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Academic artists' engagement and commercialisation

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Abstract: Academic artists are researchers who create artistic work. They form part of the cultural life of cities and contribute to welfare not only through research but also through art. They may commercialise their art or use it to engage in scientific knowledge diffusion. We seek to understand the relationship between art, academic commercialisation and engagement, and detect sociodemographic, organisational and institutional barriers to academic art. The resources needed to develop and diffuse art in addition to conducting research, may exclude women researchers and contribute to their marginalisation in science, and may be incompatible with a career focused on science quality or an organisational logic based on scientific prestige. We study the responses to a survey of some 7,000 Spanish academics and compare university researchers to other researchers. More than half of the researchers surveyed create artistic work; however, whereas engagement is the norm rather than the exception, commercialisation is rare. Being a woman researcher, working in a university and producing good quality science run counter to being an artist. Younger researchers are artists, but commercial rather than engaged. The detrimental effect of science quality on being a commercial or engaged artist turns positive after a certain threshold, which suggests polarisation among academic artists. Among commercial artists, this polarisation seems to apply specifically to university researchers. We discuss the implications for the valorisation of art across interaction channels and in research evaluations.

Keywords: Knowledge transfer · University-industry interaction · Public understanding of science

1. Introduction

Art improves our lives. It provides a means of catharsis, and contributes to pleasure, enjoyment and relief from 'will' (Belfiore and Bennett, 2008). In the classroom, it enhances students' chances of academic and social success (Lloyd, 2017). Visiting museums restores mental equilibrium (Packer, 2008). Reading fiction develops personality and helps our understanding of others (Djikic et al., 2009; Kidd and Castano, 2013). Music encourages us to dance and enter a trance-like state (Levitin et al., 2018). Artists form part of the city's creative class, which conditions firm location and local prosperity (Florida, 2019).

This creative class also includes academics (Florida, 2019). Industry and innovation hubs benefit from the buoyancy stemming from the ideas and thinking of artists and academics. Some individuals combine both identities: academic artists, researchers who produce scientific knowledge and create artistic work.

The presence of academic artists is pervasive over time, and across countries and organisation types. The archetypical academic artist is Leonardo Da Vinci (1452–1519), a polymath with knowledge in several art and science domains. Some of the most influential essayists in Western culture were scholars, for example, Robert Burton (1577-1640, Oxford University) and John Locke (1632-1704, The Royal Society). The Nobel Prize in Literature has been awarded to dramatists such as the civil engineer José Echegaray (1832-1916, Polytechnic University of Madrid), and Nobel prize winners in other categories, such as the neuroscientist Santiago Ramón y Cajal (1852-1934, University of Valencia and others), have written occasional biographies or short stories. The all-time best-selling novelists include the philologist J.R.R. Tolkien (1892-1973, Oxford University) and the

semiotician Umberto Eco (1932-2016, University of Bologna). The psychologist William Moulton Marston (1893-1947, working in private universities) created the comic book icon, Wonder Woman. The connection between Russian composers and academia is also well-known and includes the chemist Alexander Borodin (1833-1887, S.M. Kirov Military Medical Academy) and the civil engineer Victor Ewald (1860-1935, Saint-Petersburg State University). Similarly, mathematicians and computer scientists have relationships with sculpture and digital art; for example, Jacobus "Koos" Verhoeff (1927-2018, Delft University of Technology, Philips and Erasmus University Rotterdam), George W. Hart (1955, Stony Brook University), and Helaman Ferguson (1940, who worked in private firms). The philosopher, historian and physicist Peter Galison (1955, Stanford and Harvard Universities) is renowned for his documentary films and the citizen scientists, Thor Heyerdahl (1914-2002) and Wade Davis (1953), were outstanding anthropologists and essayists and documentarist and (in the latter case) photographers.[1]

