What Stimulates Researchers to Make Their Research Usable? Towards an 'Openness' Approach

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What stimulates researchers to make their research usable? Towards an 'openness' approach

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1. Introduction

There are increasing imperatives to understand how research benefits society, given the increasing dependence of socio-economic growth and wellbeing on societal capacity to create and generate new knowledge (Rutten and Boekema 2012). Academic literature has focused on understanding processes where academic knowledge creates societal value (Donovan 2007). But framed by persistent policy preconceptions of academics as preferring not to engage with 'users', a pressing scientific question remains of why academics choose to societally engage (D'Este and Perkmann 2011). Several debates exploring academic engagement behaviours and intentions ignore collaboration's 'dark side' (Bozeman et al. 2013) of knowledge exchange potentially conflicting with 'academic logic' (Sauermann and Stephan 2013) raising unpalatable choices and conflicting interests for researchers (Jain et al. 2009; Philpott et al. 2011; Tartari and Breschi 2012; Collini 2009). Others found more positive relationships between 'star scientists' and their external engagement (Bekkers and Bodas Freitas 2008; Gulbrandsen and Smeby 2005; Haeussler and Colyvas 2011; Louis et al. 1989). This ambiguity undermines understanding university-society engagement and hinders optimising research's contribution to societal development and wellbeing.

Several studies addressing researchers' motivations for engagement highlight that motivation is an extremely complex notion where insufficient conceptually development may lead to excessive reductionism (Baldini et al. 2007; D'Este and Perkmann 2011; Lam 2011; Lee 2000; Perkmann et al. 2013). To avoid this issue, we therefore begin from a slightly less challenging perspective, that of academic behaviour. We argue that researchers' external engagement can be understood within the wider scientific decision-making system (Gläser 2012) which selects and co-ordinates suitable questions for academic effort (Miller and Neff 2013). We explore the kinds of academic behaviour that might potentially make their research more easily to use by non-academic agents.

If academics are sensitive to external user needs in undertaking research processes, then external partners will later be able more easily to absorb that knowledge. We argue that what facilitates knowledge being used is that it itself builds upon others' knowledge and is cognate with users' own knowledge bases. We contend that researchers sensitive to external influences are more likely to generate findings usable[1] by external partners. Using an existing Spanish researcher survey (IMPACTO) we operationalise the way external influences[2] may emerge in different types of research processes, seeking to identify which factors are most closely associated with academics' propensity to include external influences in their research processes. Our study suggests that two main factors (academic identity and past experience) appear to determine researchers' open behaviours.

[1] We contend useful knowledge has to be usable; otherwise it can never be useful. However, usable knowledge has not necessarily to be useful. Thus, we focus on the production of usable knowledge (sensitive to users' interest) as a precondition for its eventual usefulness.

[2] By 'external influences' we refer to mechanisms through which third parties may influence the research process and thus the knowledge produced (more or less usable by external parties). External influences might occur directly (users-researcher knowledge exchange) or indirectly (researchers becoming aware of external problems).

2. Research processes as building blocks of scientific decision-making

Increasing interest in researcher engagement has paralleled a realisation conceptual frameworks should evolve away from linear models to reflect more interactive knowledge-creation processes (Geuna and Muscio 2009). Innovation processes interact with scientific production: usable knowledge for innovation emerges from research closely linked to users, as highlighted in a range of models including 'Mode 2' knowledge production (Gibbons et al. 1994), 'system of innovation' (Edquist 1997), the 'Triple Helix' (Etzkowitz and Leydesdorff 2000) or 'post-academic science' (Ziman 1996). All highlight academics' increasing responsiveness to external stakeholders in setting research agendas (Hessels and Van Lente 2008), responding to shifts in research policy priorities (Gläser 2012; Leisyte et al. 2008), changes in funding patterns (Gulbrandsen and Smeby 2005), variations in prevailing research modes (Gibbons et al. 1994), and increasing promotion of direct academic-society interactions (Martin 2003). At the same time academics retain substantial autonomy in determining which projects to develop, methods to apply and collaborations to establish (Aghion et al. 2008; Gläser 2012).

Individual research processes may involve external influences at various points, from agenda-setting to translation of results of inquiry into applications (Kitcher 2001; Sarewitz and Pielke 2007). Academics more open to external influences will create more strongly contextualized knowledge (Nowotny et al. 2001) that overlaps more with user interests, more amenable to user absorption and utilisation, and better at generating impact. We here distinguish five qualitatively different research processes potentially involving external research users and hence where 'open behaviour' may be demonstrated, each with a different degree of research concreteness: viewing the world (reframing), seeing a problem (inspiration), developing a project idea (planning), undertaking research (executing), and disseminating that research (dissemination). 'Open behaviour' in these five processes is our dependent variable. We explore which researcher-specific factors (our independent variables) are related with open researcher's behaviour in those five processes:

> (1) *reframing*: deciding a future personal research agenda of potential interesting questions, partly shaped by past research; researchers whose past research has been affected by external influences starts from a knowledge base of usable knowledge;
>
> (2) *inspiration*: identifying one potential question as one to which the individual can commit to do more research activity; researchers may be inspired by users or external issues for a concrete future research project idea;
>
> (3) *planning*: producing a tangible method and plan to answer a specific question; a researcher may include external knowledge, interests and needs as key research resources within that proposal;
>
> (4) *execution*: undertaking a piece of research, gathering and analysing data to make a scientific contribution; a researcher may incorporate external knowledges in implementation;
>
> (5) *dissemination*: presenting results in ways accessible to potential users; a researcher may disseminate with users in ways that users inspire new insights or future usable research orientations.

Researchers usually build their future research agendas blending newly encountered academic literature with their previous knowledge base: research is path-dependent (Neff 2014) and decision-impregnated (Knorr-Cetina 1981), with future decisions structured by past decisions (reframing). Literature on university-industry relationships has addressed research agenda skewness towards external influences (Lee 1996; Nelson 2001; Verspagen 2006). Researchers whose past activities (knowledge base) incorporate external influences will already overlap with potential users' knowledge, and therefore their activities are more easily taken up by potential users. Thus, we argue that past research conducted with external partners leads to future research being more usable.

Secondly, researchers may demonstrate open behaviour and include external knowledge in idea formation (inspiration) where researchers perceive a problem, identify it fitting with their research agenda, and conceptualise it as a problem that their research can solve. Researchers' open behaviour in inspiration processes corresponds to what others have referred to as scientific research orientation. Stokes (1997) typology has two dimensions of researcher *ex ante* orientations giving four quadrants based on scientific excellence and societal relevance: researchers may be oriented towards fundamental understanding (Böhr quadrant), to use considerations (Edison quadrant), to useful and excellent knowledge (Pasteur quadrant), or to gather and analyse data in ways neither immediately useful nor scientifically excellent (what Alrøe and Kristensen (2002) call the Linnaeus quadrant). Researchers who are inspired by use conditions ('Edison' or 'Pasteur') may follow research questions influenced by socio-economic considerations, choosing more research questions whose answers create more usable kinds of research.

A third dimension of research processes relates to operationalizing a question into a research proposal, setting out *ex ante* the putative research execution. The extent to which external knowledges are incorporated in project plan activities affects how cognate final knowledge will be with potential users. Reflecting on creating impact in research planning sensitises researchers to potential opportunities (Hessels and Van Lente 2008: 742). Thus researchers demonstrating these 'pro-social' research behaviours (D'Este et al. 2013) are more likely to develop research projects which, if selected, create more usable knowledge.

Fourthly are research processes involving research execution: mobilising resources to prosecute activities delivering scientific results. Previous studies identified that researchers engage externally to access knowledge resources otherwise unavailable (Abreu et al. 2009; Baldini et al. 2007; D'Este and Perkmann 2011; Lam 2011; Lee 2000; Zomer et al. 2010), and identify resource control – including over critical knowledge resources - as a common way of influencing research content (Gläser 2012: 9). Researchers' open behaviour in execution is demonstrated by involving external knowledge resources in project execution, affecting the nature of the knowledge produced, and raising its usability by making it more cognate with user knowledge.

