Understanding researchers' openness to external parties influencing academic research

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Abstract

Ambiguity surrounding the effect of external engagement on academic research has raised questions about what motivates researchers to collaborate with third parties. This paper contributes to this debate by progressing beyond the idea that researchers engage with society simply because of direct benefits. We argue that what matters for society is research that can be absorbed by users. We define 'openness' as a willingness by researchers to make research more usable by external partners by responding to external influences in their own research activities. We ask what kinds of characteristics define those researchers who are most 'open' to creating usable knowledge. Our empirical study analyses a sample of 1583 researchers working at the Spanish Council for Scientific Research (CSIC). Results demonstrate that it is personal factors (academic identity and past experience) that determine researchers' 'openness' (to societal involvement). The paper concludes that policies to encourage external engagement should focus on both the academic formation stage and ongoing opportunities to engage with third parties alongside providing direct incentives and benefits within individual projects and funding programmes.

Keywords: valorisation, usable research, external influences, researchers' societal engagement, research cycle.

1. Introduction

There are increasing policy and academic imperatives to understand how research benefits society, given the recent emergence of the social knowledge economy where societal capacity to create and generate new knowledge critically determines its growth and wellbeing (Rutten and Boekema, 2012). Academic literature has increasingly focused on understanding processes where academic knowledge creates societal value (Donovan, 2007). But with some (often policy) communities perceiving academics as preferring not to engage with 'users', a pressing scientific question regards why academics choose to engage or not (D'Este and Perkmann, 2011). Current debates focus on academic behaviours and intentions in engagement, but engagement is not value-neutral to academic communities. Recently, greater attention has been devoted to external collaboration's 'dark side' (Bozeman et al., 2013), some suggesting that knowledge exchange's conflicts with 'academic logic' (Sauermann and Stephan, 2013), forces researchers into unpalatable choices between these conflicting interests (Collini, 2009; Jain et al., 2009; Philpott et al., 2011; Tartari and Breschi, 2012). Others found a more positive relationship between being a 'star scientist' and external engagement (Bekkers and Bodas Freitas, 2008; Gulbrandsen and Smeby, 2005; Haeussler and Colyvas, 2011; Louis et al., 1989, cited in Perkmann et al., 2013: 427).

This ambiguity undermines understanding university-society engagement, hindering optimising research's contribution to societal development and wellbeing. We seek to contribute by exploring the behavioural dimension of academics' openness to external (non-academic) influences on their research. Several studies explored why researchers engage with third parties (Baldini et al., 2007; D'Este and Perkmann, 2011; Lam, 2011; Lee, 2000) despite the evidence tensions they face. We concur with Perkmann et al. (2013) that these 'motivation' debates risk being poorly theoretically grounded, failing to explore the constraints of perception-based data, instrumentally defaulting to arguing that academics engage exclusively to derive individual direct benefits.

Alongside practical problems in rigorously measuring motivation (*cf.* Perkmann et al. 2013), analyses of academics' preparedness to actively engage have avoided systematic argumentation, leaving 'motivation' a quasi-concept (in the sense of (McNeill, 2006)) assuming direct benefits motivate researchers. We argue that researchers' external engagement must 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 argue if academics are sensitive to external user needs through their research's different stages (the 'research cycle'), the more usable (or at least no less usable) will be their research for external users. We contend that researchers sensitive to external influences are more likely to generate findings usable[1] by external partners via what Spaapen and van Drooge (2011) call 'productive interaction'. This does not imply that each research project will be more directly usable, but if research builds on user knowledge then the resultant knowledge will be more easily absorbed at some point by users, and over time a science field will evolve towards being more usable by external users. Using an existing Spanish researcher survey (IMPACTO) we operationalise external influences[2] through the research cycle, identifying which factors are most salient in determining academics' propensity to include external influences in their research processes. Our study finds that *pace* the existing literature, two elements (academic identity and past experience) appear to determine 'openness' (to external stakeholder involvement).