Vindicating the importance of academic art in science and technology studies has practical implications. The history of scientific ideas stems from outstanding researchers who, also, were remarkable writers in their native languages, for example, Galileo, Poincaré, Einstein and Keynes (McCloskey, 1985). Good writing style and ability to 'fictionalise' are advantageous for making theoretical contributions and writing sections of project proposals and papers in social sciences (De Cock, 2000; Pick, 2016). Other artistic skills may be more appropriate for other domains, for example, performance for scientific comic monologues or scientific videos, filmmaking for visual ethnography, etc. Ignoring art in the scientific field entails risks such as underestimation of knowledge transfer in art and

[1] Many renowned artists have worked at universities, mainly to teach in their artistic speciality. However, our focus is on individuals whose main identity is as an academic. We also avoid examples of Art scholars; in this field, academic and artistic identities are more blurred and we are interested in use of art as an interaction channel in other fields.

humanities or burnout of artistically creative researchers whose organisations do not valorise their skills, which, ultimately, can lead to brain drain from academia to the artistic professions (Azagra-Caro et al., 2020). The cases of ethologist Diana Gabaldon (1952, ex Northern Arizona University), philologist María Dueñas (1964, ex University of Murcia) and Neuroscientist Mayim Bialik (1975, ex University of California) are such examples: the authors of the bestsellers *Outlander* and *The Time in Between* (both adapted for the screen), and one main character from the successful sitcom *The Big Bang Theory* left university to devote all of their time to writing/acting even though their competences would have benefited their universities.[2]

Our first objective is to provide more systematic analysis of the relationship between art and researchers. We focus on some sociodemographic, organisational and institutional characteristics that apply to academic entrepreneurs (a better-known type of researcher with a hybrid identity), such as gender, age, science quality and organisational logic (Sections 2.1 to 2.3), which may reveal barriers to academic art. The resources needed to develop and diffuse art in addition to conducting research, may exclude women and young researchers and contribute to their marginalisation in science, and may be incompatible with a career focused on science quality or an organisational logic based on scientific prestige.

Our second objective is to investigate what academic artists use art for: commercialisation or engagement (Perkmann et al., 2013). One of the differences between academic entrepreneurs and academic artists is that entrepreneurship is necessarily commercial, but art is not. Since the monetary incentives for public science underlie most concerns about

[2] The examples in the previous paragraph (artists who remain in academia) are all men, whereas the examples in this paragraph (artists who leave academia) are all women. This finding resulted from an unprejudiced search for cases and, although anecdotal, is evidence suggesting some discrimination against women academic artists.

academic entrepreneurship (see Section 2.4), we are interested in whether academics who commercialise their art conflict with the dynamics of open science. Conversely, academic engagement, another mode of university-industry interaction, is more compatible with open science (Perkmann et al., 2013). We investigate whether engagement, in the form of scientific diffusion through art, is similar or dissimilar to commercialisation.

2. Literature review

2.1 Women and young academic artists

The individual level is crucial for analysis of academic entrepreneurship. The individual characteristics of academic researchers, including sex and age, explain a larger number of entrepreneurial competences and behaviours than organisational or institutional characteristics (Rasmussen and Wright, 2015; Hossinger et al., 2020). Characterising who academic artists are requires attention to some individual features.

We start with sex. The uneasy situation of women in academia is a problem that has been described as the 'Matthew Matilda effect' (Rossiter, 1993), which may influence academic art. Women academics face barriers that can affect their opportunities to develop their artistic interests. Based on the biased views related to women academics' entrepreneurship, there are likely to be similar predispositions against women in relation to academic art. Following Fältholm et al. (2010):

- texts and images of academic entrepreneurs contain gender stereotypes; advertisements for courses in entrepreneurship generally feature pictures of men;
- the field of engineering is culturally male and stereotypically masculine; women academics find it difficult to prove their teaching and research worth and find it

even more difficult to demonstrate their entrepreneurial qualities, which increases their work burden;

- in areas, such as social sciences and humanities, women integrate entrepreneurship discourse, but in relation to being collaborative or introducing innovative teaching methods, which male academics do not consider to be entrepreneurial activities and consider women as stuck in their 'entrepreneurial ghettos'.