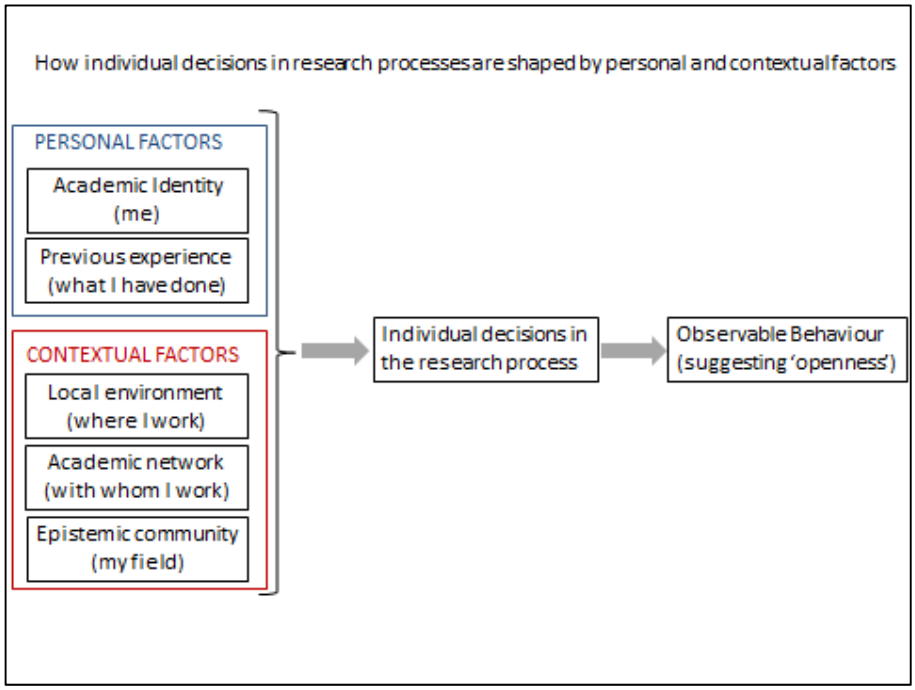
Finally, dissemination involves actively passing knowledge to either academic (e.g. via scientific journals) or societal audiences (e.g. patenting, dissemination in the media, generation of clinical guidelines). Societal dissemination activities have been widely addressed in the literature (Jensen 2011; Olmos-Peñuela et al. 2014b), and although often seen as being downstream, one-way (from researcher to user) and post-dating

research activities, they can potentially involve two-way interactions/dialogues between researchers and external actors (Martín-Sempere et al. 2008). Participating in these two-way dialogues can expose researchers to new knowledge and research opportunities. Exchange-based dissemination may influence researchers' perceptions of their findings, raising future questions more cognate with users' knowledge. We thus expect that behaviours involving participation in such co-creative societal dissemination processes are associated with higher research usability.

3. What makes researchers open to external influences?

Many factors could be associated with researchers' open behaviour (as defined above); some literatures assume a direct correspondence between engaged behaviours and academics' desires to acquire particular benefits (D'Este and Perkmann 2011; Lam 2011). However, this exclusive focus on individual benefit ignores that academics are influenced by different kinds of factors from their personal circumstances to their wider institutional scientific systems (Villanueva-Felez et al. 2013). We stylise two kinds of personal factors influencing behaviour; firstly academic *identities* that shape their decision-making processes, formed during their education and academic formation (e.g. Ph.D). Secondly, following Knorr-Cetina (1981) *previous research experiences* and completed research projects also affects future question choice. We also distinguish three kinds of contextual factor; *immediate operational environment* of the work-floor and working group, researcher's wider *personal academic contact network*, and academic discipline as an *epistemic community*. Researchers' open behaviour may be associated with a range of researcher-specific (personal/ contextual) factors, providing us with our independent variables as Figure 1 shows:

Figure 1: How individuals' research decisions are shaped by personal and contextual factors



Source: authors' own design.

3.1. Personal factors associated with academic decisions

Our first personal factor is academic identity and how academics view the extent to which it is valid/ legitimate to involve external (non-academic) interests in scientific research-question setting (Jain et al. 2009; Lam 2011). Literature defines diverse researchers' archetypes from an ideal-type pure-Mertonian scholar – where only scientific considerations are valid in research concerns (Merton 1973) – to pure post-academic science entrepreneurs – whose norms legitimate multiple kinds of knowledge and non-academic drivers (Ziman 1996). We contend that the extent to which individuals believe that they are right to involve external knowledge in research processes affects their research behaviour, and that *researchers' with an identity closer to the entrepreneurial ideal type are more likely to demonstrate open behaviour in their research processes* ***(H1).***

The second personal factor is researchers' experiences and achievements. Researchers who have acquired already usable knowledge and skills are likewise well-positioned to participate in future entrepreneurial activities (Ajzen 2001; Hoye and Pries 2009). Likewise, academic entrepreneurial intentions are well-predicted by academics' previous experience in entrepreneurial activities (Goethner et al. 2012). Researchers with past successful collaborations face fewer uncertainties/ difficulties in assessing those collaborations' potential cost or benefits compared to those with no such experience (Audretsch et al. 2010). Researchers with positive experiences of engagement are *ceteris paribus* more likely to again choose for engagement than those without previous collaborations. We thus expect that *researchers that regard that past collaborative experience positively are more likely to demonstrate 'open behaviour' in their research*

*processes than researchers that did not experience those benefits, or considered them to be scientifically irrelevant (**H2**).*

3.2. Contextual factors associated with academic decisions

We consider contextual factors – researchers' working environments and networks – may influence personal preferences via norms, standards and shared behaviours. The first contextual factor is the immediate work environment: the laboratory, research group, department or institute that influence researchers' practices (Bandura 1977; DiMaggio and Powell 1983; Miller and Neff 2013; Schein 1985). Bercovitz and Feldman (2008) suggest that academic entrepreneurs decisions' to participate in entrepreneurial activities are mainly affected by currently local norms (reflecting their academic organisations' institutional practices and support measures), as well as norms acquired during their academic formation. We therefore suggest that *researchers who perceive their working environment as offering positive institutional support for engaging with external agents are more likely to demonstrate 'open behaviour' in their research processes (**H3**).*

The second contextual factor we highlight is academics' immediate scholarly networks: researchers' behaviour depends on their professional network's behavioural norms and practices (Fromhold-Eisebith et al. 2014; Kronenberg and Caniëls 2014). If a scholar's network is exclusively related to their own discipline, with little use of external knowledges, then the research outputs will be themselves more bounded by the community. Conversely, where researchers have connections to wider networks with their own norms, either scholars from other institutes, sectors or countries, or scholars from other disciplines, then this increases the ability of knowledge to flow to users (Shane 2000; Venkataraman 1997). We thus suggest the following two hypotheses:

*Researchers active in research networks more connected to external researchers are more likely to demonstrate 'open behaviour' in research processes (**H4a**).*

*Researchers active in research networks more connected to researchers in other disciplines are more likely to demonstrate 'open behaviour in research processes (**H4b**).*

Our final contextual factor is an academic's wider disciplinary community that co-ordinates scientific activities through a mix of formal and informal institutions (Becher and Trowler 2001). Individuals' decisions are judged in various ways by these community structures and individuals modify their behaviours to receive positive community judgements. The extent to which academics demonstrate 'open behaviour' will be influenced by the extent to which open behaviour is an accepted norm within that community (Deem and Lucas 2007; Jacobson et al. 2004; Miller and Neff 2013). Thus we contend:

Researchers *in disciplines where external knowledge is seen as being a legitimate contribution towards valid knowledge creation processes are more likely to demonstrate 'open behaviour' in their research processes (**H5**).*

3.3. Other factors

Other factors may also shape researchers' propensity towards 'open behaviour', providing our control variables. An older generation of 'Ivory tower' trained researchers may embody Mertonian norms discouraging external interactions (Bercovitz and Feldman 2008; Tartari and Breschi 2012). We include researchers' academic *position* in the lifecycle to control for researchers' being part of an 'Ivory tower generation' less willing to behave openly in research.