2. The building block of scientific decision-making – the research cycle

Increasing interest in researcher engagement has paralleled a realisation that knowledge-creation processes are changing, and conceptual frameworks need to evolve away from linear models separating knowledge creation and exploitation (Geuna and Muscio, 2009). Innovation processes have interactive relationships with scientific production: usable knowledge for innovation emerges from research closely linked to users. New models of these processes include the '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 increasing

[1] We contend useful knowledge has to be usable; otherwise it would not 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 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).

responsiveness of academics to external stakeholders in setting research agendas (Hessels and Van Lente, 2008), responding to shifts in policy research 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). Despite this, final decisions regarding determining research questions – which projects to develop, methods to apply and collaborations to establish – remain reserved to individual researchers (Aghion et al., 2008; Gläser, 2012).

Individual research projects may react to external influences at various points in the research project. We conceptualise the key research transaction process as the 'research cycle', from the identification of the problematic to results dissemination. Academics more open to these external influences will therefore in aggregate create strong contextualized knowledge (Nowotny et al., 2001), scientific knowledge that overlaps to a greater degree with user interests, more amenable to productive user interactions and hence generating impact. We stylise a research cycle consisting of five sequential stages, which come together at the point in which existing research findings raise future questions. We term these five stages reframing, thinking (inspiration), planning, researching (executing), and disseminating.

For research to produce usable knowledge (to create societal impact via productive interactions), researchers will be open to incorporating external influences across the research cycle's stages. We seek to identify which factors influence academics' propensity to incorporate these external influences (for succinctness we label this 'openness') at each stage of the research cycle. 'Openness' is thus our dependent variable, enabling identifying researcher-specific factors (our independent variables) influencing whether research becomes usable. We seek evidence of 'openness' at each research cycle stage (explained in the following section; see Figure 1):

> (1) *the reframing stage*: one's past research agenda is the starting point for future research; researchers whose past research has been affected by external influences starts from a knowledge base of usable knowledge;
>
> (2) *the inspiration stage*: the researcher may be inspired by users or external issues to have a concrete idea for a future research project ;

(3) *the planning stage*: the researcher may design and produce a research project proposal including external knowledge, interests and needs as key research elements;

(4) *the execution stage*: the researcher could undertake a research by actually using external knowledge, making a research project dependent on unique knowledge held by external partners;

(5) *the societal dissemination stage*: the researcher could participate in value-added societal dissemination generating new insights or knowledge for future research orientations.

Figure 1: Conceptual framework of the research cycle incorporating external influences (openness)

Source: authors' own design.

2.1 Openness at the research framing stage

Research agenda skewness as a consequence of external influences has been a matter of concern in the literature on university-industry relationships (Lee, 1996; Nelson, 2001; Verspagen, 2006). Researchers commonly build research using both existing academic knowledge in literature alongside their previous knowledge base: research is path-dependent (Neff, 2014), characterised by its decision-impregnated (Knorr-Cetina, 1981), with future decisions structured by past decisions. Researchers whose past activities – their past knowledge base – incorporates external influences are therefore more likely to create research amenable to productive interactions. Thus, we argue that past research conducted with external partners lead to future research being more usable.

2.2 Openness at the inspiration stage

At the inspiration stage researchers' openness can be understood through the orientation of their scientific research. Stokes (1997) uses a two dimensional typology of researchers' *ex ante* orientations, towards scientific excellence and societal relevance respectively; researchers may be oriented towards fundamental understanding (Böhr quadrant), to considerations of use (Edison quadrant), to pursue both knowledge and utility purposes (Pasteur quadrant), or to gather and analyse data in ways neither immediately useful nor scientifically excellent (the Linnaeus[3] quadrant). An 'Edison' or 'Pasteur' research identity implies that research agendas are influenced by socio-economic considerations of use that may shape the whole research process construction towards a more usable kind of research.

2.3 Openness at the planning stage

The following step is operationalization in developing a research proposal: the extent to which external influences are incorporated in project plan activities affects how amenable final knowledge will be to productive interactions. Since the process of reflecting on creating impact in research planning sensitises researchers to potential opportunities (Hessels and Van Lente 2008: 742), what D'Este et al. (2013) defines as 'pro-social' research behaviour at this stage might create more usable knowledge.