Women academic artists may be confronted with visual information favouring male academic artists and experience disproportionate work burdens in masculinised fields, such as engineering, and different rhetoric about what art is in social sciences and humanities. In addition, women academics bear most of the burden of family obligations (Poggesi et al., 2020). Also, male scientists generally occupy more prominent positions than women and are better placed to mobilise resources and establish entrepreneurship (and possibly art) networks (Perkmann et al., 2013; Villanueva-Félez et al., 2015; Poggesi et al., 2020). The comparatively lower positions in academia occupied by women compared to men, force women to focus firmly on their academic career (Poggesi et al., 2020).

The evidence shows that female researchers are less likely than male researchers to participate in certain entrepreneurial activities, specifically patenting and applying for company funding, but not consulting (Haeussler and Colyvas, 2011). In the case of patenting, the major difference is in the number of inventions disclosed, but not in terms of patent licensing (Colyvas et al., 2012). In the relation to academic engagement, women generally interact less than men and, particularly, in interactions that require more time and resources, such as joint contract research (the differences are less for attendance at university-industry conferences, which require less intensive interaction and are less important for research) (Tartari and Salter, 2015). This lower level of interaction is despite

the fact that women researchers obtain more non-redundant knowledge than men through their collaborations (Díaz-Faes et al., 2020). Thus, the evidence largely supports the idea of the marginalisation of women in academic interactions with third parties; therefore, we can expect a similar effect on academic art.

Research Question 1. Are women researchers less likely to be artists than men researchers?

We next discuss the role of age. Age equates with experience. Older researchers acquire the ability to diversify their tasks at lower cost (Haeussler and Colyvas, 2011; Bozeman et al., 2013). They have had more time to build their larger networks and to gain wider access to resources, which increases their opportunities to express self and escape convention. These factors may give older aged researchers more possibilities to become academic artists.

However, age has a generational component. Given that societal pressure for academic researchers to commercialise and diffuse their scientific results is relatively recent, young researchers may be more focused on this (Bercovitz and Feldman, 2008). Since an artistic logic demands a different type of rigour and precision compared to a science logic, older researchers may be ideologically opposed to the idea (Ashraf et al., 2018; Azagra-Caro et al., 2020) or may simply lack the energy and incentive to abandon a stable position (Giulani et al., 2010). Business initiatives to foster art-science collaborations, for example, through artist-in-residence programmes, are increasing but not well-established, in part, because of their dubious results (Sandberg, 2020). However, younger researchers may be more willing to experiment while incipient new research methods and practices that mix an artistic and a research identity (e.g., visual ethnography, academic screenwriting) may be more intense among young scholars like (Rakic and Chambers, 2009; Batty and McAulay, 2020). It is

possible, also, that disoriented young researchers may believe, erroneously, that they can do science and art at the same time because they have failed to understand the exigencies related to excellence in both areas. All these reasons might explain young researchers' greater keenness to become academic artists.

An equivalent opposing set of reasons, may explain why researcher age has an ambiguous relationship with university-industry engagement and commercialisation (Perkmann et al., 2013; Hmieleski and Powell, 2018). Some studies find a null association between age and interactions (D'Este et al., 2019; Weerasinghe and Dedunu, 2020). Moderating effects show a negative impact of age on the relationship between university-industry motivations and performance (Huang et al., 2019).

Because diffusion of scientific results through art is an unconventional and less well established idea (it is not included in list of commercialisation mechanisms and channels), our initial assumption is that the reasons for a positive relationship between younger age and being an academic artist will prevail.

Research Question 2. Are older researchers less likely to be academic artists?

2.2. Science quality of academic artists

Academic researchers have given amounts of time and resources to enable their teaching and research outputs. Commercialisation of their research and interactions with companies reduces the resources available for their main tasks and endangers their provision and/or quality. It is possible, also, that the research that is conducted for firms is less cutting-edge as purely academic research; firms prioritise science aimed at short-term, tangible goals whereas academia focuses on longer term value. These arguments would suggest a negative relationship between scientific quality and university-industry interaction. There

is some evidence supporting a negative relationship between scientific quality and academic entrepreneurship, for example, spin-off creation (Buenstorf, 2009; Toole and Czarnitzki, 2010), and interaction channels such as consulting (Fudickar et al., 2018) or industry funding (Hottenrott and Thorwarth, 2011) and, especially, if combined with public funding (Hottenrott and Lawson, 2017).