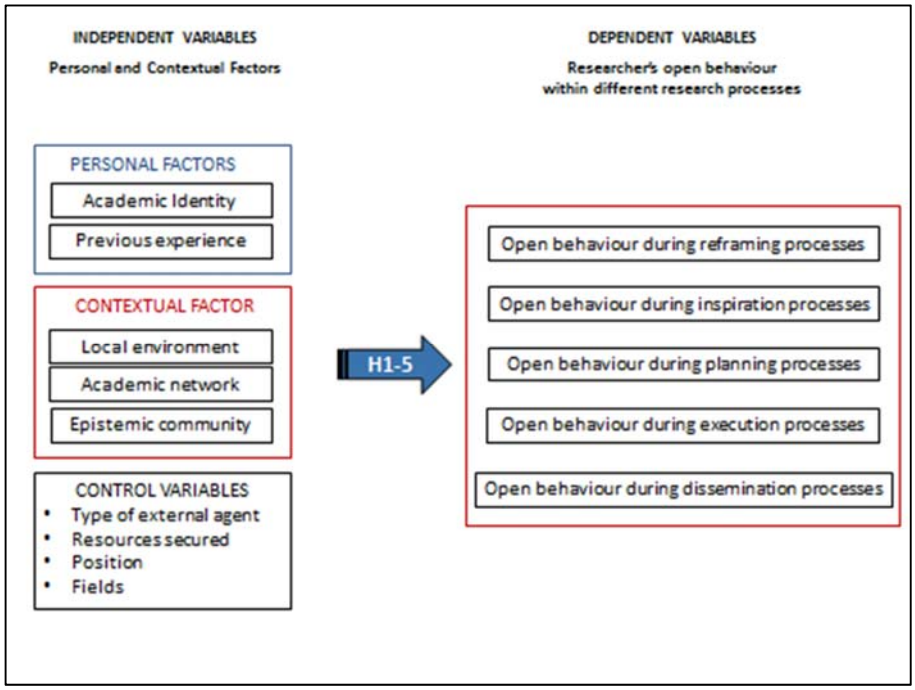
Secondly, researchers may be influenced by direct benefits that external collaborations provide, including ease of access to financial or in-kind resources and prestige (Baldini et al. 2007; D'Este and Perkmann 2011; Gulbrandsen and Smeby 2005; Lam 2011). We therefore control for the extent to which individuals have derived financial and prestige benefits otherwise unrelated to our five research processes.

Thirdly, the kind of external agent may affect that interaction and we control for three kinds of partner. Firstly, entrepreneurial science perspectives see *firms* as more legitimate research partners than other societal partners (Berman 2011). Conversely, academics engaged with interactive well informed *policy-makers* may exhibit more open research behaviour in undertaking policy research (Krueger and Gibbs 2010). Those working with *non-profit organisations* (NPOs) may be ethically committed to those organisations' goals and hence see interacting with them as valid (Tinker and Gray 2003).

We also control for researcher disciplinary field; if you accept other disciplines norms then it is easy to accept that non-academic knowledge is legitimate within disciplinary knowledge creation processes (Hessels et al. 2011; Lowe et al. 2013). Our baseline are differences between social science & humanities (SSH) and STEM fields (science, technology, engineering & mathematics) following prior research showing engagement patterns differ between SSH and STEM (Olmos-Peñuela et al. 2014a).

Personal and contextual factors (and control variables) may be associated with researchers' open behaviour in the different research processes (termed reframing, inspiration, planning, execution and dissemination) ultimately affecting the type of knowledge generated and its usability (see Figure 2). We now explain our dataset, variable construction and analytical plan.

Figure 2 Conceptual framework



Source: authors' own design

4. Data and methodology

4.1. Data

The empirical study focuses on Spain's largest public research organisation, the Spanish Council for Scientific Research (CSIC), using the IMPACTO project database containing results of a questionnaire distributed to CSIC's contracted and tenured researchers. The questionnaire[3] included questions covering researchers' profile (position, disciplinary field), their research characteristics (research orientation, operationalising research projects, researchers' task relevance), and external engagement (motivations, frequency, type of external entities, collaboration outputs). Data was collected in 2011 through a multi-method process combining online questionnaires with telephone follow-up ensuring a final sample proportionally distributed by fields and seniority.

Our study population are CSIC's 4240 contracted/ tenured researchers in 2011 across 126 research institutes organised in eight scientific fields. Our final sample was 1583 researchers (37% of the population). Table 1 gives a summary population distribution indicating the sample is representative of the study population. Chi Square tests (χ^2) indicate that for the eight fields there are no differences in population and sample distribution (except for the overrepresented agricultural sciences).

[3] See Olmos-Peñuela et al. (2014a) for more details about questionnaire structure and data collection.

Table 1: Population and sample distribution by scientific field of knowledge

	Population (N)	Population (%)	Sample (N)	Sample (%)	% Differences χ^2 test (*)
Biology & biomedicine	771	18.2%	244	15.4%	-2.8%
Food science & technology	285	6.7%	128	8.1%	1.4%
Materials science & technology	562	13.3%	201	12.7%	-0.6%
Physical science & technology	569	13.4%	204	12.9%	-0.5%
Chemical science & technology	480	11.3%	209	13.2%	1.9%
Agricultural sciences	412	9.7%	203	12.8%	3.1%*
Natural resources	759	17.9%	277	17.5%	-0.4%
Social sciences & humanities	402	9.5%	117	7.4%	-2.1%
TOTAL	**4,240**	**100**	**1,583**	**100**	

Source: Olmos-Peñuela et al. (2014a); (following Weingart (2009), we have used this table already when publishing on this database).
Note: χ^2 test was used to assess whether differences exist between population and sample distribution for each field.
* indicates statistical differences at 5%. Agricultural sciences are statistically overrepresented in the sample.

4.1.1. Dependent variables

Table 2 shows definitions and descriptive statistics of our empirical dependent variables. Five dependent variables capture 'open behaviour' in our five research processes.

The variable measuring *open behaviour during research reframing processes* is calculated using a binary variable taking the value '1' if the researcher reported experiencing *changes* or *substantial changes* in research agenda resulting from relationships with external entities (27.8%), otherwise '0'.

The variable measuring *open behaviour during inspiration processes* is a binary variable taking the value '1' if the researcher reported that the scientific activity was *inspired* or *significantly inspired* by considerations of use (71.4%), otherwise '0'.

The variable measuring *open behaviour during planning processes* is a continuous variable constructed from three items (Cronbach α= 0.789) capturing researchers' pro-social behaviour (following D'Este et al. (2013)), identifying the potential use of the results, users and intermediaries. This variable ranges from 1 to 4 with average researcher scoring 2.52.

The variable measuring *open behaviour during planning processes* is a continuous variable constructed from four items (Cronbach $\alpha = 0.713$) measuring researchers' use of external knowledge (i.e. to keep abreast of the areas of interest of external parties, to test research's feasibility/ practical application, to obtain information or materials necessary for developing current research lines, and to explore new research lines). This variable ranges from 1 to 4, the average researcher scoring 3.11.

We test that multiple-item scale variables (open behaviour in planning and execution processes) satisfy the unidimensional criterion. Additionally, Cronbach α indicates that the items forming each index are reliable; with Q–Q plots procedures showing both variables match a normal distribution.

The variable measuring *open behaviour during dissemination processes* is a binary variable with a value '1' if the researcher reported as *important* or *very important* at least one co-creative dissemination activity

(28.5%) (i.e. obtaining patents or other intellectual property right; developing exhibitions and/or catalogues; generating clinical guidelines, standards, codes of practices), and '0' otherwise.