2.4 Openness at the execution stage

The following stage is research execution: mobilising and allocating resources to prosecute activities delivering scientific results. Gläser identifies resource control as a common channels for influencing research content (Glasër 2012: 9), and much literature refers to all resources involved in research, including financial. Previous studies on engagement motivations identified knowledge resources as salient motivations for external engagement (Abreu et al., 2009; Baldini et al., 2007; D'Este and Perkmann, 2011; Lam, 2011; Lee, 2000; Zomer et al., 2010). We argue that involving external knowledge resources in project execution is a clear way of influencing research agendas. Therefore, involving external knowledge in project execution is associated with higher research usability.

[3] Following Alrøe and Kristensen (2002).

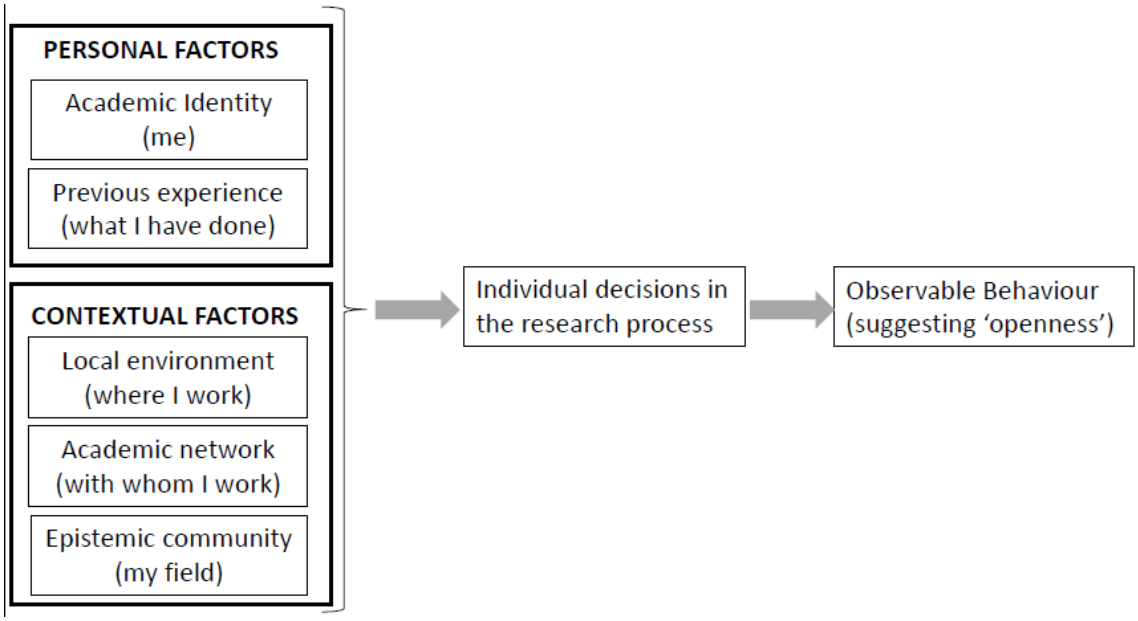
2.5 Openness at the dissemination stage

The last stage of the research cycle is dissemination, either to academia (e.g. via scientific journals) or to societal users (e.g. patenting, dissemination in the media, generation of clinical guidelines). Societal dissemination activities have been widely addressed in the literature (e.g. Jensen, 2011; Olmos-Peñuela et al., 2014). In the course of the research cycle, these activities might involve two-way interactions and dialogues between researchers and external actors (Martín-Sempere et al., 2008) exposing researchers to new knowledge and exploitation opportunities. Therefore, two-way flow knowledge in dissemination contributes to shape researchers' perceptions of their findings ('usability') thereby bringing external knowledge into their knowledge pool upon which future research will be built. Then, we could expect that participation in such added-value societal dissemination activities will be associated with higher research usability.

3. What makes researchers open to external influences?

We assume that many factors influence researchers' openness, with scientific decisions taken by partly-autonomous individual researchers (Gläser, 2012). Literature assumes individuals have simple motivations in taking those decisions (linked to their potential benefits). We argue that academics are influenced by the socialised institutional systems within which they are situated (Villanueva-Felez et al., 2013) at a variety of degree of externality to the researcher from the personal to the epistemic: researchers' openness is influenced by factors at these different levels (see Figure 2). Researchers have internal academic *identities*, formed during their education and academic formation (e.g. Ph.D). Following Knorr-Cetina (1981), their choice of questions is also affected by *previous research experiences*. Likewise, external factors play a role, including the *immediate operational environment* of the work-floor, a researcher's wider *personal academic contact network*, and the academic discipline as an *epistemic community*.

