68] Downloaded on 16 February 2011 from http://unesdoc.unesco.org/images/0008/000829/082946eb.pdf

where i=1 to N corresponds to the number of different disciplines within each research groups, and p_i captures the proportion of researchers belonging to the i^{th} discipline in the research group. Shannon diversity index takes a positive value that ranges from 0 if a research group is monodisciplinary and increases towards infinity for variety and even distribution of the disciplinary backgrounds of research group members. Therefore, the computed variable degree of multidisciplinarity is constructed from the Shannon diversity index, resulting in a continuous variable following a normal distribution.

Three binary independent variables are included: one for research group characteristics (focus on *users' needs*) and two corresponding to the characteristics of the leader of the research group (*status* and *star scientist*). The variable focus on users' needs has been widely measured in the literature based on the reported opinion of researchers on the extent to which projects are focused on users' needs (Amara et al., 2004; Landry et al., 2001; Landry et al., 2003; Landry et al., 2007). Following these studies, we construct this variable on the basis of a similar method: respondents were asked to what extent their research group considered, within the objectives of the research undertaken, the potential application of their results. The responses, originally measured as a categorical variable using a four point likert scale (from 'seldom' to 'very often'), were transformed into a binary variable that takes the value 1 if the research group answered 'very often', and 0 otherwise.

The binary variable corresponding to academic status of the research group leader takes the value 1 if the leader is a research professor and 0 otherwise. In CSIC there are three categories corresponding to a permanent position: tenured scientist, scientific researcher and research professor. This last represents the highest status for an academic in CSIC. Our binary variable differentiates research professors from the rest of the academics which allows us to test whether holding the top academic position is related to engagement in KT activities.

The binary variable corresponding to star scientist was constructed following a two-step procedure. First, we measured the impact of the research undertaken by the leaders of research groups by computing the average number of citations per year per publication received from the time of their first publication until 2007. A measure of academic research quality based on citations (Abramo et al., 2010) is a more complete approach to identifying a star scientist in terms of their academic impact (citations received from peers) rather than only considering number of publications. We used the Thomson Reuters' ISI WoS (SSCI and A&HCI databases) as the source of information and applied the following formula:

$$\text{Research impact index} = \sum_{i=1}^{N} \left(\frac{\text{number of citations}}{2007 - \text{publication year}} \right) \Big/ \text{number of publications}$$

where i=1 to N captures the N publications of each research group leader. Since the index research impact has a skewed distribution, in a second stage we identified a group of researchers with the highest research impact: those in the upper quartile of the research impact index. The binary variable star scientist takes the value 1 if the research group leader belongs to the first quartile of the research impact index, and 0 otherwise.

Finally, we include a binary variable to control for the *area* of the research group, which is coded 1 if the research group belongs to the social sciences and 0 if the research group belongs to the humanities.

A correlation matrix of the independent variables included in our analysis is presented at Appendix Table 7.A.1. Results indicate that the highest correlation is 0.478 and corresponds to the continuous variables multidisciplinarity and size. Table A.1 column 2 reports the tolerance statistic values for these variables (reciprocal of variance inflation factors, VIF), which indicate whether an independent variable has a strong linear relationship with the other independent variables. We see that all the tolerance statistic values are much higher than 0.2, which provides assurance that multicollinearity does not represent a problem in the regression analysis (Field, 2009).

7.5.4. Descriptive statistics

The descriptive analysis of the variables included in this study is reported in Table 7.2 About 50% of the research groups reported having engaged at least once in consultancy (51%), and contract research (46%) in the period 2005-2007, and more than a third of the research groups had been involved at least once in joint research (39%) and training activities (36%). Only 13% of the sample had participated in personnel mobility activity. For other KT activities, the questionnaire asked about the participation of research groups in transfer of property rights; however, none reported participating in this activity in the period 2005-2007 so it is not included in the analysis.

In relation to research group characteristics, size ranges from 1 to 23 full time researchers with an average group size of 5.7 researchers. The range of the study backgrounds among members of the research groups ranges from 1 (21.5% of the sample are monodisciplinary groups) to 8 for the most multidisciplinary group. Results indicate that multidisciplinarity, according to the Shannon diversity index, ranges from 0 to 2.10 with an average of 0.73. A quarter (25%) of the research groups indicated often considering users' needs when establishing their research objectives. Descriptive statistic referring to the control variable for research group area indicates that 24% of the sample belongs to the social sciences, and the remaining 76% to the humanities. For characteristics of research group leaders, research professors represent 30% of the sample. Those with the highest computed research impact index, considered star scientists, represent 25% of the sample.

Table 7.2: Descriptive statistics (N=83)*

Variables	Minimum	Maximum	Mean	St. deviation
Continuous Variables				
• Size	1	23	5.69	3.52
• Multidisciplinarity	0	2.10	0.73	0.51
Binary Variables				
• Consultancy	0	1	0.51	0.50
• Contract research	0	1	0.46	0.50
• Joint research	0	1	0.39	0.49
• Training	0	1	0.36	0.48
• Personnel mobility	0	1	0.13	0.34
• Users' needs	0	1	0.25	0.44
• Status (professor=1)	0	1	0.30	0.46
• Star scientist	0	1	0.25	0.44
• Area (social sciences=1)	0	1	0.24	0.44

*N=70 for the variables corresponding to the five knowledge transfer activities.

7.6. Determinants of knowledge transfer activities in social sciences and humanities

7.6.1. Regression model

The engagement of SSH research groups in different KT activities is measured through binary variables, one for each activity considered. To identify the factors related to the likelihood of a research group engaging in these KT activities, the basic model estimated is:

$$Log\ (Pi/1-Pi) = \beta 0 + \beta 1\ ln(size) + \beta 2\ multidisciplinarity + \beta 3\ users'\ need + \beta 4\ status + \beta 5\ star\ scientist + \beta 6\ area + \varepsilon$$

where β*j* (*j* = 0....6) are the parameters to be estimated, and ε is an error term. Log (Pi/1−Pi) is the ratio of the probability that a research group *i* has engaged in a specific type of KT activity relative to the probability that the same research group has not engaged in a specific KT activity.

We estimated five binary logistic regressions, one for each form of KT activity considered. The final number of observation used in the regressions is N=70.[69]

7.6.2. Regression results

The results of the five binary logistic regressions are summarized in Table 7.3 (columns 2-6). The equations formulated for the regression models are good predictors (with the exception of *joint research*) of whether or not research groups engaged in a specific KT activity. In the case of joint research, overall the model is not globally significant, suggesting that the variables included in the regression do not capture adequately the variations in the engagement of research groups in joint research activities. For the remaining regressions (i.e. consultancy, contract research, training activities and personnel mobility) the four models estimated by computing the value of the likelihood ratio, are significant. The values of the percentage of correct predictions go from 88.6%

[69] Overall, 27 research groups have been excluded from the regression for the following reasons: (i) we did not have information from both questionnaires (14 groups), as we mentioned in Section 5.2; (ii) missing data related to responses associated to the dependent variables (13 groups), as reported in footnote of Table 2. Nevertheless, all the institutes and fields are represented in our working sample for the regression analysis.

to 71.4%, and the values of the Nagelkerke R^2 (Pseudo R^2) range from 0.408 to 0.272, which are acceptable for qualitative dependent variable models (Landry et al., 2006: 1609). The analysis of both the relationships between the independent variables considered in the study and the likelihood of the research group to be involved in different KT activities, are presented below.

Research group characteristics

The size of the research group is significantly associated with its engagement in *consultancy* and *contract research*. The likelihood of research groups to participate in these two activities increases with the number of full time research personnel in the group. For the degree of multidisciplinarity of the research group, results indicate that higher diversity and evenness in the disciplines of members of research groups are significantly and positively related to their higher levels of participation in *contract research*. Consideration of users' needs in research objectives is a significant variable in all the regressions. More specifically, the likelihood to engage in *consultancy activities*, *contract research*, *training* and *personnel mobility* increases when the research groups consider the societal relevance of their research in their research objectives. Finally, when we control for the area to which the research group belongs, we find differences for two out of the five regressions. The likelihood of the research group to engage in *contract research* increases for research groups in social sciences compared to humanities. Conversely, the likelihood of engagement in *personnel mobility* increases for research groups in the humanities compared to social science. For the other KT activities, no differences were found between scientific areas.

Individual characteristics of the research group leaders

The academic status of the research group leader is significant in three of the five regressions. The likelihood of research group engaging in *consultancy*, *training* and *personnel mobility* is positively associated with research group leaders in the highest academic position (i.e. research professor). The research impact of research group leader is significant in two of the five regressions. More specifically, the probability that the research group participates in *consultancy* and *contract research* is positively related to research groups led by star scientists.