Table 2: Operational definitions and descriptive statistics of the dependent variables: researchers' open behaviour during different research processes [a]

Dependent variables (continuous)	Measure	Sub-items	Method and descriptive statistics
Open behaviour during planning processes	Measured as an index on a Likert scale ranging from 1 (never) to 4 (regularly) for frequency that researcher engages in each listed activity when conducting research. Scores initially ranged from 3 to 12. To account for "does not apply" answers, each respondent's index was calculated as arithmetic mean of applicable sub-items divided by number of applicable sub-items	• Identify the potential results of your research that can benefit users • Identify the potential users who can apply the results of your research • Identify intermediaries in order to transfer the results of your results	Sum of three items divided by number of applicable items **Range: 1-4** **Mean: 2.52** **S.D: 0.73** **Cronbach's α:0.789**
Open behaviour during execution processes	Measured as an index on a Likert scale ranging from 1 (not important) to 4 (very important) for degree of importance researcher attaches to listed sub-item as reason for interacting with external entities (firms, public administration agencies, non-profit organisations). Scores initially ranged from 4 to 16. To account for "does not apply" answers, each respondent's index was calculated as arithmetic mean of applicable sub-items divided by number of applicable sub-items	• To keep abreast of about the areas of interest of these non-academic entities • To test the feasibility and practical application of your research • To obtain information or materials necessary for the development of your current lines of research • To explore new lines of research	Sum of four items divided by number of applicable items **Range: 1-4** **Mean: 3.11** **S.D: 0.55** **Cronbach's α:0.713**

Dependent variables (categorical)	Description	Descriptives % of '1'
Open behaviour during reframing processes	Dichotomous variable: - coded '1' if researcher experienced changes or substantial changes in past research agenda as result of relationships with external entities, otherwise '0'	**27.8%**
Open behaviour during inspiration processes	Dichotomous variable: - coded '1' if researcher scientific activity was inspired or significantly inspired by practical use and/or application of knowledge outside academic environment, otherwise '0'	**71.4%**
Open behaviour during dissemination processes	Dichotomous variable: - coded '1' if researcher reported at least one of following three activities as important or very important external collaboration result: 1) obtaining patents or other intellectual property right; 2) developing exhibitions and/or exhibition catalogues; 3) generating clinical guidelines, standards, & codes of practices, '0' otherwise	**28.5%**

[a] This paper adopts the convention that all material reproduced from the questionnaire appears translated into English by the authors and represents a faithful rendering of the Spanish original

4.1.2. Independent and control variables

Our explanatory variables are regrouped in six categories: (1) academic identity; (2) previous experience; (3) local environment; (4) academic network; (5) epistemic community; and (6) control variables. For succinctness these variables' operational definitions and descriptive statistics are presented in Table 3 with correlation coefficients shown in Appendix A.

First we present descriptive results of our control variables to illustrate the sample's main characteristics. Our sample is composed of *Post-Doc* contracted researchers (18.1%) and permanent researchers categorised following CSIC's structure as *Tenured scientists* (36.4%), *Scientific researchers* (27.2%) and

Research professors (18.3%).[4] Following the CSIC classification, the sample is divided in eight scientific fields: *natural resources* (17.5%) is the largest sample field, followed by *biology & biomedicine* (15.4%); *chemical science & technology* (13.2%); *physical science & technology* (12.9%); *agricultural sciences* (12.8%) and *materials science & technology* (12.7%). Among the smallest field of the sample we found *food science & technology* (8.1%) and *social sciences & humanities* (7.4%). Our sample researchers collaborated at least once over the last 3 years with *firms* (76.2%), *government agencies* (78.3%) and *non-profit organisations* (48.6%). Our last control variable is a continuous variable labelled *resources secured* (proxying direct benefits excluding knowledge, *cf.* section 3.3) measured as an index of 5 items (Cronbach $\alpha = 0.668$, indicating its reliability) covering the degree of importance the researcher attaches to non-knowledge resources in interacting with external entities. This variable ranges from 1 to 4 with average researcher scoring 2.86, satisfies the unidimensionality criterion, and matches with a normal distribution (according to the Q-Q plot procedure).

Regarding our independent variables, the academic identity category is captured through the binary variable *entrepreneurial ideal*, taking the value '1' if the researcher reported to attach *importance* or *significant importance* to contributing to the resolution of socioeconomic problems (64%), otherwise '0'.

We capture previous research experience in accessing knowledge using the binary variable *knowledge accessed,* taking the value '1' if the researcher reported obtaining *important* or *very important* information or material for research development as a direct consequence of working with external entities (58.5%), otherwise '0'.

Local environment is captured using two binary variables, institute informal support and institute formal support. *Institute informal support* takes a value '1' if the researcher reported their research institution environment *positively* affects relationships with external entities (28.7%), otherwise '0'. Likewise, *institute administrative support* takes the value '1' if the researcher reported the research centre's administrative and managerial capacity for collaboration *positively* affects external relationships (25.6%), otherwise '0'.

Personal academic network is captured using two variables, personal network and multidisciplinary network. *Personal academic network* is a continuous variable ranging from 1 to 6 capturing (following van Rijnsoever et al. 2008) the extent to which researchers are organisationally distant from their academic collaborators. The average researcher scores 3.46,higher scores meaning higher organisational distances. This variable's normality was verified with the Q-Q plot procedure. *Multidisciplinary network* is a binary variable that takes the value '1' if the researcher reported to *usually* conduct research with researchers from other scientific disciplines (28.8%), otherwise '0'.

The epistemic community category is captured using the binary variable *lack of scientific merit*, which measures whether the lack of scientific merit attached to external collaborations hinders establishing external relationships. 29.7% of the sample reported lack of scientific merit associated with external

[4] CSIC academic ranking system has three kinds of permanent positions, research professor ('profesor de investigación') being the most senior figure, followed by scientific researcher and tenured scientist ('investigador científico' and 'científico titular', respectively).

collaborations as *a major obstacle or an obstacle* (coded as '1') for establishing relationships with external entities, otherwise '0'.

Table 3: Operational definitions and descriptive statistics of the independent (personal and contextual factors) and control variables [a]

Independent variables (continuous)	**Measure**	**Sub-items**	**Method and descriptive statistics**
Personal academic network	Personal academic network is measured as index capturing researchers' organisational distance from people with whom they usually conduct research activities. Researchers were asked to indicate two most frequent type of people with whom they usually conduct research. 'Type of people' is an ordinal variable ranked according to researchers' distance from other academics, and ranges as follows: 1. Alone or with people from firms and non-academic entities 2. With people from own research group. 3. With people from own research institute. 4. With people from other CSIC research institute 5. With people from universities and research centres in Spain 6. With people from universities and research centres in other countries Respondents' scores are computed as average of two most frequent options and weighted in order to account for "does not apply" answers. Thus, for each respondent, the sum of the score was divided by number of applicable item(s). Final scores take non-integer values from 1 to 6, where 1 indicates that researchers' do not usually work with other academics, and 6 indicates they primarily work with researchers in other countries		Sum of two most frequent options divided by number of applicable items **Range: 1-6** **Mean: 3.42** **S.D: 0.84** **Cronbach's α: N.A**
Resources secured	Measured as an index on a Likert scale ranging from 1 (not important) to 4 (very important) for degree of importance researcher attaches to each sub-item as personal motivation for external interactions (firms, public administration agencies, non-profit organisations). Scores initially ranged from 5 to 20. To account for "does not apply" answers, each respondent's index was calculated as arithmetic mean of applicable sub-items divided by number of applicable sub-items	• To obtain additional funds for your research • To be part of a professional network or expand your professional network • To have access to the experience of non-academic professionals • To have access to equipment and infrastructure necessary for your lines of research • To obtain grants and job opportunities for your students	Sum of five items divided by number of applicable items **Range: 1-4** **Mean: 3.05** **S.D: 0.53** **Cronbach's α: 0.668**