Figure 2: How individuals' research decisions are shaped by personal and contextual factors



Source: authors' own design.

3.1. Personal levels

Our first personal level is academic identity and the way academics set research questions and involve external interests (Jain et al., 2009; Lam, 2011). Scientist identity can be mapped along a continuum ranging from pure Mertonian scientist (Merton, 1973) emphasizing fundamental understanding, to pure post-academic science entrepreneur (Ziman, 1996), more accepting of and involved in external commercial and collaborative research activities. We contend that 'openness' is influenced by researchers' identity, and that *researchers' with an identity closer to the entrepreneurial ideal type are more likely to demonstrate 'openness' at the different stages of the research cycle* ***(Hypothesis 1).***

The second personal level is researchers' experiences and achievements. Researchers with past successful collaborations are *ceteris paribus* likely to again choose for engagement; scholars without previous collaborations with external agents have, in the absence of effective experiences, difficulties in assessing the potential cost or benefits from these collaborations (Audretsch et al., 2010). Conversely, researchers with personal previous entrepreneurial experiences acquire knowledge and skills that contribute to their aspiration and ability to participate in entrepreneurial activities (Hoye and Pries, 2009). As noted by Ajzen (2001) prior experiences may explain actual

intention and behaviour to perform an activity; for instance academic entrepreneurial intentions are predicted by academics' previous experience engaging in entrepreneurial activities (Goethner et al., 2012). On this basis, we expect that *researchers with a positive evaluation of past collaborative experience are more likely to demonstrate 'openness' at the different stages of the research cycle than researchers with negative or not past experiences. (**Hypothesis 2**).*

3.2. Contextual levels

A second set of levels are exogenous to the academic, formed by three distinctive kinds of research milieu. The first is the researcher's 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) show institutional norms' relevance, suggesting academic entrepreneurs conform to local norms (reflecting their academic institutions institutional practices and support measures) in their decisions regarding participating in entrepreneurial activities, rather to norms acquired during their academic formation. We therefore suggest that *researchers with a positive perception about institutional support for engaging with external agents are more likely to demonstrate 'openness' at the different stages of the research cycle (**Hypothesis 3**).*

The second contextual level is academics' scholarly networks: research is socially situated, and researcher´s behaviour depends on their immediate professional network's behavioural norms and practices (Fromhold-Eisebith et al., 2014; Kronenberg and Caniëls, 2014). A key issue is how far an academic's research can travel beyond the scholarly domain and usefully connect with other knowledge communities with other norms, values and meaning structures. This is indicated by connections to wider networks, both scholars from other institutes, sectors or countries, as well as scholars from other disciplines (*cf.* Shane, 2000; Venkataraman, 1997, cited in Bercovitz and Feldman, 2008). We thus suggest:

*Academic agents who are active in an research network that is more connected to external academic agents are more likely to demonstrate 'openness' at the different stages of the research cycle (**Hypothesis 4a**).*

*Academic agents who are active in an research network that is more connected to academic agents in other disciplines are more likely to demonstrate 'openness' at the different stages of the research cycle (**Hypothesis 4b**).*

Our final contextual level is the academic's wider disciplinary community (Becher and Trowler, 2001). An academic discipline co-ordinates scientific activities working as 'communities at a distance', enacted through formal/ informal institutions, including conferences, journals, learned societies, departmental and faculty structures. Individuals make judgements framed by disciplinary structures, and therefore academics' openness will be influenced by the extent to which 'openness' is a common norm within one's discipline (Deem and Lucas, 2007; Jacobson et al., 2004; Miller and Neff, 2013). We therefore suggest that *academic agents in disciplines where external agents are seen as being legitimate contributors towards the creation of valid knowledge are more likely to demonstrate 'openness' at the different stages of the research cycle (**Hypothesis 5**).*

3.3. Other factors

Alongside these situational factors, other factors which may also play a role (as control variables) in shaping researchers' openness. Previous studies support the idea of an older generation of researchers trained in the 'Ivory tower' (Sauermann and Stephan, 2013) with Mertonian norms that discourage external interactions (Bercovitz and Feldman, 2008; Tartari and Breschi, 2012). We include researchers' academic *position* in the lifecycle to control for researchers inclusion in a supposed 'Ivory tower generation' with a lower propensity to openness.