Table 7.3: Relationship between research groups' engagement in KT activities and characteristics of research group and individual (leader): binary logistic regressions

	Consultancy	Contract research	Joint Research	Training	Personnel mobility
Constant	- 1.927 (0.787)	- 3.657 (0.938)	- 1.204 (0.703)	- 1.164 (0.728)	- 1.867 (1.136)
Group variables					
• Size (ln)	**0.685* (0.504)**	**1.096** (0.576)**	0.156 (0.455)	0.276 (0.480)	- 1.045 (0.824)
• Multidisciplinarity	- 0.286 (0.601)	**0.993* (0.735)**	0.194 (0.598)	- 0.618 (0.659)	1.062 (0.902)
• Users' needs	**1.979*** (0.734)**	**0.938* (0.648)**	**0.819* (0.560)**	**1.667*** (0.687)**	**1.256** (0.757**)
Individual variables (Leader)					
• Status (professor)	**1.124** (0.667)**	0.151 (0.748)	- 0.381 (0.596)	**1.018** (0.571)**	**1.928*** (0.826)**
• Star scientist	**1.289** (0.781)**	**1.289** (0.795)**	0.589 (0.662)	- 0.114 (1.029)	- 0.641 (1.540)
Control variable					
• Area (social sciences)	- 0.176 (0.768)	**1.928*** (0.813)**	0.233 (0.638)	- 0.966 (0.811)	**- 2.025** (1.147)**
Number of observations	70	70	70	70	70
Chi-square (d.f.)	**14.81 (6)****	**16.78 (6)****	3.93 (6)	**10.76 (6)***	**10.55 (6)***
Nagelkerke R^2 (pseudo R^2)	0.300	0.408	0.071	0.245	0.272
Percentage of correct predictions	71.4	72.9	61.4	72.9	88.6

Dependent variables: engagement in five KT activities.
One tailed t-test: * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$. Robust standard errors are between brackets.

7.7. Discussion and conclusions

This paper has explored the extent to which CSIC SSH research groups engage in different types of KT activities to interact with non-academic communities in the Spanish context, and the factors directing these interactions. Our empirical analysis indicates that CSIC SSH research groups are actually involved with external agents through a variety of KT activities; however, this involvement is not shaped by the same factors.

Patterns of interactions in SSH do not differ greatly from those identified in the literature for other non-SSH disciplines. First, engagement of SSH research groups in commercial activities is insignificant compared to their participation in other more collaborative KT activities. Studies conducted in fields other than SSH provide evidence of the involvement of researchers in commercial activities such as intellectual property rights licensing and spin off creation, which rank last compared to engagement in more collaborative KT activities (Abreu et al., 2009; D'Este and Patel, 2007; D'Este and Perkmann, 2011; Ramos-Vielba et al., 2010). This characteristic is even more marked in our sample, with SSH research groups reporting any participation in intellectual property rights transfer activities. This is not entirely surprising since patents are rarely generated within the SSH area. Second, the most frequent KT activities for SSH research groups are consultancy and contract research. These findings are in line with several studies conducted in non-SSH fields (D'Este and Patel, 2007; D'Este and Perkmann, 2011), but do not support the findings in Schartinger et al. (2002) who found personnel mobility and training courses to be the most important KT activities in the field of economics, and training courses for firms and lectures to firm members dominant in the economics and social sciences. An explanation for the low engagement in personnel mobility in our sample could be related to the characteristics of the Spanish context. Social sciences fields generally are heavily involved in public administration promoting a natural flow of personnel in social sciences from academia to government agencies through advisory and technical positions. In the Spanish context, however, academics do not have an economic incentive to move to these technical positions which imply loss of freedom (in research) and detachment from the academic sphere. Indeed, the control variable introduced in the regression shows that belonging to the social sciences is negatively related to the probability of personnel mobility. In addition, the technical and advisory functions related to mobility tend to be provided in the form of consultancy activities, which explains the high involvement in Spain in this activity as opposed to personnel mobility.

Our study also explored the factors associated with higher engagement of SSH research groups in specific KT activities. For research groups' characteristics, the findings suggest a positive relationship between consideration of users' needs in setting the research objectives of the group, and higher engagement in all the KT activities analysed. This result is in line with the results for other fields such as engineering and the natural sciences (Landry et al., 2007). The size of the research group is positively related to a higher propensity to participate in consultancy and contract research, which is confirmed in other studies focusing on non-SSH fields (D'Este and Perkmann, 2011; Landry et al., 2010; Schartinger et al., 2002). Our results also show that the level of multidisciplinarity of the research group is positively linked to a higher probability to engage in contract research. Since contract research often involves balancing potentially conflicting demands (i.e. scientists' motivations for scientific knowledge generation and specific problem-solving demands of clients), a diversity of skills (both basic and applied) is necessary within the collective conducting this activity. The participation of research groups in contract research activities is thus favoured when the research group environment presents a wide diversity of disciplinary backgrounds among its members.

Our findings suggest that the leader's characteristics are significantly associated with the involvement of the research group in the KT activities considered. First, leader's academic status is positively related to the likelihood of the group's participation in consultancy, training and personnel mobility. Similar results for consultancy have been found in other fields such as engineering, and the physical and natural sciences (D'Este and Perkmann, 2011; Landry et al., 2010). Second, having a star scientist as the group leader is positively and significantly linked to a higher probability for the research group to engage in consultancy and contract research. The key role of star scientists in commercial activities has been shown to matter in other fields such as biotechnology (Zucker and Darby, 1996), but no comparative empirical studies have been found for collaborative KT activities.

There are some managerial implications from this study. First, CSIC SSH research groups are involved in KT activities with non-academic communities. CSIC is a public research organisation orientated basically towards knowledge advancement, in which tenured researchers enjoy a high level of stability. Incentives to engage in transfer activities are relatively low compared to the incentives for conducting research of high scientific impact, which is the main criterion for career progress. KT activities measurement indicators mainly account for intellectual property licensing spin off creation and R&D contracts, which does not fully reflect SSH practices. Within this institutional context, it is not surprising that SSH researchers feel they do not get much support from CSIC to engage with non-academic communities (Castro-Martínez et al., 2008). However, despite the lack of incentive, we show that KT does occur. Consultancy and contract research, the two most frequent KT activities, are related to the size and social orientation of the research group; therefore, policies designed to increase human resources and encourage research projects that have a strong focus on societal impact and users' needs might be enough to stimulate participation in those activities.

There is a second implication which is related to the research group leaders. We find that research group leaders play a crucial role in the engagement in KT activities of the research group (see also Ramos-Vielba et al., 2012). The academic status of leaders and the scientific impact of their research are associated significantly with involvement of the research groups with non-academic communities. Therefore, in addition to a focus on research group organisation, institutional policies should also be aimed at leaders as potential drivers of KT practices, and place a higher weight on KT activities in promotion and tenure decisions.

There are some limitations associated with measuring the impact of research in SSH based on the ISI WoS database. Standard citation indicators have been developed mainly for non-SSH disciplines and their use for humanities publications has been questioned (Linmans, 2010; Nederhof, 2006) for the following reasons: (i) ISI WoS does not include the majority of SSH publications; (ii) many are written in languages other than English; (iii) most are usually published as books. Therefore, the construction of bibliometric indicators for the humanities is still a debated issue and further research should consider alternative indicators to capture research impact. Another limitation is related to the variable multidisciplinarity: future research could address alternative measures to capture multidisciplinarity by considering the cognitive distance between disciplines (Rafols and Meyer, 2010).

Unlike the empirical work in the KT literature, this paper focuses on the research groups rather than on researchers, as the agent involved in KT activities. Therefore, we are aware that this decision in the context of our study implies working with small samples that may raise questions about the robustness of results from multivariate analysis. However, although in absolute terms the number of observations is small, our sample accounts for about 86% of the population. Therefore, it is highly representative of the total population of the CSIC SSH research groups. Bearing this in mind, our results should be taken as preliminary and should be contrasted with similar research in different institutional settings.

The type of agents with which research groups interact would be an interesting factor to examine, since SSH collaborate with a wide range of non-academic stakeholders. The type of non-academic partner could be associated with the different propensity of research groups to engage in specific KT activities. Moreover, based on the extant literature on KT in non-SSH fields, we would suggest focusing on a number of additional variables not considered explicitly in this study such as the sources of research funding (Gulbrandsen and Smeby, 2005; Landry et al., 2007, 2010), the motivations for collaboration (D'Este and Perkmann, 2011; Lam, 2011) and the barriers perceived by academics as hampering collaboration (Tartari et al., 2012). The transfer activities analysed in this paper illustrate the main forms of collaboration with non-academics and the factors that shape these interactions within the SSH area. Future research related to SSH KT should also address the nature of these collaborations since informal interactions are frequent in this area.

7.8. References

Abramo, G., D'Angelo, C.A., Di Costa, F., 2010. Citations versus journal impact factor as proxy of quality: could the latter ever be preferable? Scientometrics 84 (3), 821-833.

Abreu, M., Grinevich, V., Hughes, A., Kitson, M., 2009. Knowledge exchange between academics and the business, public and third sectors. UK- Innovation Research Center (downloaded on 21 November 2011 from http://www.cbr.cam.ac.uk/pdf/AcademicSurveyReport.pdf).

Abreu, M., Grinevich, V., Hughes, A., Kitson, M., Ternouth, P., 2008. Universities, Business and Knowledge Exchange. Council for Industry and Higher Education, and Center for Business Research (downloaded on 21 November 2011 from http://www.cbr.cam.ac.uk/pdf/University%20Business%20Knowledge%20Exchange%20v7.pdf).

AHRC, 2009a. Leading the World. The economic impact of UK arts and humanities research. AHRC (downloaded on 29 November 2011 from http://www.ahrc.ac.uk/News-and-Events/Publications/Documents/Leading-the-World.pdf).

AHRC, 2009b. Shaping metrics for HEI Cultural Engagement - Knowledge Transfer. AHRC project report (downloaded on 29 November 2011 from http://www.gla.ac.uk/media/media_126455_en.pdf).

Amara, N., Ouimet, M., Landry, R., 2004. New evidence on instrumental, conceptual, and symbolic utilization of university research in government agencies. Science Communication 26 (1), 75-106.

Bakhshi, H., Schneider, P., Walker, C., 2008. Arts and humanities research and innovation. AHRC, and NESTA (downloaded on 7 November 2011 from http://www.nesta.org.uk/library/documents/arts-humanities-innovation-report.pdf).