Other arguments suggest the opposite. Resources increase following contracts and other endeavours with stakeholders. This may compensate for the extra burden of these additional tasks and boost the quality of the academic's scientific output due to these extra resources. Academic researchers are likely to be selective about the firms they choose to interact with and work only with those requiring good quality science. For all these reasons, we expect a positive relationship between scientific quality and university-industry interaction. There is evidence supporting a positive relationship between scientific quality and academic patenting (Azoulay et al., 2009; Martínez et al., 2013; Fischer et al., 2018; Acosta et al., 2019), patent licensing (Buenstorf, 2009) and spin-off creation (Fischer et al., 2018).

There might be non-linearities in these relationships that explain both directions of causality. We can suggest reasons for inverted U-shaped and U-shaped non-linearity.

Collaboration with industry may be detrimental to academics' science quality only after a certain threshold, which means we would first see a positive relationship and then a negative one, that is, a curvilinear relationship inverted U-shaped relation. To our knowledge, there are no direct tests of this link, but there are some indirect tests based on the negative effect of industry funding on the amount of scientific production (Manjarrés-Henríquez et al., 2008; Banal-Estanol et al., 2015): if we assume that a smaller publications output implies lack of good ideas (Banal-Estanol et al., 2015), then scientific production equates with scientific quality. At the university level, there is indirect evidence related to

the *efficiency* of third mission funding and non-linear effects on science quality, with an inverted U-shaped relation only for older universities, not newer ones and not for the whole sample (Degl'Innocenti et al., 2019).

In contrast, we could also expect a negative relationship up to a certain threshold after which the interaction will involve good quality science, that is, we expect a curvilinear U-shaped relationship. There is a need for some training in order to benefit from interaction and that, having established a reputation, the academic researchers might overcome their peers' usual dislike for commercialisation (Haeussler and Colyvas, 2011) and plan collaborations that will add to or sustain their scientific quality (Schaeffer et al., 2020). It has been suggested that star scientists benefit from complementary resources that are not available to ordinary researchers. These include a citation premium from interorganisational coauthorship (Zucker and Darby, 1996) and greater involvement in knowledge transfer activities (Olmos-Peñuela et al., 2014; Giones et al., 2020). There is evidence showing that long-term university-industry relationships lead to papers with higher scientific impact (Garcia et al., 2020) and that for established researchers (senior, male, with more resources and larger stocks of publications) 'science and commerce go hand in hand' (Haeussler and Colyvas, 2011: 50).

We expect that being an academic artist will show a U-shaped relationship with scientific quality, that is, an initial negative relationship which turns positive after a certain threshold.

In the case of the initial negative relationship, some academics develop art as a hobby and, presumably, in their spare time, and the activity has little relationship with their scientific quality. However, if they devote some part of their worktime to this hobby activity this could have negative consequences on their scientific quality. Academics working in non-artistic disciplines may develop art as part of an individual and societal motivation to interact with the public, for example, by writing books aimed at non-specialist audiences.

However, this, again, leads to deprivation of the resources for research, which will have a negative effect on scientific quality. Finally, academics in artistic disciplines may find it easier to combine scientific quality and art, since art is their research domain, and feedback between both activities is more natural; however, this does not imply a positive relationship, just a lack of interference. We would expect to find no relationship between art and scientific quality in this context.

At some point, scientific quality can be beneficial for artistic creation. High quality researchers may have more to say about and have the ability to produce art without much extra effort. Their facility for scientifically impactful ideas likely allows them to be more creative artistically. It may be the case that prestige attracts research collaborators and that the star scientist is required to make minimum input which leaves room for the art. This is another dimension of the Matthew effect in scientific credit and recognition (Merton, 1968), academic entrepreneurship (Van Looy et al., 2004), science funding (Ranga et al., 2016; Bol et al., 2018) and funding of university-industry interaction (Azagra-Caro et al., 2010).