Independent variables (categorical)	**Description**	**Descriptives % of '1'**
Entrepreneurial ideal	Dichotomous variable: - coded '1' if researcher attaches importance or significant importance to contributing to the resolution of socioeconomic problems, otherwise '0'	**64%**
Knowledge accessed	Dichotomous variable: - coded '1' if researcher, as a direct consequence of external collaboration, has obtained important or very important information or material for the development of the research lines, otherwise '0'	**58.5%**
Institute informal support	Dichotomous variable: - coded '1' if researcher reports that research institute support to initiate collaborative activities positively affects current external relationships, otherwise '0'	**28.7%**
Institute formal support	Dichotomous variable: coded '1' if researcher reports that research institute's administrative and managerial capacity positively affects current external relationships, otherwise '0'	**25.6%**
Multidisciplinarity network	Dichotomous variable: - coded '1' if researcher reports usually conducting research with researchers from other scientific disciplines, otherwise '0'	**28.8%**
Lack of scientific merit	Dichotomous variable: - coded '1' if researcher reports that lack of scientific merit is an obstacle or a major obstacle in establishing external relationships, otherwise '0'	**29.7%**
Position	Academic position was measured as follows: **post-doc [POST]** researcher is a binary variable coded '1' if researcher is post-doctoral contracted scientist, otherwise '0'; **tenured scientist [TEN]** is a binary variable coded '1' if researcher is tenured scientist, otherwise '0'; **scientific researcher [SCIEN]** is a binary variable coded '1' if researcher is scientific researcher, otherwise '0'; finally, **professor researcher [PROF]** is a binary variable coded '1' if researcher is professor researcher, otherwise '0'. The first category was used as reference category in the econometric models. These mutually exclusive categories are based on CSIC's research staff categorisation	**POST: 18.1%** **TEN: 36.4%** **SCIEN: 27.2%** **PROF: 18.3%**
Firm	Dichotomous variable: - coded '1' if researcher has collaborated at least once over last three years with firms located in Spain, otherwise '0'	**76.2%**

Government agencies	Dichotomous variable: - coded '1' if researcher has collaborated at least once over last three years with government agencies, otherwise '0'	**78.3%**
Non-profit organizations (NPOs)	Dichotomous variable: - coded '1' if researcher has collaborated at least once over last three years with NPOs, otherwise '0'	**48.6%**
Fields	Research fields were measured with a series of dichotomous variables defined as follows: **Biology & biomedicine [BIO]** is a binary variable coded '1' if respondent is researcher in biology and medicine, otherwise '0'; **Food science & technology [FOOD]** is a binary variable coded '1' if respondent is researcher in food science and technology, otherwise '0'; **Materials science & technology [MAT]**, is a binary variable coded '1' if respondent is a researcher in materials science & technology, otherwise '0'; **Physical science & technology [PHY]** is a binary variable coded '1' if respondent is researcher in physical science & technology, otherwise '0'; **Chemical science & technology [CHE]**is a binary variable coded '1' if respondent is researcher in chemical science & technology, otherwise '0'; **Agricultural sciences [AGR]** is a binary variable coded '1' if respondent is researcher in agricultural sciences, otherwise '0'; **Natural resources [NAT]** is a binary variable coded '1' if respondent is researcher in natural resources, otherwise '0'; and finally **Social science & humanities [SSH]** is a binary variable coded '1' if respondent is researcher in social science and humanities, otherwise '0'. This last category of researchers was used as the economist model's reference category. These mutually exclusive categories are based on CSIC's scientific areas organisation	**BIO: 15.4%** **FOOD: 8.1%** **MAT: 12.7%** **PHY: 12.9%** **CHE: 13.2%** **AGR: 12.8%** **NAT: 17.5%** **SSH: 7.4%**

[a] This paper adopts the convention that all material reproduced from the questionnaire appears translated into English by the authors and represents a faithful rendering of the Spanish original.

4.1.3. Analytical plan

The analytical plan conducted using the structural equation package Mplus 3, (see Muthén 1998–2004) consists of using a multivariate model allowing estimating simultaneously a number of regressions for explaining 'open behaviour'. More specifically, testing our conceptual framework requires estimating five regression equations, one for each dependent variable associated with 'open behaviour' during different research processes. Due our dependent variables' nature, we use different kind of regressions: binary probit for our binary variables (open behaviour during reframing, inspiration and dissemination processes), and ordinary least square for our continuous variables (open behaviour during planning and execution processes). The multivariate model analysis simultaneously estimates these five equations, accounting for possible correlations between the five dependent variables. Controlling for the existence of mutual covariances between equations disturbances allows us to overcome receiving inefficient estimators that could be obtained if error terms would be correlated when separately estimating regressions (Belderbos et al. 2004). We use weighted least squares mean and variance adjusted estimators – WLSMV (Landry et al. 2010; Ouimet et al. 2007) since we combine different types of regressions.

The first analytic stage consists of estimating the saturated multivariate model, estimating the five regressions jointly, but that cannot assess for model fit because of its zero degrees of freedom.

The second stage is to estimate the previous saturated model but removing the insignificant independent variables (i.e. when p-value>10%, two-tail), which means fixing insignificant coefficient at zero. This leads to the unsaturated model with free error terms. We conduct an iterative process in which we progressively remove all insignificant independent variables identified at each iteration until obtaining a model with all significant parameters for the independent variables. The resulting unsaturated model with free error terms can be assessed for model fit, since fixing insignificant parameters at zero allows estimating a model with degrees of freedom (unlike the saturated model). The insignificance of this unsaturated model with free error terms indicates a good fit of the model.

Finally, to verify whether it would be more appropriate to estimate separately the five regression equations, we estimate the 'constrained unsaturated model with free error terms fixed at zero', the result of estimating the final unsaturated model (without insignificant independent variables) but fixing the covariances between the equation error-terms at zero. This constrained unsaturated model's lack of significance indicates the model has a good fit – and it is appropriate to estimate the regressions separately; whereas its significance indicates a poor fit of the model – and the appropriateness of estimating the regressions simultaneously through a multivariate model.

5. Results

Table 4 presents the fit of the unsaturated model with free error terms, excluding insignificant parameters found in the saturated model. The results of comparing the unsaturated model and the constrained unsaturated model are reported in Table 4's lower section. The unsaturated model has 36 degrees of freedom and an insignificant χ^2 statistic of 38.25 (p-value=0.368), indicating that the final unsaturated model has a very good fit. The R^2 estimates are presented in Table 4's lower section: 'open behaviour' is most effectively explained during execution processes. For the constrained unsaturated model, the computed value of the χ^2 is significant ($\chi^2 = 257.66$; 44 degree of freedom; p-value=0.000), indicating a poor model fit. This suggests that the use of separate regression models is not appropriate to estimate the factors affecting 'open behaviour' during different research processes since it avoids the interdependences between the openness dependent variables, which may lead to inefficient estimators. For our empirical analysis, this implies that the unsaturated model with error-term covariances better reflects the data than the constrained unsaturated model with error-term covariances fixed at zero.

Error-term covariances between 'open behaviour' during different research processes (indicating interdependences between the dependent variables) are listed in Table 4's lower part. Results show strong significant and positives associations between researchers' open behaviour during the five research processes (except for a positive weak relation between open behaviour during execution and dissemination processes). More specifically, covariances range from 0.354 to 0.029, being the highest relationship between open behaviour during reframing and inspiration processes. Overall, this suggests that researchers demonstrating open behaviour tend to demonstrate it consistently throughout their research processes.

Regarding factors associated with researchers' open behaviour, we firstly focus on independent variables systematically significantly associated with open behaviour during all research processes, and then, we address to which extent hypotheses have been validated. Table 5 summarises only those results showing a significant relationship between the independent variables and researchers' open behaviour.

We find 3 variables significantly related to open behaviour in all five research processes: *entrepreneurial ideal*, *knowledge accessed*, and collaborating with *firms*. This confirms our hypotheses that researchers with an identity closer to the entrepreneurial ideal (H1) and researchers with a positive evaluation of their past collaborative experience (H2) are more reactive to third party influences in their research processes. Likewise, collaborations with firms emerge as related to researchers' open behaviour, whereas

collaborations with government agencies and NPO are not related with open behaviour in all research processes, but in *planning* processes (government agencies and NPO) and *dissemination* processes (NPO).

For H3, we only find a positive relationship between researchers' positive perception about *informal institutional support* and open behaviour in dissemination processes. Likewise, for H4a results indicate a low significant negative relation between *personal network* and open behaviour in *execution* processes.