Bate, J. (Ed), 2011. The public value of the humanities. Bloomsbury, London.

Benneworth, P., Jongbloed, B.W., 2010. Who matters to universities? A stakeholder perspective on humanities, arts and social sciences valorisation. Higher Education 59 (5), 567-588.

Bercovitz, J., Feldman, M., 2008. Academic entrepreneurs: Organizational change at the individual level. Organization Science 19 (1), 69-89.

Bercovitz, J., Feldman, M.P., 2011. The mechanisms of collaboration in inventive teams: Composition, social networks, and geography. Research Policy 40 (10), 81-93.

Bishop, K., D'Este, P., Neely, A., 2011. Gaining from interactions with universities: Multiple methods for nurturing absorptive capacity. Research Policy 40 (1), 30-40.

Boardman, P.C., Corley, E.A., 2008. University research centers and the composition of research collaborations. Research Policy 37 (5), 900-913.

Boardman, P.C., Ponomariov, B.L., 2009. University researchers working with private companies. Technovation 29 (8), 142-153.

Bonaccorsi, A., Piccaluga, A., 1994. A theoretical framework for the evaluation of university-industry relationships. R & D Management 24 (3), 229-247.

Bozeman, B., 2000. Technology transfer and public policy: a review of research and theory. Research Policy 29 (4-5), 627-655.

Braam, R., van den Besselaar, P., 2010. Life cycles of research groups: the case of CWTS. Research Evaluation 19 (3), 173-184.

Braxton, J.M., Del Favero, M., 2002. Evaluating scholarship performance: Traditional and emergent assessment. New Directions for Institutional Research 2002 (114), 19-32.

British Academy, 2004. That Full Complement of Riches': The Contributions of the Arts, Humanities and Social Sciences to the Nation's Wealth. The British Academy (downloaded on 15 November 2011 from http://www.britac.ac.uk/templates/asset-relay.cfm?frmAssetFileID=6386).

British Academy, 2008. Punching our weight: the humanities and social sciences in public policy making. A British Academy Report (downloaded on 15 November 2011 from http://www.allea.org/Content/ALLEA/WG%20Evaluating/Punching_our_weight.pdf).

Bryson, J.R., 2000. Spreading the message: Management consultants and the shaping of economic geographies in time and space, in: Bryson, J. R., Daniels, P.W., Henry, N., Pollard, J. (Eds), Knowledge, space, economy. Routledge, London, pp. 157-175.

Caplan, N., 1979. The two-communities theory and knowledge utilization. American Behavioral Scientist 22 (3), 459-470.

Carayol, N., Matt, M., 2004. Does research organization influence academic production? Laboratory level evidence from a large European university. Research Policy 33 (8), 1081-1102.

Carayol, N., Matt, M., 2006. Individual and collective determinants of academic scientists' productivity. Information Economics and Policy 18 (1), 55-72.

Cassity, E., Ang, I., 2006. Humanities-industry partnerships and the 'knowledge society': The Australian experience. Minerva 44 (1), 47-63.

Castro-Martínez, E., Fernández-de-Lucio, I., Pérez-Marín, M., Criado-Boado, F., 2008. The knowledge transfer from the humanities: possibilities and characteristics. ARBOR - Ciencia Pensamiento y Cultura 184 (732), 619-636.

Crossick, G., 2009. So who now believes in the transfer of widgets? Talk given at the Knowledge Future Conference, Warden of Goldsmiths, University of London, 16-

17 October (downloaded on 15 November 2011 from http://mars.gold.ac.uk/media/transfer-of-widgets.pdf).

CSIC, 2008. Annual report 2007. CSIC, Madrid.

D'Este, P., Patel, P., 2007. University-industry linkages in the UK: what are the factors underlying the variety of interactions with industry? Research Policy 36 (9), 1295-1313.

D'Este, P., Perkmann, M., 2011. Why do academics engage with industry? The entrepreneurial university and individual motivations. Journal of Technology Transfer 36 (3), 316-339.

Dahlin, K.B., Weingart, L.R., Hinds, P.J., 2005. Team diversity and information use. Academy of Management Journal 48 (6), 1107-1123.

DEA, 2007. When Social Sciences and Humanities research generates profit (downloaded on 12 September 2012 from http://fuhu.dk/filer/DEA/Publikationer/2007/When%20SSH%20research%20generates%20profit.pdf).

DEA, 2011. The Social Sciences and the Humanities - use it don't lose it. Position paper from DEA (downloaded on 15 October 2012 from http://dea.nu/sites/default/files/DEA.eu-visionspapir.enkelt.pdf).

De Jong, J.P.J., Den Hartog, D.N., 2007. How leaders influence employees' innovative behaviour. European Journal of Innovation Management 10 (1), 41-64.

Di Gregorio, D., Shane, S., 2003. Why do some universities generate more start-ups than others? Research Policy 32 (2), 209-227.

Diamond, R.M., 1993. Instituting change in the faculty reward system. New Directions for Higher Education 1993 (81), 13-22.

European Commission, 2007. Report of the Expert Group on Humanities. Positioning Humanities Research in the 7th Framework Programme. Directorate-General for Research (downloaded on 15 October 2012 from http://ec.europa.eu/research/social-sciences/pdf/egh-report_en.pdf).

Field, A., 2009. Discovering Statistics Using SPSS (3rd ed.). SAGE publications Ltd, London.

Friedman, J., Silberman, J., 2003. University technology transfer: do incentives, management, and location matter? The Journal of Technology Transfer 28 (1), 17-30.

Gascoigne, T., Metcalfe, J., 2005. Commercialisation of research activities in the humanities, arts and social sciences in Australia. CHASS Occasional Papers №1, Council for Humanities, Arts and Social Sciences (CHASS) (downloaded on 15 November 2011 from http://www.chass.org.au/papers/pdf/PAP20050501TG.pdf).

Geuna, A., Muscio, A., 2009. The governance of university knowledge transfer: a critical review of the literature. Minerva 47 (1), 93-114.

Gibbons, M., Limoges, C., Nowotny, H., Schwartzman, S., Scott, P., Trow, M., 1994. The case of the Humanities, in: Gibbons, M., Limoges, C., Nowotny, H., Schwartzman, S., Scott, P., Trow, M. (Eds), The new production of knowledge: the dynamics of science and research in contemporary societies. Sage, London, pp. 90-110.

Gulbrandsen, M., Mowery, D., Feldman, M., 2011. Introduction to the special section: Heterogeneity and university-industry relations. Research Policy 40 (1), 1-5.

Gulbrandsen, M., Smeby, J.C., 2005. Industry funding and university professors' research performance. Research Policy 34 (6), 932-950.

Haeussler, C., Colyvas, J.A., 2011. Breaking the Ivory Tower: Academic Entrepreneurship in the Life Sciences in UK and Germany. Research Policy 40 (1), 41-54.

Hernández, N., Fernández, M., Ramos, I., 2009. The organizational structure of research groups in a regional university system. Paper presented at 9th Conference of European Sociological Association, Lisbon, 05 September.

Hughes, A., Kitson, M., Probert, J., Bullock, A., Milner, I., 2011. Hidden Connections: Knowledge exchange between the arts and humanities and the private, public and third sectors. AHRC, and Center for Business Research, (downloaded on 15 October 2012 from http://www.ahrc.ac.uk/News-and-Events/Publications/Documents/Hidden-Connections.pdf).

Ibarra, A., Barrenechea, J., Castro, J., 2006. Indicadores para evaluar las actividades de investigación en Ciencias Sociales y Humanidades en la UPV/EHU. Hacia la construcción de un índice de actividad científica. Documento de trabajo nº4. Cátedra Sánchez-Mazas UPV/EHU, Universidad del País Vasco, Spain.

Janik, A., 2010. A future for the humanities? Innovation: The European Journal of Social Science Research 23 (1), 1-12.

Jensen, R.A., Thursby, J.G., Thursby, M.C., 2003. Disclosure and licensing of University inventions: 'The best we can do with the s**t we get to work with'. International Journal of Industrial Organization 21 (9), 1271-1300.

Lam, A., 2011. What motivates academic scientists to engage in research commercialization: 'Gold', 'ribbon' or 'puzzle'? Research Policy 40 (10), 1354-1368.

Landry, R., Amara, N., Lamari, M., 2001. Utilization of social science research knowledge in Canada. Research Policy 30 (2), 333-349.

Landry, R., Amara, N., Ouimet, M., 2007. Determinants of knowledge transfer: evidence from Canadian university researchers in natural sciences and engineering. Journal of Technology Transfer 32 (6), 561-592.

Landry, R., Amara, N., Rherrad, I., 2006. Why are some university researchers more likely to create spin-offs than others? Evidence from Canadian universities. Research Policy 35 (10), 1599-1615.

Landry, R., Lamari, M., Amara, N., 2003. The extent and determinants of the utilization of university research in government agencies. Public Administration Review 63 (2), 192-205.

Landry, R., Saihi, M., Amara, N., Ouimet, M., 2010. Evidence on how academics manage their portfolio of knowledge transfer activities. Research Policy 39 (10), 1387-1403.

Laredo, P., Mustar, P., 2000. Laboratory activity profiles: an exploratory approach. Scientometrics 47 (3), 515-539.

Link, A.N., Scott, J.T., Siegel, D.S., 2003. The economics of intellectual property at universities: an overview of the special issue. International Journal of Industrial Organization 21 (9), 1217-1225.