Secondly, researchers might be influenced by the direct benefits they acquire from external collaborations, 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).

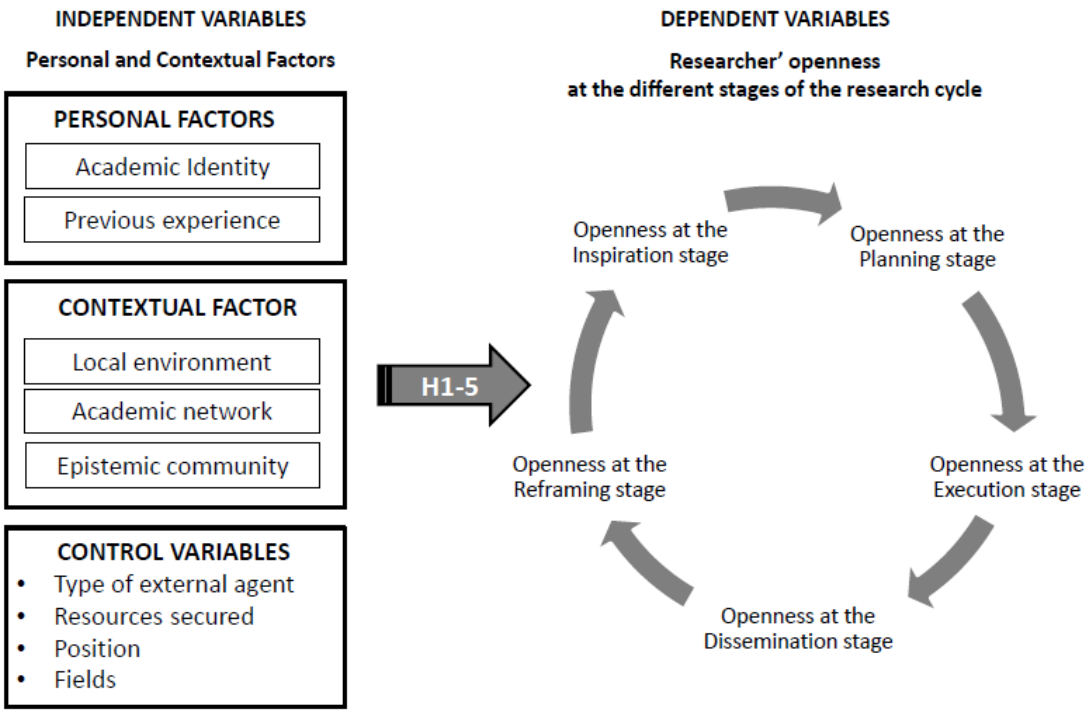
Thirdly, different kinds of external agents may be attractive to academic partners. Entrepreneurial science sees firms as more legitimate research partners than other kinds of societal partners (Berman, 2011). Academics more engaged with policy-makers may be more 'open' because policy research provides an interesting field laboratory (Krueger and Gibbs, 2010). Those working with non-profit organisations (NPOs) may

be ethically committed to those organisations' goals (Tinker and Gray, 2003). Thus, we control also for these kinds of external partner in the empirical analysis.

We add researcher disciplinary fields as a final control variable, since previous research suggesting that tensions between excellence and usefulness vary across fields (Hessels et al., 2011). Our baseline are differences between social science & humanities (SSH) and other fields (science, technology, engineering & mathematics, STEM) with prior research showing engagement patterns differ across SSH and STEM (Olmos-Peñuela et al., 2013), which suggests researchers' openness may vary across these fields.

Personal and contextual factors (and control variables) may affect researchers' openness at the research cycle's different stages (reframing, inspiration, planning, execution and dissemination) ultimately affecting the type of knowledge generated and its usability (see Figure 3). To better frame the testing process, we now explain our dataset, variable construction and analytical plan.