Research Question 3. Is scientific quality positively or negatively, linearly on non-linearly, related to being an artist?

2.3. Academic artists and organisational logic

Researchers work in different types of organisations: universities, research institutes, health facilities, firms, foundations, etc. University researchers are the most numerous and have distinctive characteristics: in universities, teaching and entrepreneurship are respectively more and less institutionalised than in the other organisations. The organisations most similar to universities are public research organisations (e.g., the

French CNRS, the Italian CNR, the Spanish CSIC, the German Max Planck Society, etc.), because promotion based on scientific research quality is also the norm compared to other types of organisations. However, research organisations typically work on applied research, enjoy larger shares of industry funding and have a shorter-term orientation (Gulbrandsen and Smeby, 2005; Edler et al., 2011). The evidence shows that university researchers are less likely than public research organisation researchers to participate in entrepreneurial activities such as consulting, patenting and applying for company funding (Haeussler and Colyvas, 2011). In the medical field, university researchers compared to non-university researchers, perceive research for industry as conflicting with societal impact (Azagra-Caro and Llopis, 2018).

Similarly, we expect that university researchers will find it more difficult than researchers in other organisations to become artists. University researchers have to compete with non-university researchers, often in inferior conditions, similar to the competition between university and non-university entrepreneurs (Ayoub et al. 2016). University scientists may have to suffer worse conditions than non-university researchers because, under a university logic, art is not highly valued in evaluation of merit, and peers may interpret engagement in artistic activities as frivolous. In other words, art could reduce the university researcher's reputation with non-artistic university peers given that, for the former, merit is based on publication in top journals. Production of art could be seen as a waste of time. Within a non-university logic, a piece of art may be an acceptable way to demonstrate research competence and third parties who are not academics, may consider it a complementary asset. These societal actors may attach more importance to art since most do not read many scientific articles. This would explain why university researchers might confine their art to their spare time, whereas for non-university researchers it may be part of their profession (Azagra-Caro et al., 2020).

Research Question 4. Are university researchers less likely to be artists than non-university researchers?

We have theorised that researchers keen to build a reputation for good quality science will tend to avoid artistic activities. University science faculty will especially avoid art since scientific reputation is more important for them than for non-university researchers who may be more interested in financial gain and problem-solving (Lam, 2011). The pressure to publish can increase to the point of dereliction of other duties, working excessive hours and performing research in order not to be punished by omnipresent evaluators (Gonzales et al., 2014). However, we have indicated, also, that prestige may make room for art if the researcher has sufficient resources. Specifically, university researchers may experience this because reputation gains exacerbate differences among individuals (Kwiek, 2019). For instance, reputation among university researchers leads to tenure, which has no equivalent in other research professions (Bozeman and Gaughan, 2011). Among university researchers, reputation and, especially, professorships allow faculty to become principal investigators on research projects and to supervise more PhD students. In academia, multiple co-principal investigator projects typically include a prestigious senior academic to support the junior PI who leads the funding proposal.

Research Question 5. Are university researchers less likely to be artists than non-university researchers because of the pressure for scientific quality?

2.4. Academic artists' commercialisation and engagement

Academic researchers may confine their possible artistic activities to their private sphere. In the case that they reveal them to a wider audience, this might be in order to compete for a monetary prize, to compensate their effort or to signal that the work is valuable. In

addition to creating the artistic piece, this commercialisation attempt, similar to other market activity, requires extra resources. It involves more work and/or more overtime working which detract from traditional academic duties and may be stigmatising vis-à-vis peers. Therefore, art commercialisation indicates *depth* of commitment to art (in the sense of Laursen and Salter, 2006), the same as creativity research considers commercialisation as a sign of commitment to art (Carson et al., 2005). This depth will make that sociodemographic, organisational and institutional barriers to be an academic artist are also barriers to be a commercial academic artist.