Linmans, A.J.M., 2010. Why with bibliometrics the Humanities does not need to be the weakest link: indicators for research evaluation based on citations, library holdings, and productivity measures. Scientometrics 83 (2), 337-354.

Louis, K.S., Blumenthal, D., Gluck, M.E., Stoto, M.A., 1989. Entrepreneurs in academe: an exploration of behaviors among life scientists. Administrative Science Quarterly 34 (1), 110-131.

Lowe, R.A., Gonzalez-Brambila, C., 2007. Faculty entrepreneurs and research productivity. Journal of Technology Transfer 32 (3), 173-194.

Manjarrés-Henríquez, L., Gutiérrez-Gracia, A., Carrión-García, A., Vega-Jurado, J., 2009. The effects of university–industry relationships and academic research on scientific performance: Synergy or substitution? Research in Higher Education 50 (8), 795-811.

Manjarrés-Henríquez, L., Gutiérrez-Gracia, A., Vega-Jurado, J., 2008. Coexistence of university-industry relations and academic research: barrier to or incentive for scientific productivity. Scientometrics 76 (3), 561-576.

Moed, H.F., Luwei, M., Nederhof, A.J., 2002. Towards research performance in the humanities. Library Trends 50 (3), 498-520.

Molas-Gallart, J., Salter, A., Patel, P., Scott, A., Duran, X., 2002. Measuring third stream activities. Final Report to the Russell Group of Universities. SPRU, Brighton.

Molas-Gallart, J., Tang, P., Morrow, S., 2000. Assessing the non-academic impact of grant-funded socio-economic research: results from a pilot study. Research Evaluation 9 (3), 171-182.

Nederhof, A.J., 2006. Bibliometric monitoring of research performance in the social sciences and the humanities: a review. Scientometrics 66 (1), 81-100.

O'Shea, R.P., Allen, T.J., Chevalier, A., Roche, F., 2005. Entrepreneurial orientation, technology transfer and spinoff performance of U.S. universities. Research Policy 34 (7), 994-1009.

Pelz, D.C., 1978. Some expanded perspectives on use of social science in public policy, in: Yinger, J.M., Cutler, S.J. (Eds), Major social issues: A multidisciplinary view. Free Press, New York, pp. 346-357.

Perkmann, M., King, Z., Pavelin, S., 2011. Engaging excellence? Effects of faculty quality on university engagement with industry. Research Policy 40 (4), 539-552.

Perkmann, M., Walsh, K., 2008. Engaging the scholar: Three types of academic consulting and their impact on universities and industry. Research Policy 37 (10), 1884-1891.

Ponomariov, B.L., 2008. Effects of university characteristics on scientists' interactions with the private sector: an exploratory assessment. Journal of Technology Transfer 33 (5), 485-503.

Ramos-Vielba, I., Fernandez-Esquinas, M., Espinosa-de-los-Monteros, E., 2010. Measuring university-industry collaboration in a regional innovation system. Scientometrics 84 (3), 649-667.

Ramos-Vielba, I., Díaz, C.; Calero, J., 2012. Researchers motivations to collaborate with industry and knowledge transfer channels. Insights from a case study. Paper presented at the Annual Meeting of the Society for Social Studies of Science (4S), Copenhagen , 17-20 October.

Rafols, I., Meyer, M., 2010. Diversity and network coherence as indicators of interdisciplinarity: Case studies in bionanoscience. Scientometrics 82 (2), 263-287.

Rey-Rocha, J., Martin-Sempere, M.J., Garzon, B., 2002. Research productivity of scientists in consolidated vs. non-consolidated teams: the case of Spanish university geologists. Scientometrics 55 (1), 137-156.

Rey-Rocha, J., Martin-Sempere, M.J., Sebastian, J., 2008. Structure and dynamics of research groups. ARBOR - Ciencia Pensamiento y Cultura 184 (732), 743-757.

Rosen, S., 1974. Hedonic prices and implicit markets: product differentiation in pure competition. Journal of Political Economy 82 (1), 34-55.

Schartinger, D., Rammer, C., Fischer, M.M., Frohlich, J., 2002. Knowledge interactions between universities and industry in Austria: sectoral patterns and determinants. Research Policy 31 (3), 303-328.

Schartinger, D., Schibany, A., Gassler, H., 2001. Interactive relations between universities and firms: empirical evidence for Austria. The Journal of Technology Transfer 26 (3), 255-268.

Shane, S.A., 2004. Academic entrepreneurship. University spinoffs and wealth creation. Edward Elgar Cheltenham, UK.

Tartari, V., Salter, A., D'Este, P., 2012. Crossing the Rubicon: exploring the factors that shape academics' perceptions of the barriers to working with industry. Cambridge Journal of Economics 36 (3), 655-677.

Wuchty, S., Jones, B.F., Uzzi, B., 2007. The increasing dominance of teams in production of knowledge. Science 316 (5827), 1036-1039.

Yukl, G., 2002. Leadership in Organisations (5th ed). Prentice-Hall, Englewood Cliffs, NJ.

Zucker, L.G., Darby, M.R., 1996. Star scientists and institutional transformation: patterns of invention and innovation in the formation of the biotechnology industry. Proceedings of the National Academy of Sciences 93 (23), 12709-12716.

7.9. Appendix

Table 7.A.1: Non-parametric correlations between independent variables

Variables	Tolerance statistics	Multidisciplinarity	Users' needs	Status	Star scientist
Size (ln)	0.712	0.478 [a]	- 0.113	0.088	0.148
Multidisciplinarity	0.731	1	- 0.045	- 0.115	0.126
Users' needs	0.957		1	0.101	- 0.098
Status	0.911			1	0.201
Star scientist	0.913				1

[a] Relationship between Size (ln) and Multidisciplinarity calculated using Pearson's Correlation.

CHAPTER 8

GENERAL CONCLUSIONS

The question of how interactions between science and society are established in the SSH remains at the forefront of research interest. In the dissertation this topic has been addressed through three studies that, together, aim to advance our knowledge by highlighting some key aspects of this field, in terms of SSH research characteristics, its usefulness and patterns of interactions between researchers and social agents. This chapter reflects on the studies, offering some concluding observations and consideration of the policy and managerial implications of the research findings. A final section establishes the limitations of the research conducted, along with some directions for future research.

8.1. Conclusions

The dissertation aims at providing a deeper understanding of science-society interactions in SSH, a field that has traditionally received less attention in the literature than has STEM. The studies conducted make a contribution to the literature in that they explicitly addresses this issue by identifying the differentiating aspects of this field, and by investigating knowledge exchange processes (nature, mechanisms and the social agents involved). A better understanding of how these interactions are established is of interest for the design of science and innovation policies. Specifically, results could be useful for policy-makers seeking to boost science-society interactions in a particular field such as the SSH, but also in other fields.

The first objective of the study was to identify whether there was evidence substantiating the idea that the knowledge produced by the SSH is somehow less useful than that produced in STEM fields. According to our results, the usefulness or relevance of the research conducted in the SSH does not differ from that in other fields. However, differences are observed in the interaction practices and the users of SSH knowledge. SSH researchers are more involved through informal collaborations with government agencies and non-profit organisations compared to other fields, where the prevailing practices are formal collaborations with firms. Nevertheless, this finding does not imply that SSH research outputs are less useful than those in other fields; rather it suggests they are just different. Indeed, SSH research does not appear to have a lower orientation towards utility but just a different way of contributing to society. This includes collaborating with a wider variety of different social agents to cover societal needs, in ways that are not necessarily easily measurable in economic terms or by the commonly used knowledge transfer indicators.

Indeed, in the current crisis problems of ethics related to financial and political corruption make it very reasonable to consider that learning from ethics, philosophy or history could make a valuable contribution to society. Such contributions might not be easy to identify and quantify, but this does not imply that they are not (or even less) useful contributions to society. The importance of research outputs from areas such as sociology, economics, geography or demographics that address social changes and difficulties arising from issues such as migration, intercultural education, the ageing workforce, patterns of health, disability and dependence, care and unpaid work, etc., is also evident. A good understanding of these issues is essential to develop public policies of great importance for current citizens as well as for future generations.

As the above findings refer to researchers (i.e. individual level), the following step has been to analyse research groups, since they are a relevant form of scientific organisation unit of analysis not widely addressed in the literature. The second main objective was to further explore the nature of the collaborations established in the SSH, especially informal collaborations. Results indicate that SSH researcher groups primarily establish their collaboration through informal mechanisms that are neither institutionalised nor visible to the research organisation. This prevalence of informal collaborations implies that a huge amount of science-society interactions take place ‘under the radar’ of the organisation, which might lead to the false impression that SSH researcher groups are isolated in their ivory tower and not working with societal agents or disseminating their research outputs beyond the scientific sphere. This perception is problematic since policy-makers might conclude that research in the SSH is not providing the returns (either economic or social) expected from the public funding received.

The policy and managerial conclusions that arises from this result are of a negative nature. The implementation of policies to foster science-society interactions does not affect a collective of SSH researchers that are not using the institutional mechanisms to set up their collaborations. Moreover, to force researchers to formalise their collaborations could be counterproductive. On the one hand, there is the difficulty of establishing control mechanisms to ensure the formalisation of collaborations. On the other hand, there is considerably risk of researchers deciding to stop their collaborations if the bureaucratic burden is too high. However, it is apparent that it would be interesting to bring this huge amount of informal collaboration within the institutional framework, to make the organisation aware of the scientific practices conducted within its 'walls' and to make visible SSH contributions to the socio-economic environment. Thus, the implementation of formal instruments to bring informal collaborations into formal should be relatively 'light' (neither time-consuming nor complicated). An adaptation process and the provision of support from the research organisation need to be considered to facilitate researchers' willingness to formalise their collaborations.