H 4b is not verified for all research processes: *multidisciplinary network* emerges as significant and positively associated with open behaviour in three of the five processes (*inspiration, planning* and *dissemination).* With H4b, our results suggest that researchers habitually connected with academic agents in other disciplines demonstrate an open behaviour in planning and dissemination processes, but not in execution and reframing processes.

Of the other control variables, *academic position* is not significantly associated with open behaviour whereas *resources secured* is significant and positively associated with open behaviour in *planning* and *execution*, but barely significant and negatively linked to openness during reframing processes. The variables related to *field* are largely inconclusive with results suggesting a higher open behaviour amongst SSH researchers' compared to those in natural resource disciplines in three processes (*reframing*, *inspiration* and *dissemination*). Conversely, SSH researchers' open behaviour is lower than researchers in food and physical science & technology in *planning* and *execution* processes.

Table 4: Unsaturated multivariate model results explaining 'open behaviour' during different research processes

Dependent variables	Open behaviour during reframing		Open behaviour during inspiration		Open behaviour during planning		Open behaviour during execution		Open behaviour during dissemination	
Independent variables	Coeff *(β)*	*t* value	Coeff. *(β)*	*t* value	Coeff. *(β)*	*t* value	Coeff. *(β)*	*t* value	Coeff. *(β)*	*t* value
Intercept					1.536***	9.757	1.129***	11.970		
Threshold 1	1.023***	3.019	0.286	0.691					1.752***	4.920
Academic identity										
• Entrepreneurial ideal	0.309***	3.130	1.026***	10.246	0.360***	8.545	0.095***	3.553	0.167*	1.689
Previous Experience										
• Knowledge accessed	0.356***	3.888	0.313***	3.106	0.171***	4.128	0.119***	4.780	0.640***	6.665
Local environment										
• Institute informal support									0.244**	2.594
• Institute administrative support										
Academic network										
• Personal network							-0.027*	-1.782		
• Multidisciplinary network			0.292**	2.643	0.162***	3.913			0.194**	2.176
Epistemic community										
• Lack of scientific merit			0.274**	2.554						
Control variables										
• Firm	0.449***	3.276	0.329**	2.695	0.248***	4.548	0.101***	3.191	0.563***	4.088
• Government Agency					0.142**	2.668				
• Non-profit organisation					0.171***	4.317			0.228**	2.575
• Resources secured	-0.148*	-1.750			0.079**	2.052	0.589***	25.857		
• Tenured scientist[a]										
• Scientific researcher[a]							-0.065**	-2.506		
• Professor researcher[a]										
• Biology & Biomedicine[b]										
• Food science & technology[b]					0.240***	3.064	0.106**	2.143		
• Materials science & technology[b]			0.761***	4.328						
• Physical science & technology[b]					0.251***	4.069	0.144***	3.762		
• Chemical science & technology[b]										
• Agricultural sciences[b]	-0.342***	-2.390					0.098**	2.407	-0.342**	-2.390
• Natural resources[b]	-0.298***	-2.202	-0.491***	-3.530					-0.298**	-2.202
Covariance between disturbances	ε_1		ε_2		ε_3		ε_4			

ε_2	0.354***				
ε_3	0.127***	0.209***			
ε_4	0.062***	0.072***	0.034***		
ε_5	0.287***	0.235***	0.116***	0.029*	
Number of cases	1064				
R^2	0.112	0.325	0.219	0.437	0.202
Unsaturated model with free error terms		χ^2 (36) = 38.25, *p-value* =0.368			
Constrained unsaturated model with free error terms fixed at zero:		χ^2 (44) = 257.66, *p-value* =0.000			

Notes: *, ** and *** indicate that the variable is significant at the 10%, 5% and 1% level, respectively

[a] The reference category is Post-Doc

[b] The reference category is social sciences & humanities

Table 5: Summary overview of significance and directionality of results in Table 4

Independent variables	Open behaviour during reframing	Open behaviour during inspiration	Open behaviour during planning	Open behaviour during execution	Open behaviour during dissemination
Academic identity					
• Entrepreneurial ideal	+++	+++	+++	+++	+
Previous Experience					
• Knowledge accessed	+++	+++	+++	+++	+++
Local environment					
• Institute informal support					++
Academic network					
• Personal network				-	
• Multidisciplinary network		++	+++		++
Epistemic community					
• Lack of scientific merit		++			
Control variables					
• Firm	+++	++	+++	+++	+++
• Government Agency			++		
• Non-profit organisation			+++		++
• Resources secured	-		++	+++	
• Scientific researcher[a]				- -	
• Food science & technology[b]			+++	++	
• Materials science & technology[b]		+++			
• Physical science & technology[b]			+++	+++	
• Agricultural sciences[b]	- - -			++	- -
• Natural resources[b]	- - -	- - -			- -

The number of characters corresponds to significance: 1 is 10%, 2 is 5%, 3 is 1%.
Signs correspond to the direction of the relationship between dependent and independent variables: '+' is positive direction, '-' is negative direction
[a] The reference category is Post-Doc
[b] The reference category is social sciences & humanities

6. Discussion and conclusion

In this paper, we address researchers' openness to external influences in various research processes to understand what influences researchers' open behaviour. We are driven by D'Este and Perkmann (2011)'s argument that understanding researchers' decisions to engage externally is a pressing question demanding further fundamental consideration in science policy studies. Our approach has sought to clarify the hitherto ambivalent relationship between external engagement and research activities, and whether engagement is a benefit or a hindrance for core research activities (Gulbrandsen and Smeby 2005). We define a new concept, 'openness', as researcher willingness to allow external partners to affect their different research processes, arguing that incorporating user knowledge into these research processes makes knowledge produced ultimately more easily taken forward by users (more 'usable') (Spaapen and van Drooge 2011).

We explore 'openness' via considering qualitatively different kinds of behaviours (what we call the empirical 'open behaviour') by those researchers involved in scientific knowledge creation (research) processes. The extent to which each researcher reacts in each research process affects in aggregate how far their research outcomes incorporate user knowledge, which then makes it easier to be appropriated and exploited by potential external users. We contend that our conceptual construct 'openness' might be influenced by different factors relating to researchers and their environments. Our results indicate that the most salient factors explaining 'open behaviour' in different processes are related to personal characteristics (academic identity, past experiences), and the type of external agent collaborated with (i.e. firms), corresponding to previous studies suggesting that institutional norms are more salient than personal norms (Bercovitz and Feldman 2008).

Our study validates recent interest in researcher influences and motivations, underscoring a need for further research to explore how personal and contextual factors influence researchers' external engagement decisions. Complementing Lam (2011)'s work on extrinsic rationales for engagement, our results suggest that researchers' openness is also influenced by intrinsic factors, namely identity and previous experiences. Given this complementarity, and the fact that our own research is exploratory, further research is needed to integrate these literatures. As our study analyses a single institution (CSIC) within one national context, then we cannot explore comparatively how researchers' decisions are influenced by either CSIC's own characteristics, or the place of engagement in Spain's socio-technical imaginary (Jasanoff and Kim 2013). Our future research will compare different (kinds of) institutions analysing whether the more symbolic and systems-level factors affects individual researcher 'openness', and homologisation of researcher norms across science systems (Nedeva 2013). Given our research was quantitative, we see clear value in further exploring these broad-brush results with more qualitative data asking researchers about how they incorporate user knowledge in their various research processes.

Finally, our message to policy-makers (including universities) is that propensity towards open behaviour appears continuously in formation during an academic career – beginning with the Ph.D. and followed with later engagement experiences. Policy-makers aiming to promoting researchers' external engagement should not exclusively use short-run incentive and benefits measures, but shape longer-term processes related to

academic identify formation and provide researchers with opportunities to engage with third parties. If policy-makers are serious at stimulating scholars' openness and creating knowledge more useful for society, then they should target creating positive opportunities for engagement experiences, and ensure academic formation processes highlights that good research does create impact.