Another argument along these lines is that academic commercialisation is less compatible than academic engagement with research (Perkmann et al., 2013). If we accept the analogy between art commercialisation and academic commercialisation, that is, that both pursue control over the diffusion of results, seek monetary reward and obey extrinsic motivations, it is likely, also, that forces against becoming an academic artist and a commercial academic artist coincide.

Research Question 6. Do the antecedents of being an academic artist in general and being a commercial academic artist coincide?

Academic artists face another disjuncture. They may use art to express concepts unrelated to their academic research; they may feel each serves a different purpose or that art provides an escape from day-to-day routine (Azagra-Caro et al., 2020). However, artists draw on experience and, if this experience is based on their research, scientific knowledge will spontaneously permeate their creative work. Some researchers may use art deliberately to diffuse science, because they consider it part of their mission. Moreover, original artistic work may require research, so the research related to their scientific

objectives becomes a mining activity which facilitates art, similar to the idea of basic research constituting a mining activity to facilitate applied research (David et al., 1994).

These reasons suggest that engagement in academic art is aimed more at research, compared to commercialisation. If so, it might be that the antecedents to becoming an academic artist or a commercial academic artist are the reverse of those required to become an engaged academic artist. However, our commercial academic artist argument applies also to an engaged academic artist: diffusing science through art requires additional effort to create the artistic work while carrying out research duties and accumulating recognition and prestige. Academic artists' engagement is another sign of *depth* of the commitment to art and be determined by the same forces as being an academic artist or a commercial academic artist. Thus, we face opposing set of reasons in determining whether engaged academic artists behave like commercial academic artists or not.

Research Question 7. Do the antecedents of being an academic artist in general and being an engaged academic artist differ or coincide?

3. Data and methods

3.1. Data

The study population is Spanish researchers, defined as authors of scientific publications, affiliated to a Spanish organization and taken from the corresponding authors on publications in the Web of Science (WoS) listings from 2013 to 2016. Our choice of corresponding author was practical one; it allowed us to obtain e-mail addresses to enable an online survey. In addition, the corresponding author is usually one of the lead authors

and lead contributors to the content of the manuscript (Mattsson et al., 2011) or is perceived as so (Bhandari et al., 2014). Editors appoint corresponding authors as reviewers (Weiss, 2012) and they are considered reliable sources of knowledge about the publication and the underlying research (Wren et al., 2006). Thus, corresponding authors match our concept of academic researcher, that is, academic regardless of organisation type, and the idea of researchers who identify as academic rather than artistic.

We gathered some 65,000 valid e-mails. To launch the survey, we obtained ethical certificates from our two mother organisations, CSIC and UPV. We ran a first pilot in July 2017, a second pilot in April 2018 and the definitive survey was administered between July and November 2018. We received over 7,300 responses, that is, a response rate of 11%. The final sample excludes outliers.

Our first dependent variable is *academic artist*, which is a dummy equal to 1 if the researcher has created some artistic work in at least one art field. The survey included a Short Creativity Achievement Questionnaire (SCAQ: see Appendix, Table A1), adapted from Carson et al. (2005). Respondents chose those art fields they had practised, and our measure shows whether they indicated a minimum of one. Fig. 1 shows that 58% of the researchers are academic artists.