Figure 3 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 contracted and tenured researchers working at CSIC. The questionnaire[4] included a range of questions about researchers' profile (position, disciplinary field), their research characteristics (research orientation, operationalising research projects, researchers' task relevance), or their external engagement (motivations, frequency, type of external entities, results of the collaboration). 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 scientific categories. Our study population are CSIC's 4240 contracted and tenured researchers in 2011, distributed in 126 research institutes organised along eight main scientific fields. Our final sample is 1583 researchers (37% of total 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 8 areas of knowledge there are no differences in population and sample distribution (except for agricultural sciences, overrepresented in the sample).

[4] See Olmos-Peñuela et al. (2013) 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. (2013); (ffollowing 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 knowledge area.

* 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. We consider five dependent variables capturing 'openness' at the different stages of the research cycle.

The variable measuring *openness at the reframing stage* 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 *openness at the inspiration stage* 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 *openness at the planning stage* 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 *openness at the execution stage* is a continuous variable constructed from four items (Cronbach α = 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 both these multiple-item scale variables (openness at planning and execution stages) satisfy the unidimensional criterionity. 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 *openness at the dissemination stage* is a binary variable with a value '1' if the researcher reported as *important* or *very important* at least one added-value dissemination activity (obtaining patents or other intellectual property right; developing exhibitions and/or catalogues; generating clinical guidelines, standards, codes of practices), and '0' otherwise. 28.5% of the sample reported undertaking any of these activities.

Table 2: Operational definitions and descriptive statistics of the dependent variables: researchers' openness at the different stages of the research cycle [5]

Dependent variables (continuous)	Measure	Sub-items	Method and descriptive statistics
Openness at the planning stage	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**
Openness at the execution stage	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'
Openness at the reframing stage	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%**
Openness at the inspiration stage	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%**
Openness at the dissemination stage	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%**

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.

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*

[5] 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.

scientists (36.4%), *Scientific researchers* (27.2%) and *Research professors* (18.3%).[6] Following the CSIC classification, the sample is divided in 8 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 $\alpha = 0.668$) 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, satisfying the unidimensionality criterion; Cronbach α indicates that the 5 items in the index are reliable, and according to the Q-Q plot procedure, the variable matches with a normal distribution.

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

[6] 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).

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 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: [7]

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, where1 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%**

[7] 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.

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%**

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 path model allowing estimating simultaneously a number of regressions for explaining 'openness'. More specifically, testing our conceptual framework requires estimating five regression equations, one for each dependent variable associated with 'openness' at the research cycle's different stages. Due our dependent variables' nature, we use different kind of regressions: binary probit for our binary variables (openness at reframing, inspiration and dissemination stages), and ordinary least square for our continuous variables (openness at planning and execution stages). The path 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 path 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 path 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 path 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 path 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 path model with free error terms fixed at zero', the result of estimating the final unsaturated path 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 path 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 path model and the constrained unsaturated path model are reported in Table 4's lower section. The unsaturated path model has 36 degrees of freedom and an insignificant χ^2 statistic of 38.25 (p-value=0.368), indicating that the final unsaturated

path model has a very good fit. The R^2 estimates are presented in Table 4's lower section: 'openness' is most effectively explained at the execution stage. For the constrained unsaturated path model, the computed value of the χ^2 is significant (χ^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 'openness' at the different stages of the research cycle 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 path model with error-term covariances better reflects the data than the constrained unsaturated path model with error-term covariances fixed at zero.

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

Regarding factors affecting researchers' openness, we focus on independent variables systematically significantly associated with openness through the research cycle; we therefore do not further consider those variables significant at fewer than 3 stages, as they do not affect our putative 'openness' variable. Table 5 summarises only those results showing a significant relationship between the independent variables and researchers' openness.

We find 3 variables significantly related to openness over all 5 research cycle stages: *entrepreneurial ideal*, *knowledge accessed*, and collaborating with *firms*. This confirms our hypotheses that researchers with an identity closer to the entrepreneurial ideal (Hypothesis 1) and researchers with a positive evaluation of their past collaborative experience (Hypothesis 2) are more reactive to third party influences in their research. Likewise, collaborations with firms emerges as relevant related to researchers' openness, whereas collaborations with government agencies and NPO are occasionally

associated with openness but our results are insufficiently significant to regard them having a determining influence on openness.

Hypothesis 4b is partially verified since *multidisciplinary network* emerges as significant and positively associated with openness at three of the five stages, namely *inspiration (**), planning (***)* and *dissemination (**) stages*. Following hypothesis 4b, our results suggest that researchers habitually connected with other academic agents in other disciplines demonstrate more openness.