Furthermore, in the particular case of Spain, the most widely used indicators to assess the knowledge transfer activities of research entities are based on the technology transfer model constructed for science and technology (e.g. R&D contracts, spin-offs creation, patents licenses). The type of output generated within the SSH often does not fit the technology transfer model. Indeed, SSH aim to produce meaning, to provide the lens for better understanding of current social phenomena and to produce content for the cultural sector (media, videogames, museums, historic heritage, etc.), among other activities. Technology transfer type indicators do not seem the most adequate to capture the extent to which SSH researchers are engaged with society through the flow of research outputs between the scientific and socio-economic environment. This implies that a change in the evaluation process would be needed to address this problematic. An alternative could be to identify new indicators and to conduct a more formative evaluation (rather than auditing), closer to the researcher, and strongly based on qualitative techniques aiming to provide a better and deeper understanding of collaborative practices, even aiming to steer and support them. This approach is not only useful for the SSH but also for the entire scientific community, because non-formalised interaction activities are also found in other fields. Unfortunately, the implementation of this type of more inclusive and formative set of indicators remains an open challenge.

The third main objective of the study was to identify the extent to which SSH research groups engage in different collaborative knowledge transfer activities. Results indicate that SSH research groups are engaged with society through a wide set of activities to establish interactions with social agents, allowing them to contribute to social needs and to solve social problems. The most frequent activities, similar to results found in other fields and contexts, are consultancy and contract research, followed by joint research and training. Conversely, personnel mobility arises as a marginal activity among those considered in the study.

The characteristics of research groups such as their size and their degree of disciplinarily, are factors that influence groups' engagement in consultancy and contract research. However, a factor that is systematically related with all the five knowledge transfer activities analysed is the consideration of the social uses of research outputs. Thus, results suggest that groups including within the research objectives the potential social application of their research outputs are more likely to engage in each of the knowledge transfer activities analysed. The underlying idea arising from this result is the relevance of conducting research linked to the context of application, i.e. the influence on the knowledge exchange processes of generating knowledge in Mode 2.

The flow of knowledge between the parties is not an automatic process in the SSH, where one could (sometimes wrongly) expect that, since SSH research is focused on the study of societies (among other subjects), the inherent process might lead to engagement with societal issues that are confronted. However, this might not necessarily be the case. Put simply, to study a social or cultural phenomenon does not necessarily imply that the new knowledge generated will flow outside the academic sphere or that this knowledge will cover social needs. Indeed, much of the motivation for current policies regarding engagement stems from, at least in part, the 'ivory tower' image of researchers whose work is perceived to lack societal relevance. Therefore, it seems reasonable, according the findings of this study, to include within the development of research objectives the social uses of the research outputs, as a way to foster relevant science-society interactions, since it is not a process that is automatically linked to the research activity.

The results also highlight the important role of research group leaders as a direct trigger of groups' knowledge transfer practices. Thus, policies aimed at enhancing knowledge transfer activities could consider taking advantage of the potential influence of leaders in their groups to achieve the desired objectives in terms of knowledge transfer practices. This could be done by increasing the weight of knowledge transfer indicators in tenure and promotion decisions relative to activities more rewarded in academic career promotion structures, such as scientific publications. The current scientific policy incentives could be a deterrent to researchers participating in knowledge transfer activities if their aim is to be promoted within their organisation.

The findings of the thesis can have practical utility for the design and management of policies to encourage knowledge flows and for assessing interactions from a wider approach, through indicators able to capture the types of practices identified in the SSH field. Overall, there is a general disjuncture between, on the one hand, the interactive way in which knowledge is produced and science-society relations are set up, and on the other hand, the policy focus based on an 'expired' technology transfer model from which a narrow set of economic indicators are derived. This disjunction has implications for all scientific fields, not only for the SSH, since most or part of researchers' collaboration remains invisible (or uncovered) within a narrow approach that does not consider the social value derived from the different uses of research outputs. Thus, further efforts should be directed to embracing a broad concept of science-society interactions (from which to derive wider and richer indicators) that considers the broad range of collaborative and relational activities which lead to a clearer picture of the actual role of science in society.

8.2. Limitations and future research

The studies share some limitations and suggest avenues for future research. First, there is room for future research in line with the type of organisation analysed in the dissertation (CSIC). All the three studies focus on a public research organisation which allows for certain homogeneity throughout the research. However, the specific characteristics of the CSIC could reduce the generalisation of the results to other kind of research organisations, for instance, universities. Unlike the CSIC, university researchers devote most of their time to teaching activities (the first mission). This could lead to diverse findings since researchers differently distribute their time among a wider range of activities (namely teaching, research and knowledge transfer). This implies that university researchers' motivations (and benefits) to engage with society may differ, and thus, the patterns and intensity of their collaborations. Therefore, to extend the study to other kind of organisations and other contexts could allow for generalisation of the results.

Second, a more detailed analysis could be conducted considering the individual fields included in the SSH. Our reason to analyse SSH as a whole responds to the way in which research organisations are structured and policies are implemented –there is a 'natural' division between SSH and other fields. Nevertheless, it should be acknowledged that SSH is a heterogeneous area. For instance, a philosopher does not share the same research and transfer practices as an archaeologist. Moreover, some practices in the SSH approximate those in the STEM for certain fields. An archaeologist and a biologist conduct fieldworks and need a huge amount of resources to carry out the research, whereas a philosopher and a mathematician do not need many resources for their research. Bearing this in mind, a more accurate analysis allowing the disentangling of different characteristics among disciplines emerges as an interesting subject for future research.

Finally, the studies stress that appropriate indicators do not exist for measuring the social utilisation of SSH research outputs. SSH does not fit the prevailing technology transfer model created for STEM and adequate indicators that capture SSH contributions to society have not yet been implemented. It is expected that these studies pave the way for future research on SSH indicators, hoping that the recommendations to manage researchers-social agents interactions will be taken into account. Since it is still an important challenge from management and policy perspective, future research agenda should tackle the development of indicators properly adapted to SSH specificities.

The opening of research questions and future lines of research are frequent when a study is conducted. Therefore, it is not uncommon that, as moving forward in the research, one can realize that the things not known exceed the answers that are provided. However, these studies will enrich the discussion around the usefulness of research outputs and the particularities of SSH researchers-social agents interaction practices.

REFERENCES

Abramovitz, M. and David, P. A. (1996). Technological change and the rise of intangible investments: the US economy's growth-path in the twentieth century. In: Foray, D. and Lundvall, A. (Eds.), *Employment and Growth in the Knowledge-based Economy*. Paris: OECD Document, pp.35-50.

Abreu, M. and Grinevich, V. (2013). The nature of academic entrepreneurship in the UK: Widening the focus on entrepreneurial activities. *Research Policy* 42 (2): 408-422.

Abreu, M.; Grinevich, V.; Hughes, A. and Kitson, M. (2009). *Knowledge exchange between academics and the business, public and third sectors*. Centre for Business Research and UK-IRC: Cambridge.

Abreu, M.; Grinevich, V.; Hughes, A.; Kitson, M. and Ternouth, P. (2008). *Universities, Business and Knowledge Exchange*. Council for Industry and Higher Education, and Center for Business Research. Accessed 21 November 2011: http://www.cbr.cam.ac.uk/pdf/University%20Business%20Knowledge%20Exchange%20v7.pdf.

AHRC (2009). Leading the World. The economic impact of UK arts and humanities research. Arts and Humanities Research Council. Accessed 21 November 2011: http://www.ahrc.ac.uk/News-and-Events/Publications/Documents/Leading-the-World.pdf.

Amara, N.; Landry, R. and Halilem, N. (2013). Faculty consulting in natural sciences and engineering: between formal and informal knowledge transfer. *Higher Education* 65 (3): 359-384.

Amara, N.; Ouimet, M. and Landry, R. (2004). New evidence on instrumental, conceptual, and symbolic utilization of university research in government agencies. *Science Communication* 26 (1): 75-106.

Amesse, F. and Cohendet, P. (2001). Technology transfer revisited from the perspective of the knowledge-based economy. *Research Policy* 30 (9): 1459-1478.

Andrew, C. and Klein, J. L. (2010). *Social Innovation: What is it and why is it important to understand it better*. Centre de recherche sur les innovations sociales (CRISES): Québec.

Arza, V. (2010). Channels, benefits and risks of public-private interactions for knowledge transfer: conceptual framework inspired by Latin America. *Science and Public Policy* 37 (7): 473-484.

Bakhshi, H.; Schneider, P. and Walker, C. (2009). Arts and Humanities Research in the Innovation System: The UK Example. *Cultural Science* 2 (1): 1-23.

Bakhshi, H. and Throsby, C. D. (2010). *Culture of Innovation: An economic analysis of innovation in arts and cultural organisations*. Research Report. National Endowment for Science, Technology and the Arts (NESTA): London.

Bate, J. (2011). *The public value of the humanities*. London: Bloomsbury.

Bekkers, R. and Bodas-Freitas, I. (2008). Analysing knowledge transfer channels between universities and industry: To what degree do sectors also matter? *Research Policy* 37 (10): 1837-1853.

Beyer, J. M. and Trice, H. M. (1982). The utilization process: A conceptual framework and synthesis of empirical findings. *Administrative Science Quarterly* 27 (4): 591-622.

Boardman, P. C. and Ponomariov, B. L. (2009). University researchers working with private companies. *Technovation* 29 (8): 142-153.