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Appendix A: Correlation coefficients for independent and control variables

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1. Entrepreneurial ideal	1																					
2. Knowledge accessed	.120	1																				
3. Institute informal support	.026	.091	1																			
4. Institute administrative support	.052	.070	.649	1																		
5. Personal network	-.070	-.072	-.026	-.025	1																	
6. Multidisciplinary network	.144	.104	-.037	.015	.036	1																
7. Lack of scientific merit	-.045	-.062	-.004	-.023	-.013	-.027	1															
8. Firm	.222	.143	.010	.019	-.107	.104	-.070	1														
9. Government Agency	.117	.104	.056	.065	.007	.045	-.012	.120	1													
10. Non-profit organisation	.132	.128	-.017	-.002	.031	.140	.006	.187	.232	1												
11. Resources secured	.208	.183	.092	.081	-.021	.059	-.037	.096	.084	.066	1											
12. Post-doc scientist	-.007	.014	.083	.093	.013	-.063	.068	-.205	-.042	-.082	.115	1										
13. Tenured scientist	-.012	.021	.063	.083	-.027	.010	-.037	.053	-.025	-.051	.023	-.356	1									
14. Scientific researcher	-.027	.011	-.079	-.123	-.010	.027	.012	.051	.053	.083	-.050	-.287	-.462	1								
15. Professor researcher	.053	.053	-.061	-.041	.032	.019	-.033	.079	.011	.048	-.086	-.222	-.358	-.289	1							
16. Biology & biomedicine	-.064	-.091	-.079	-.064	-.085	-.074	.007	-.059	-.055	-.056	.023	.008	-.018	-.033	.052	1						
17. Food science & technology	.098	.052	.027	-.018	-.123	.069	-.062	.128	-.023	.016	.055	-.091	.045	.017	.016	-.127	1					
18. Materials science & technology	-.029	.002	-.086	-.037	.022	.019	.007	.078	-.052	.040	.047	.018	.011	-.041	.016	-.163	-.113	1				
19. Physical science & technology	-.041	-.032	.067	.050	.083	-.065	-.011	-.074	-.022	-.082	-.053	.029	.003	-.006	-.026	-.164	-.114	-.147	1			
20. Chemical science & technology	.006	.028	.056	.055	-.017	.055	-.033	-.017	-.115	-.092	.026	-.048	.003	.030	.009	-.166	-.116	-.149	-.150	1		
21. Agricultural sciences	.096	.001	-.020	.003	-.066	-.060	-.018	.103	.072	-.026	-.007	-.127	.047	.050	.009	-.164	-.114	.-146	-.148	-.150	1	
22. Natural resources	-.059	.041	-,009	-.026	.093	.031	.053	-.064	.103	.057	-.038	.133	-.052	-.001	-.067	-.197	-.137	-.176	-.177	-.180	-.177	1
23. Social science & Humanities	.029	.009	.071	.051	.081	.052	.049	-.075	.102	.183	-.053	.055	-.028	-.015	-.002	-.121	-.084	-.108	-.109	-.110	-.108	-.130

Note: Beyond .051 de correlation coefficient are significant at standard level 5%

Bibliography

Abreu, Maria, Vadim Grinevich, Alan Hughes, and Michael Kitson. 2009. Knowledge exchange between academics and the business, public and third sectors. Cambridge: Centre for Business Research and UK-IRC.

Aghion, Philippe, Mathias Dewatripont, and Jeremy C. Stein. 2008. Academic freedom, private-sector focus, and the process of innovation. *RAND Journal of Economics* 39: 617–635.

Ajzen, Icek. 2001. Nature and operation of attitudes. *Annual review of psychology* 52 (1): 27-58.

Alrøe, Hugo Fjelsted, and Erik Steen Kristensen. 2002. Towards a systemic research methodology in agriculture: Rethinking the role of values in science. *Agriculture and Human Values* 19 (1): 3-23.

Audretsch, David B, Werner Bönte, and Stefan Krabel. 2010. Why do scientists in public research institutions cooperate with private firms. In *DRUID Working Paper, 10-27*.

Baldini, Nicola, Rosa Grimaldi, and Maurizio Sobrero. 2007. To patent or not to patent? A survey of Italian inventors on motivations, incentives, and obstacles to university patenting. *Scientometrics* 70 (2): 333-354.

Bandura, Albert. 1977. *Social Learning Theory*. Englewood Cliffs, NJ.: Prentice-Hall.

Becher, Tony, and Paul Trowler. 2001. *Academic tribes and territories: Intellectual enquiry and the culture of disciplines*. McGraw-Hill International.

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

Belderbos, René, Martin Carree, Bert Diederen, Boris Lokshin, and Reinhilde Veugelers. 2004. Heterogeneity in R&D cooperation strategies. *International Journal of Industrial Organization* 22 (8): 1237-1263.

Bercovitz, Janet, and Maryann Feldman. 2008. Academic entrepreneurs: Organizational change at the individual level. *Organization Science* 19 (1): 69-89.

Berman, Elizabeth Popp. 2011. *Creating the market university: How academic science became an economic engine*. Princeton University Press.

Bozeman, Barry, Daniel Fay, and Catherine P Slade. 2013. Research collaboration in universities and academic entrepreneurship: the-state-of-the-art. *The Journal of Technology Transfer* 38 (1): 1-67.

Collini, Stefan. 2009. Impact on humanities Researchers must take a stand now or be judged and rewarded as salesmen. *The Times Literary Supplement, 13th november 2009* (5563): 18-19.

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

D'Este, Pablo, Oscar Llopis, and Alfredo Yegros. 2013. Conducting pro-social research: Cognitive diversity, research excellence and awareness about the social impact of research: INGENIO (CSIC-UPV) Working Paper Series.

Deem, Rosemary, and Lisa Lucas. 2007. Research and teaching cultures in two contrasting UK policy contexts: Academic life in education departments in five English and Scottish universities. *Higher Education* 54 (1): 115-133.

DiMaggio, Paul J, and Walter W Powell. 1983. The iron cage revisited: Institutional isomorphism and collective rationality in organizational fields. *American sociological review* 48 (2): 147-160.

Donovan, Claire. 2007. The qualitative future of research evaluation. *Science and Public Policy* 34 (8): 585-597.

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

Etzkowitz, Henry, and Loet Leydesdorff. 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.

Fromhold-Eisebith, Martina , Claudia Werker, and Marcel Vojnic. 2014. Tracing the social dimension in innovation networks. In *The social dynamics of innovation networks*, eds. Roel Rutten, Paul Benneworth, Frans Boekema, and Dessy Irawati. London: Routledge (in press).

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

Gibbons, Michael, Camille Limoges, Helga Nowotny, Simon Schartzman, Peter Scott, and Martin Trow. 1994. *The new production of knowledge: the dynamics of science and research in contemporary societies*. London: Sage.

Gläser, J. 2012. How does Governance change research content? On the possibility of a sociological middle-range theory linking science policy studies to the sociology of scientific knowledge. Technical University Berlin. *Technology Studies Working Papers. http://www.ts.tu-berlin.de/fileadmin/fg226/TUTS/TUTS-WP-1-2012.pdf*. Accessed 16 February 2015.

Goethner, Maximilian, Martin Obschonka, Rainer K Silbereisen, and Uwe Cantner. 2012. Scientists' transition to academic entrepreneurship: Economic and psychological determinants. *Journal of Economic Psychology* 33 (3): 628-641.

Gulbrandsen, Magnus, and Jens-Christian Smeby. 2005. Industry funding and university professors' research performance. *Research Policy* 34 (6): 932-950.

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

Hessels, Laurens K, Harro van Lente, John Grin, and Ruud EHM Smits. 2011. Changing struggles for relevance in eight fields of natural science. *Industry and Higher Education* 25 (5): 347-357.

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

Hoye, Kate, and Fred Pries. 2009. 'Repeat commercializers,'the 'habitual entrepreneurs' of university–industry technology transfer. *Technovation* 29 (10): 682-689.

Jacobson, Nora, Dale Butterill, and Paula Goering. 2004. Organizational factors that influence university-based researchers' engagement in knowledge transfer activities. *Science Communication* 25 (3): 246-259.