Our results do not support hypotheses 3, 4a and 5, as the variables related are not systematically significantly associated to openness. In some cases we found isolated significant relationships at some research cycle stages, but insufficiently consistently to suggest a relationship between these factors and openness.

Of the other control variables, *academic position* is not significantly associated with openness whereas *resources secured* shows non-conclusive results about its association with openness (with different directionality across the different stages of the research cycle). The variables related to *field* are largely inconclusive; results suggest a higher SSH researchers' openness compared to those in natural resources at three stages, but non-conclusive with agricultural sciences researchers since directionality changes across the three significant research cycle stages. For other fields, results were not sufficiently significant across research stages to claim an association between field and researchers' openness.

Table 4: Unsaturated multivariate path model results explaining 'openness' at the different stages of the research cycle

Dependent variables	Openness at the Reframing Stage		Openness at the Inspiration Stage		Openness at the Planning Stage		Openness at the Execution Stage		Openness at the Dissemination Stage	
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 path model with free error terms		χ^2 (36) = 38.25, *p-value* =0.368			
Constrained unsaturated path 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	Openness at the Reframing Stage	Openness at the Inspiration Stage	Openness at the Planning Stage	Openness at the Execution Stage	Openness at the Dissemination Stage
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. We seek to extend literatures addressing researchers' societal engagement motivations that have emphasised direct benefits that external engagement provides researchers, what Lam calls gold, puzzle and ribbons (Lam, 2011). As we find that our proxy for motivation (*resources secured*) was not universally significant across the stages, we contend that instrumental benefits are merely one component of those factors underlying engagement decisions. We thus concur with D'Este and Perkmann (2011) that understanding researchers' decisions to engage externally is a pressing question demanding further fundamental consideration. Our analysis also sought to improve our understanding on the ambivalent relationship (optimistic/ pessimistic views) between external engagement and research activities (Gulbrandsen and Smeby, 2005). Our start point is exploring researchers' willingness to let external partners affect their research at different research process stages (our variable 'openness') in ways that improves its capacity for uptake in productive interactions (its 'usability') (Spaapen and van Drooge, 2011).

We explore 'openness' as a characteristic visible through the research cycle, our individual 'research transaction' by which scientific knowledge is created and diffused. The extent to which each research cycle reacts to external stimuli affects how far research outcomes incorporate user knowledge, a precondition for its appropriation then exploitation by potential external users. We find 'openness' to be positively correlated across the stages, suggesting it has an underlying empirical coherence matching its conceptual coherence. We contend that 'openness' might be influenced by different elements of the various social structures within which researchers are embedded. Our results indicate that the most salient factors explaining openness relate to researchers' personal characteristics (i.e. academic identity, past experiences), and type of external agent with whom they collaborate (i.e. firms). These findings contrast with previous studies suggesting that institutional norms are more salient than personal norms (Bercovitz and Feldman, 2008).

Given our findings seem slightly at odds with some existing studies, and our own research is exploratory, clearly more research is needed. As our study analyses a single

institution (CSIC), then we cannot explore comparatively how CSIC's own characteristics influence researcher decisions. Thus, future research should consider comparing different (kinds of) institutions to analyse whether macro-level organisation policies affects openness. Our study does validate recent interest in motivation, underscoring a need for further research to explore how personal and contextual factors influence researchers' external engagement decisions, complementing Lam et al. (2011)'s work. But rather than assuming exclusively extrinsic rationales for engagement, our results suggest that researchers' identity and previous experiences also shape researchers' openness to external influences.

Finally, our message to policy makers (including universities themselves) is that incentive structures alone do not change behaviour: propensity to engage is formed over the course of an academic career – beginning with the Ph.D. and followed with later experiences in engagement. Policy-makers aim at promoting researchers' external engagement should not use exclusively short-run incentive and benefits measures. Fostering researchers' involvement in engagement to optimise societal impact is anchored in a more long-term process related to academic formation (when academic identity is shaped) and opportunities to engage with third parties (previous engagement practices). Therefore, ensuring positive opportunities for engagement experiences, and underscoring during academic formation that good research creates impact, are most important to stimulating scholars' openness and creating knowledge more useful for society.

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