Bonaccorsi, A. and Piccaluga, A. (1994). A theoretical framework for the evaluation of university industry relationships. *R&D Management* 24 (3): 229-247.

Bozeman, B. (2000). Technology transfer and public policy: a review of research and theory. *Research policy* 29 (4-5): 627-656.

Bozeman, B. and Gaughan, M. (2007). Impacts of grants and contracts on academic researchers' interactions with industry. *Research policy* 36 (5): 694-707.

Bradley, S. R.; Hayter, C. S. and Link, A. N. (2013). Models and methods of university technology transfer. *Foundations and Trends in Entrepreneurship* 9 (6): 571-650.

Breschi, S. and Malerba, F. (1997). Sectoral innovation systems: technological regimes, Schumpeterian dynamics and spatial boundaries. In: Edquist, C. (Ed.), *System of Innovation: Technologies, Institutions and Organisations*. London: Pinter, pp.130-156.

British Academy (2008). *Punching our weight: the humanities and social sciences in public policy making*. The British Academy: London.

Bush, V. (1945). *Science, the endless frontier: A report to the President*. United States Government Printing Office: Washington. Accessed 27 October 2011: http://www.nsf.gov/od/lpa/nsf50/vbush1945.htm.

Carlsson, B. and Stankiewicz, R. (1995). On the nature, function and composition of technological systems. In: Carlsson, B. (Ed.), *Technological Systems and Economic Performance: The Case of Factory Specialisation*. Dordrecht: Kluwer, pp.21-56.

Castro-Martínez, E.; Fernández-de-Lucio, I.; Pérez-Marín, M. and Criado-Boado, F. (2008). La transferencia de conocimientos desde las Humanidades: posibilidades y características. *Arbor* 184 (732): 619-636.

Cloutier, J. (2003). *Qu'est-ce que l'innovation sociale?* Centre de recherche sur les innovations sociales (CRISES): Québec. Accessed 18 October 2009: http://www.crises.uqam.ca/upload/files/publications/etudes-theoriques/et0314.pdf.

Cohen, W. M.; Nelson, R. R. and Walsh, J. P. (2002). Links and impacts: the influence of public research on industrial R&D. *Management science* 48 (1): 1-23.

Cooke, P. (1992). Regional innovation systems: competitive regulation in the new Europe. *Geoforum* 23 (3): 365-382.

Cooke, P. (1996). Regional innovation systems: an evolutionary approach. In: Baraczyk, H., Cooke, P. and Heidenreich, R. (Eds.), *Regional Innovation Systems*. London: University of London Press.

CSIC (2006). Plan Estratégico del área 1: Humanidades y Ciencias Sociales (2006-2009). Madrid: CSIC.

CSIC (2007). Annual Report 2006 Madrid: CSIC.

CSIC (2008). Annual Report 2007. Madrid: CSIC.

CSIC (2009). Annual Report 2008. Madrid: CSIC.

CSIC (2010). Annual Report 2009. Madrid: CSIC.

CSIC (2011). Annual Report 2010. Madrid: CSIC.

CSIC (2012). Annual Report 2011. Madrid: CSIC.

Christopherson, S.; Kitson, M. and Michie, J. (2008). Innovation, networks and knowledge exchange. *Cambridge Journal of Regions, Economy and Society* 1 (2): 165-173.

D'Este, P. and Patel, P. (2007). University–industry linkages in the UK: What are the factors underlying the variety of interactions with industry? *Research Policy* 36 (9): 1295-1313.

D'Este, P. and Perkmann, M. (2011). Why do academics engage with industry? The entrepreneurial university and individual motivations. *Journal of Technology Transfer* 36 (3): 316-339.

David, P. A. and Foray, D. (1995). Assessing and expanding the science and technology knowledge base. *STI Review* 16: 13-68.

David, P. A. and Foray, D. (2002). An introduction to the economy of the knowledge society. *International Social Science Journal* 54 (171): 9-23.

Ding, W. and Choi, E. (2011). Divergent paths to commercial science: A comparison of scientists' founding and advising activities. *Research Policy* 40 (1): 69-80.

Dosi, G. (1982). Technological Paradigms and Technological Trajectories - a Suggested Interpretation of the Determinants and Directions of Technical Change. *Research Policy* 11 (3): 147-162.

Druilhe, C. and Garnsey, E. (2004). Do academic spin-outs differ and does it matter? *The Journal of Technology Transfer* 29 (3): 269-285.

Edquist, C. (1997). System of innovation approaches: their emergence and characteristics. In: Edquist, C. (Ed.), *Systems of Innovation: Technologies, Institutions and Organizations*. London: Pinter, pp.1-35.

Edquist, C. (2005). Systems of innovation: Perspective and Challenges. In: Fagerberg, J., Mowery, D. C. and Nelson, R. (Eds.), *The Oxford handbook of innovation*. Oxford: Oxford University Press, pp.181-208.

Edquist, C. and Johnson, B. (1997). Institutions and Organisations in the System of Innovation. In: Edquist, C. (Ed.), *Systems of Innovation: Technologies, Institutions and Organizations*. London: Pinter, pp.41-63.

Etzkowitz, H. and Leydesdorff, L. (2000). The dynamics of innovation: from National Systems and "Mode 2" to a Triple Helix of university-industry-government relations. *Research Policy* 29 (2): 109-123.

European Commission (2009). *Metrics for knowledge transfer from public research organisations in Europe*. Report from the European Commission's Expert Group on Knowledge Transfer Metrics: Bruxelles. Accessed 10 September 2012: http://ec.europa.eu/invest-in-research/pdf/download_en/knowledge_transfer_web.pdf.

Fernández-Esquinas, M.; Sebastian, J.; Lopez-Facal, J. and Tortosa-Martorell, E. (2009). Growth rings in the tree of science. The institutional evolution of the Spanish Council for Scientific Research. *Revista Internacional De Sociología* 67 (2): 251-284.

Fernández-Esquinas, M. and Torres-Albero, C. (2009). La ciencia como institución social: clásicos y modernos institucionalismos en la sociología de la ciencia. *Arbor* 185 (738): 663-687.

Fernández-de-Lucio, I.; Mas-Verdu, F. and Tortosa, E. (2010). Regional innovation policies: the persistence of the linear model in Spain. *The Service Industries Journal* 30 (5): 749-762.

Formentín-Ibañez, J. and Villegas, M. J. (2007). Las pensiones de la JAE. In: Puig-Samper Mulero, M. A. (Ed.), *Tiempos de investigación: JAE-CSIC, cien años de ciencia en España*. Madrid: CSIC-Dpto. de Publicaciones, pp.95-101.

Freeman, C. (1987). *Technology policy and economic performance: lessons from Japan*. London: Pinter.

Gardner, P. L.; Fong, A. Y. and Huang, R. L. (2007). Measuring the impact of knowledge transfer from public research organizations: a comparison of metrics used around the world. *ISMOT'07, Proceedings of the Fifth International Symposium on Management of Technology*, Zheijang University :Hangzhou.

Gibbons, M.; Limoges, C.; Nowotny, H.; Schartzman, S.; Trow, M. and Scott, P. (1994). *The new production of knowledge: the dynamics of science and research in contemporary societies*. London: Sage.

Giuliani, E.; Morrison, A.; Pietrobelli, C. and Rabellotti, R. (2010). Who are the researchers that are collaborating with industry? An analysis of the wine sectors in Chile, South Africa and Italy. *Research Policy* 39 (6): 748-761.

Godin, B. (1998). Writing performative history: the new New Atlantis? *Social Studies of Science* 28 (3): 465-483.

Godin, B. (2004). *L'organisation innovante: D'un système d'indicateurs appropriés*. Consortium canadien sur les indicateurs de science et d'innovation (CSIIC). Accessed 10 May 2012: http://collections.banq.qc.ca/ark:/52327/bs64427.

Godin, B. (2006). The linear model of innovation. *Science, Technology & Human Values* 31 (6): 639-667.

Godin, B. and Doré, C. (2005). *Measuring the impacts of science on society: Beyond the economic dimension*. INRS-UCS: Montreal. Accessed 10 January 2012: http://www.csiic.ca/PDF/Godin_Dore_Impacts.pdf.

Gopalakrishnan, S. and Santoro, M. D. (2004). Distinguishing between knowledge transfer and technology transfer activities: the role of key organizational factors. *IEEE Transactions on engineering management* 51 (1): 57-69.

Göransson, B.; Maharajh, R. and Schmoch, U. (2009). New activities of universities in transfer and extension: multiple requirements and manifold solutions. *Science and Public Policy* 36 (2): 157-164.

Grant, A. M.; Campbell, E. M.; Chen, G.; Cottone, K.; Lapedis, D. and Lee, K. (2007). Impact and the art of motivation maintenance: The effects of contact with beneficiaries on persistence behavior. *Organizational Behavior and Human Decision Processes* 103 (1): 53-67.

Grimpe, C. and Fier, H. (2010). Informal university technology transfer: a comparison between the United States and Germany. *The Journal of Technology Transfer* 35 (6): 637-650.

Grimpe, C. and Hussinger, K. (2008). *Formal and informal technology transfer from academia to industry: complementarity effects and innovation performance*. ZEW-Centre for European Economic Research Discussion Paper No. 08-080. Accessed 3 December 2011: ftp://ftp.zew.de/pub/zew-docs/dp/dp08080.pdf.

Gulbrandsen, M.; Mowery, D. and Feldman, M. (2011). Introduction to the special section: Heterogeneity and university-industry relations. *Research Policy* 40 (1): 1-5.