Jain, Sanjay, Gerard George, and Mark Maltarich. 2009. Academics or entrepreneurs? Investigating role identity modification of university scientists involved in commercialization activity. *Research Policy* 38 (6): 922-935.

Jasanoff, Sheila, and Sang-Hyun Kim. 2013. Sociotechnical imaginaries and national energy policies. *Science as Culture* 22 (2): 189-196.

Jensen, Pablo. 2011. A statistical picture of popularization activities and their evolutions in France. *Public Understanding of Science* 20 (1): 26-36.

Kitcher, Philip. 2001. *Science, truth, and democracy*. Oxford: Oxford University Press.

Knorr-Cetina, Karin. 1981. *The Manufacture of Knowledge: An Essay on the Constructivist and Contextual Nature of Science*. Oxford: Pergamon Press.

Kronenberg, Kristin, and Marjolein Caniëls. 2014. Professional proximity in research collaborations. In *The social dynamics of innovation networks*, eds. Roel Rutten, Paul Benneworth, Frans Boekema, and Dessy Irawati. London: Routledge (in press).

Krueger, Rob, and David Gibbs. 2010. Competitive global city regions andsustainable development': an interpretive institutionalist account in the South East of England. *Environment and planning A* 42: 821-837.

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

Landry, Réjean, Malek Saïhi, Nabil Amara, and Mathieu Ouimet. 2010. Evidence on how academics manage their portfolio of knowledge transfer activities. *Research Policy* 39 (10): 1387-1403.

Lee, Yong S. 1996. 'Technology transfer'and the research university: a search for the boundaries of university-industry collaboration. *Research Policy* 25 (6): 843-863.

Lee, Yong S. 2000. The sustainability of university-industry research collaboration: An empirical assessment. *The Journal of Technology Transfer* 25 (2): 111-133.

Leisyte, Liudvika, Jürgen Enders, and Harry De Boer. 2008. The Freedom to Set Research Agendas—Illusion and Reality of the Research Units in the Dutch Universities. *Higher Education Policy* 21 (3): 377-391.

Louis, Karen Seashore, David Blumenthal, Michael E Gluck, and Michael A Stoto. 1989. Entrepreneurs in academe: An exploration of behaviors among life scientists. *Administrative Science Quarterly* 34 (1): 110-131.

Lowe, Philip, Jeremy Phillipson, and Katy Wilkinson. 2013. Why social scientists should engage with natural scientists. *Contemporary Social Science* 8 (3): 207-222.

Martín-Sempere, María José, Belén Garzón-García, and Jesús Rey-Rocha. 2008. Scientists' motivation to communicate science and technology to the public: surveying participants at the Madrid Science Fair. *Public Understanding of Science* 17 (3): 349-367.

Martin, Ben. 2003. The changing social contract for science and the evolution of the university. In *Science and Innovation: Rethinking the rationales for funding and governance*, eds. A. Geuna, A.J. Salter, and W.E. Steinmueller, 7-29. Cheltenhan, UK: Edward Elgar.

Merton, Robert K. 1973. *The sociology of science: Theoretical and empirical investigations*. Chicago: University of Chicago press.

Miller, Thaddeus R, and Mark W Neff. 2013. De-facto science policy in the making: how scientists shape science policy and why it matters (or, why STS and STP scholars should socialize). *Minerva* 51 (3): 295-315.

Muthén, Bengt O. 1998–2004. Mplus Technical Appendices. Muthén & Muthén. Los Angeles, CA.: Muthén & Muthén.

Nedeva, Maria. 2013. Between the global and the national: Organising European science. *Research Policy* 42 (1): 220-230.

Neff, Mark William. 2014. Research Prioritization and the Potential Pitfall of Path Dependencies in Coral Reef Science. *Minerva* 52 (2): 213-235.

Nelson, Richard R. 2001. Observations on the post-Bayh-Dole rise of patenting at American universities. *The Journal of Technology Transfer* 26 (1): 13-19.

Nowotny, Helga, Peter Scott, and Michael Gibbons. 2001. *Re-thinking science: knowledge and the public in an age of uncertainty*. Cambridge: Polity Press.

Olmos-Peñuela, Julia, Paul Benneworth, and Elena Castro-Martínez. 2014a. Are 'STEM from Mars and SSH from Venus'?: Challenging disciplinary stereotypes of research's social value. *Science and Public Policy* 41: 384-400.

Olmos-Peñuela, Julia, Elena Castro-Martínez, and Manuel Fernández-Esquinas. 2014b. Diferencias entre áreas científicas en las prácticas de divulgación de la investigación: un estudio empírico en el CSIC. *Revista Española de Documentación Científica*. doi:10.3989/redc.2014.2.1096.

Ouimet, Mathieu, Nabil Amara, Réjean Landry, and John Lavis. 2007. Direct interactions medical school faculty members have with professionals and managers working in public and private sector organizations: A cross-sectional study. *Scientometrics* 72 (2): 307-323.

Perkmann, M., V. Tartari, M. McKelvey, E. Autio, A. Brostrom, P. D'Este, R. Fini et al. 2013. Academic engagement and commercialisation: A review of the literature on university-industry relations. *Research Policy* 42 (2): 423-442.

Philpott, Kevin, Lawrence Dooley, Caroline O'Reilly, and Gary Lupton. 2011. The entrepreneurial university: Examining the underlying academic tensions. *Technovation* 31 (4): 161-170.

Rutten, Roel, and Frans Boekema. 2012. From learning region to learning in a socio-spatial context. *Regional Studies* 46 (8): 981-992.

Sarewitz, Daniel, and Roger A. Pielke. 2007. The neglected heart of science policy: reconciling supply of and demand for science. *Environmental Science & Policy* 10 (1): 5-16.

Sauermann, Henry, and Paula Stephan. 2013. Conflicting logics? A multidimensional view of industrial and academic science. *Organization Science* 24 (3): 889-909.

Schein, Edgar H. 1985. *Organizational Culture and Leadership: A Dynamic View*. San Francisco, CA.: Jossey-Bass.

Shane, Scott. 2000. Prior knowledge and the discovery of entrepreneurial opportunities. *Organization Science* 11 (4): 448-469.

Spaapen, Jack, and Leonie van Drooge. 2011. Introducing 'productive interactions' in social impact assessment. *Research Evaluation* 20 (3): 211-218.

Stokes, Donald E. 1997. *Pasteur's quadrant: Basic science and technological innovation*. Washington, DC: Brookings Institution Press.

Tartari, Valentina, and Stefano Breschi. 2012. Set them free: scientists' evaluations of the benefits and costs of university–industry research collaboration. *Industrial and Corporate Change* 21 (5): 1117-1147.

Tinker, Tony, and Rob Gray. 2003. Beyond a critique of pure reason: from policy to politics to praxis in environmental and social research. *Accounting, Auditing & Accountability Journal* 16 (5): 727-761.

van Rijnsoever, Frank J, Laurens K Hessels, and Rens LJ Vandeberg. 2008. A resource-based view on the interactions of university researchers. *Research Policy* 37 (8): 1255-1266.

Venkataraman, Sankaran. 1997. The distinctive domain of entrepreneurship research: An editor's perspective. *Advances in entrepreneurship, firm emergence, and growth* 3: 119-138.

Verspagen, Bart. 2006. University research, intellectual property rights and European innovation systems. *Journal of Economic Surveys* 20 (4): 607-632.

Villanueva-Felez, Africa, Jordi Molas-Gallart, and Alejandro Escribá-Esteve. 2013. Measuring Personal Networks and Their Relationship with Scientific Production. *Minerva* 51 (4): 465-483.

Weingart, Peter. 2009. Editorial for Issue 47/3. *Minerva* 47 (3): 237-239.

Ziman, John. 1996. 'Postacademic science': constructing knowledge with networks and norms. *Science Studies* 1: 67-80.

Zomer, Arend H, Ben WA Jongbloed, and Jürgen Enders. 2010. Do spin-offs make the academics' heads spin? The Impacts of Spin-Off Companies on Their Parent Research Organisation. *Minerva* 48 (3): 331-353.