Gupta, A. K.; Sinha, R.; Koradia, D.; Patel, R.; Parmar, M.; Rohit, P.; Patel, H.; Patel, K.; Chand, V. S. and James, T. J. (2003). Mobilizing grassroots' technological innovations and traditional knowledge, values and institutions: articulating social and ethical capital. *Futures* 35 (9): 975-987.

Guston, D. H. (2000). *Between Politics and Science: Assuring the Productivity and Integrity of Research*. Cambridge: Cambridge University Press.

Guston, D. H. and Keniston, K. (1994). Introduction: the social contract for science. In: Guston, D. H. and Keniston, K. (Eds.), *The fragile contract: University Science and the Federal Government*. Cambridge: MIT Press, pp.1-41.

Haeussler, C. and Colyvas, J. A. (2011). Breaking the ivory tower: Academic entrepreneurship in the life sciences in UK and Germany. *Research Policy* 40 (1): 41-54.

Harmon, B.; Ardishvili, A.; Cardozo, R.; Elder, T.; Leuthold, J.; Parshall, J.; Raghian, M. and Smith, D. (1997). Mapping the university technology transfer process. *Journal of Business Venturing* 12 (6): 423-434.

Hartley, J. and Cunningham, S. (2001). Creative Industries: from Blue Poles to fat pipes. In: Gilles, M. (Ed.), *Paper presented at the National Humanities and Social Sciences Summit July 2001*. Canberra: Commonwealth of Australia, pp.16-26.

Hessels, L. K. and van Lente, H. (2008). Re-thinking new knowledge production: A literature review and a research agenda. *Research Policy* 37 (4): 740-760.

Hessels, L. K.; van Lente, H. and Smits, R. (2009). In search of relevance: the changing contract between science and society. *Science and Public Policy* 36 (5): 387-401.

Hirsch, P. M. (2000). Cultural industries revisited. *Organization science* 11 (3): 356-361.

Holi, M.; Wickramasinghe, R. and van Leeuwen, M. (2008). Metrics for the evaluation of knowledge transfer activities at universities. *Cambridge: Library House*.

Hotho, S. and Champion, K. (2011). Small businesses in the new creative industries: innovation as a people management challenge. *Management Decision* 49 (1): 29-54.

Hughes, A. and Kitson, M. (2012). Pathways to impact and the strategic role of universities: new evidence on the breadth and depth of university knowledge exchange in the UK and the factors constraining its development. *Cambridge journal of economics* 36 (3): 723-750.

Hughes, A.; Kitson, M.; Probert, J.; Bullock, A. and Milner, I. (2011). Hidden Connections: Knowledge exchange between the arts and humanities and the private, public and third sectors. Cambridge.

IIT Research-Institute (1968). Technology in retrospect and critical events in science (TRACES). Washington: National Science Foundation.

Jaaniste, L. (2009). Placing the creative sector within innovation: The full gamut. *Innovation: management, policy & practice* 11 (2): 215-229.

Jacobson, N.; Butterill, D. and Goering, P. (2004). Organizational factors that influence University-Based Researchers' Engagement in Knowledge Transfer activities. *Science Communication* 25 (3): 246-259.

Jiménez-Buedo, M. and Ramos-Vielba, I. (2009). ¿Más allá de la ciencia académica?: modo 2, ciencia posnormal y ciencia posacadémica. *Arbor* 185 (738): 721-737.

Jiménez-Contreras, E.; Moya-Anegón, F. and Delgado López-Cózar, E. (2003). The evolution of research activity in Spain: The impact of the National Commission for the Evaluation of Research Activity (CNEAI). *Research Policy* 32 (1): 123-142.

Johnson, B. and Andersen, A. D. (2012). *Learning, Innovation and Inclusive Development: New perspectives on economic development strategy and development aid*. Aalborg University Press: Denmark. Accessed 14 Mars 2013: http://vbn.aau.dk/ws/files/70880770/Learning_Innovation_and_Inclusive_Development.pdf.

Kellogg, D. (2006). Toward a post-academic science policy: Scientific communication and the collapse of the Mertonian norms. *International Journal of Communications Law and Policy* Special Issue, Access to Knowledge, Autumn 2006.

Kline, S. J. and Rosenberg, N. (1986). An overview of Innovation. In: Landau, R. and Rosenberg, N. (Eds.), *The positive sum strategy: Harnessing technology for economic growth*. Washington DC: The National Academy Press., pp.275-305.

Knott, J. and Wildavsky, A. (1980). If Dissemination Is the Solution, What Is the Problem? *Knowledge: creation, diffusion, utilization* 1 (4): 537-78.

Landry, R.; Amara, N. and Ouimet, M. (2007). Determinants of knowledge transfer: evidence from Canadian university researchers in natural sciences and engineering. *Journal of Technology Transfer* 32 (6): 561-592.

Landry, R.; Lamari, M. and Amara, N. (2003). The extent and determinants of the utilization of university research in government agencies. *Public Administration Review* 63 (2): 192-205.

Landry, R.; Saïhi, M.; Amara, N. and Ouimet, M. (2010). Evidence on how academics manage their portfolio of knowledge transfer activities. *Research Policy* 39 (10): 1387-1403.

Laudel, G. (2001). Collaboration, creativity and rewards: why and how scientists collaborate. *International Journal of Technology Management* 22 (7-8): 762-781.

Lavis, J. N.; Robertson, D.; Woodside, J. M.; McLeod, C. B. and Abelson, J. (2003). How can research organizations more effectively transfer research knowledge to decision makers? *Milbank Quarterly* 81 (2): 221-248.

Lee, Y.S. (1996). Technology transfer and the research university: a search for the boundaries of university-industry collaboration. *Research Policy* 25 (6): 843-863.

Lee, Y. S. (2000). The sustainability of university-industry research collaboration: An empirical assessment. *The Journal of Technology Transfer* 25 (2): 111-133.

Link, A. N.; Siegel, D. S. and Bozeman, B. (2007). An empirical analysis of the propensity of academics to engage in informal university technology transfer. *Industrial and Corporate Change* 16 (4): 641-655.

Loogma, K.; Tafel-Viia, K. and Ümarik, M. (2012). *Social Innovation: Three Approaches*. ZSI Discussion Paper № 24: Zentrum für Soziale Innovation. Accessed 14 Mars 2013: https://www.sea-eu.net/attach/DP24_Loogma_et_al.pdf.

Lundvall, B. A. (1992). *National systems of innovation: towards a theory of innovation and interactive learning*. London: Pinter.

Maclaurin, W. R. (1953). The sequence from invention to innovation and its relation to economic growth. *The Quarterly Journal of Economics* 67 (1): 97-111.

Malerba, F. (2002). Sectoral systems of innovation and production. *Research Policy* 31 (2): 247-264.

Manjarrés-Henríquez, L.; Gutiérrez-Gracia, A. and Vega-Jurado, J. (2008). Coexistence of university-industry relations and academic research: barrier to or incentive for scientific productivity. *Scientometrics* 76 (3): 561-576.

Manjarrés-Henríquez, L.; Gutiérrez-Gracia, A.; Carrión-García, A. and Vega-Jurado, J. (2009). The effects of university–industry relationships and academic research on scientific performance: Synergy or substitution? *Research in Higher Education* 50 (8): 795-811.

Martin, B. (2003). The changing social contract for science and the evolution of the university. In: Geuna, A., Salter, A. J. and Steinmueller, W. E. (Eds.), *Science and Innovation: Rethinking the rationales for funding and governance*. Cheltenhan, UK: Edward Elgar, pp. 7-29.

Martin, B. and Etzkowitz, H. (2000). *The origin and evolution of the university species*. Electronic Working Paper Series, Sussex University, Science and Technology Policy Research Unit (SPRU). Accessed 7 April 2010: http://www.staff.uni-marburg.de/~roepke/Documents/sewp59.pdf.

Martín-Lou, M. A. (2002). Área de Humanidades y Ciencias Sociales: una visión en el tiempo. *Arbor* 172 (679-680): 537-548.

Merton, R. K. (1942). The normative structure of science. In: Storer, N. W. (Ed.), *The sociology of science: theoretical and empirical investigations*. Chicago: University of Chicago Press, pp.267-280.

Merton, R. K. (1949). *Social Theory and Social Structure*. New York: Free Press.

Merton, R. K. (1973). *The sociology of science: Theoretical and empirical investigations*. Chicago: University of Chicago Press.

Meyer-Krahmer, F. and Schmoch, U. (1998). Science-based technologies: university-industry interactions in four fields. *Research Policy* 27 (8): 835-851.

Miles, I. and Green, L. (2008). *Hidden innovation in the creative industries*. Research Report. National Endowment for Science, Technology and the Arts (NESTA): London.

Mitroff, I. I. (1974). Norms and counter-norms in a select group of the Apollo moon scientists: A case study of the ambivalence of scientists. *American Sociological Review* 39: 579-595.

Molas-Gallart, J. (1997). Which way to go? Defence technology and the diversity of 'dual-use' technology transfer. *Research Policy* 26 (3): 367-385.

Molas-Gallart, J.; Salter, A.; Patel, P.; Scott, A. and Duran, X. (2002). Measuring Third Stream Activities. Brighton: Final Report to the Russell Group of Universities. Science and Technology Policy Research (SPRU), University of Sussex.

Molas-Gallart, J.; Tang, P. and Morrow, S. (2000). Assessing the non-academic impact of grant-funded socio-economic research: results from a pilot study. *Research Evaluation* 9 (3): 171-182.

Mowery, D. C. (1983). Economic-Theory and Government Technology Policy. *Policy Sciences* 16 (1): 27-43.

Mowery, D. C.; Nelson, R. R.; Sampat, B. N. and Ziedonis, A. A. (2001). The growth of patenting and licensing by U.S. universities: an assessment of the effects of the Bayh-Dole act of 1980. *Research Policy* 30 (1): 99-119.

Mowery, D. C.; Nelson, R. R.; Sampat, B. N. and Ziedonis, A. A. (2004). *Ivory tower and industrial innovation: university-industry technology transfer before and after the Bayh-Dole act in the United States*. Palo Alto, CA: Stanford University Press.

Mulgan, G. (2006). The process of social innovation. *Innovations: technology, governance, globalization* 1 (2): 145-162.

Mulgan, G. (2012). Social Innovation Theories: Can Theory Catch Up with Practice? In: Franz, H. W., Hochgerner, J. and Howaldt, J. (Eds.), *Challenge Social Innovation*. Berlin Heidelberg: Springer, pp.19-42.

Mulkay, M. J. (1976). Norms and ideology in science. *Social Science Information* 15 (4-5): 637-656.

Muñoz, E. (2001) Veinticinco años en la evolución del sistema. *Quark: Ciencia, medicina, comunicación y cultura* 22-23: 12-17.

Muñoz, E. and García-Arroyo, A. (2006). *El nacimiento de la ley de la ciencia: el sueño del progreso*. Madri+d revista electrónica. Accessed 22 November 2011: http://www.madrimasd.org/revista/revistaespecial1/articulos/munozarroyo.asp.

Nelson, R. R. and Rosenberg, N. (1993). Technical innovation and national systems. In: Nelson, R. R. (Ed.), *National systems of innovation: A comparative analysis*. Oxford: Oxford University Press, pp.3-21.

OECD (1992). *Oslo Manual. OECD Proposed Guidelines for Collecting and Interpreting Technological Innovation Data*, 1st ed. Paris: OECD.

OECD (1996). The Knowledge-based Economy. París: OECD.

OECD (2005). *Oslo Manual. OECD Proposed Guidelines for Collecting and Interpreting Technological Innovation Data*, 3rd ed. Paris: OECD.

Olivé, L. (2006). Los desafíos de la sociedad del conocimiento: cultura científico-tecnológica, diversidad cultural y exclusión. *Revista Científica de Información y comunicación* 3: 29-51.

Perkmann, M.; Tartari, V.; McKelvey, M.; Autio, E.; Broström, A.; D'Este, P.; Fini, R.; Geuna, A.; Grimaldi, R. and Hughes, A. (2012). Academic engagement and commercialisation: A review of the literature on university-industry relations. *Research Policy* 42 (2): 423-442.

Perkmann, M. and Walsh, K. (2007). University–industry relationships and open innovation: Towards a research agenda. *International Journal of Management Reviews* 9 (4): 259-280.

Pestre, D. (2003). Regimes of Knowledge Production in Society: Towards a More Political and Social Reading. *Minerva* 41 (3): 245-261.

Ponomariov, B. L. (2008). Effects of university characteristics on scientists' interactions with the private sector: an exploratory assessment. *The Journal of Technology Transfer* 33 (5): 485-503.

Potts, J. (2009). Introduction: Creative industries and innovation policy. *Innovation: management, policy & practice* 11 (2): 138-147.

Pratt, A. C. (2005). Cultural industries and public policy: An oxymoron? *International journal of cultural policy* 11 (1): 31-44.

Ramos-Vielba, I.; Fernández-Esquinas, M. and Espinosa-de-los-Monteros, E. (2010). Measuring university-industry collaboration in a regional innovation system. *Scientometrics* 84 (3): 649-667.

Rennings, K. (2000). Redefining innovation—eco-innovation research and the contribution from ecological economics. *Ecological economics* 32 (2): 319-332.

Rip, A. (2002). Science for the 21st century. In: Tindemans, P., Verrijn-Stuart, A. and Visser, R. (Eds.), *The Future of Science and the Humanities*. Amsterdam: Amsterdam University Press, pp.99-148.

Sahal, D. (1981). Alternative conceptions of technology. *Research Policy* 10 (1): 2-24.

Sahal, D. (1982). The transfer and utilization of technical knowledge. In: Sahal, D. (Ed.), *The form of technology*. Lexigton MA: Lexington Publishing, pp.125-139.

Sampat, B. N.; Mowery, D. C. and Ziedonis, A. A. (2003). Changes in university patent quality after the Bayh-Dole act: a re-examination. *International Journal of Industrial Organization* 21 (9): 1371-1390.

Sánchez-Ron, J. M. (2007). La JAE un siglo después. In: Mulero, M. A. P.-S. (Ed.), *Tiempos de investigación: JAE-CSIC, cien años de ciencia en España*. Madrid: CSIC - Dpto. de Publicaciones, pp.29-37.

Santesmases, M. J. and Romero-de-Pablos, A. (2008). Introducción para una reconstrucción histórica de los apoyos públicos a la investigación en España. In: Santesmases, M. J. and Romero-de-Pablos, A. (Eds.), *Cien años de política científica en España*. Bilbao: Fundación BBVA, pp.13-19.

Sanz-Menéndez, L. (1995). Research actors and the state: research evaluation and evaluation of science and technology policies in Spain. *Research Evaluation* 5 (1): 79-88.

Schartinger, D.; Rammer, C.; Fischer, M. M. and Frohlich, J. (2002). Knowledge interactions between universities and industry in Austria: sectoral patterns and determinants. *Research Policy* 31 (3): 303-328.

Schartinger, D.; Schibany, A. and Gassler, H. (2001). Interactive relations between universities and firms: empirical evidence for Austria. *The Journal of Technology Transfer* 26 (3): 255-268.

Schmookler, J. (1966). *Invention and economic growth*. Cambridge, Massachussetts: Harvard University Press.

Schumpeter, J. A. (1934). *The Theory of Economic Development*. Cambridge, Massachussetts: Harvard University Press.

Schumpeter, J. A. (1939). *Business cycles*. New York: McGraw-Hill.

Schumpeter, J. A. (1942). *Capitalism, Socialism, and Democracy*. New York: Harper & Brothers.

Sebastián, J. and López-Facal, J. (2007). Transición y cambio en el CSIC. In: Puig-Samper Mulero, M. A. (Ed.), *Tiempos de investigación: JAE-CSIC, cien años de ciencia en España*. Madrid: CSIC - Dpto. de Publicaciones, pp.357-361.

Seyfang, G. and Smith, A. (2007). Grassroots innovations for sustainable development: Towards a new research and policy agenda. *Environmental Politics* 16 (4): 584-603.

Shane, S. (2004). Encouraging university entrepreneurship? The effect of the Bayh-Dole Act on university patenting in the United States. *Journal of Business Venturing* 19 (1): 127-151.

Sharif, N. (2006). Emergence and development of the National Innovation Systems concept. *Research Policy* 35 (5): 745-766.

Siegel, D. S.; Waldman, D. and Link, A. N. (2003). Assessing the impact of organizational practices on the relative productivity of university technology transfer offices: an exploratory study. *Research Policy* 32 (1): 27-48.

Sklair, L. (1972). The political sociology of science. *The Sociological Review Monograph* 18: 43-59.

Smith, K. (1995). Interactions in knowledge systems: Foundations, policy implications and empirical methods. *STI Review* 16.

Stoneman, P. (2007). *An introduction to the definition and measurement of soft innovation*. Research Report. National Endowment for Science, Technology and the Arts (NESTA): London. Accessed 15 November 2012: http://www.nesta.org.uk/library/documents/soft_innovation_working_paper_NESTA.pdf.

Stoneman, P. (2008). Soft innovation: changes in product aesthetics and aesthetic products. *Royal Economic Society Annual Conference*, Universtity of Warwick, University of Warwick. March 17 – 19, 2008.

Thompson, G. N.; Estabrooks, C. A. and Degner, L. F. (2006). Clarifying the concepts in knowledge transfer: a literature review. *Journal of advanced nursing* 53 (6): 691-701.

U.S Department-of-Defense (1969). *Project hindsight final report*. Office of the Director of Defense Research and Engineering: Washington, D.C. Accessed 11 November 2012: http://www.dtic.mil/cgi-bin/GetTRDoc?Location=U2&doc=GetTRDoc.pdf&AD = AD0495905.

Uriona-Maldonado, M.; Dos-Santos, R. N. M. and Varvakis, G. (2012). State of the art on the Systems of Innovation research: a bibliometrics study up to 2009. *Scientometrics* 91 (3): 977-996.

Urquijo-Goitia, J. R. (2000). Humanidades y ciencias sociales. *Arbor* 166 (653): 155-170.

Vilalta, J. M. and Pallejà, E. (2003). *Universidades y desarrollo territorial en la sociedad del conocimiento*. Barcelona: Diputación de Barcelona.

Weiss, C. H. (1979). The many meanings of research utilization. *Public Administration Review* 39 (5): 426-431.

Zhao, L. and Reisman, A. (1992). Toward meta research on technology transfer. *IEEE Transactions on Engineering Management* 39 (1): 13-21.

Ziman, J. (1994). *Prometheus bound: Science in a Dynamic Steady State*. Cambridge: Cambridge University Press.

Ziman, J. (1996). Post-academic science: constructing knowledge with networks and norms. *Science Studies* 9 (67-80).

Ziman, J. (2000). *Real Science: What it is, and What it Means*. Cambridge: Cambridge University Press.