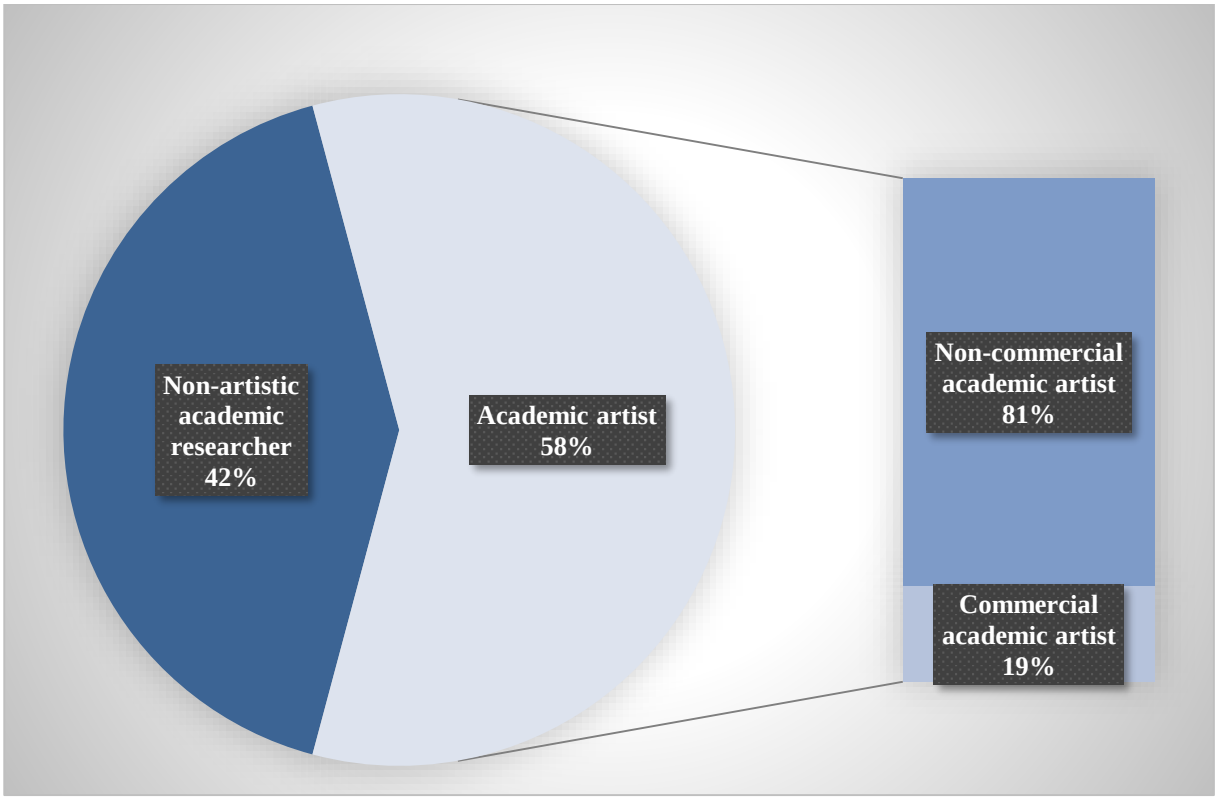

Fig. 1. Distribution of academic artists (n=7,324)

Our second dependent variable is *commercial academic artist*, equal to 1 if the academic artist was paid to create the work or he/she exploited it in the market. Fig. 1 shows that commercialisation is relatively infrequent: 11% of all researchers (19% of academic artists) are commercial artists.

Our third dependent variable is *engaged academic artist*, which is equal to 1 if the academic artist diffuses knowledge through art. The survey used the 12-item Science Through Art Questionnaire (STAQ, see Appendix Table A2), based on the case study in Azagra-Caro et al. (2020). It includes items on direct knowledge diffusion (degree to which the researcher uses art for diffusing scientific knowledge), indirect knowledge diffusion (degree to which the researcher-artist diffuses scientific knowledge by word-of-mouth with art business people, other artists and the public, i.e. the cultural world) and reverse knowledge diffusion (degree to which the researcher gets ideas from art business people,

other artists and the public for future scientific production). Reliability was high with a Cronbach's alpha of .88. We calculated the mean of the 12 items, which ranged between 1 and 5, and transformed it into a binary variable, equal to 1 if the average was equal or higher than 1.5.

We have responses from the full sample on *academic artists* and *commercial academic artists*. However, the questionnaire about *engaged academic artists* was administered to a subsample of *respondent* academic artists who agreed to answer this second part of the survey: over 2,500 responses, that is, 59% of the total number of academic artists. We checked for variation in the characteristics of the academic artist who responded to the second part of the survey with those who did not and found no major variation. Fig. 2 shows that 55% of academic artists engaged in scientific diffusion through art.

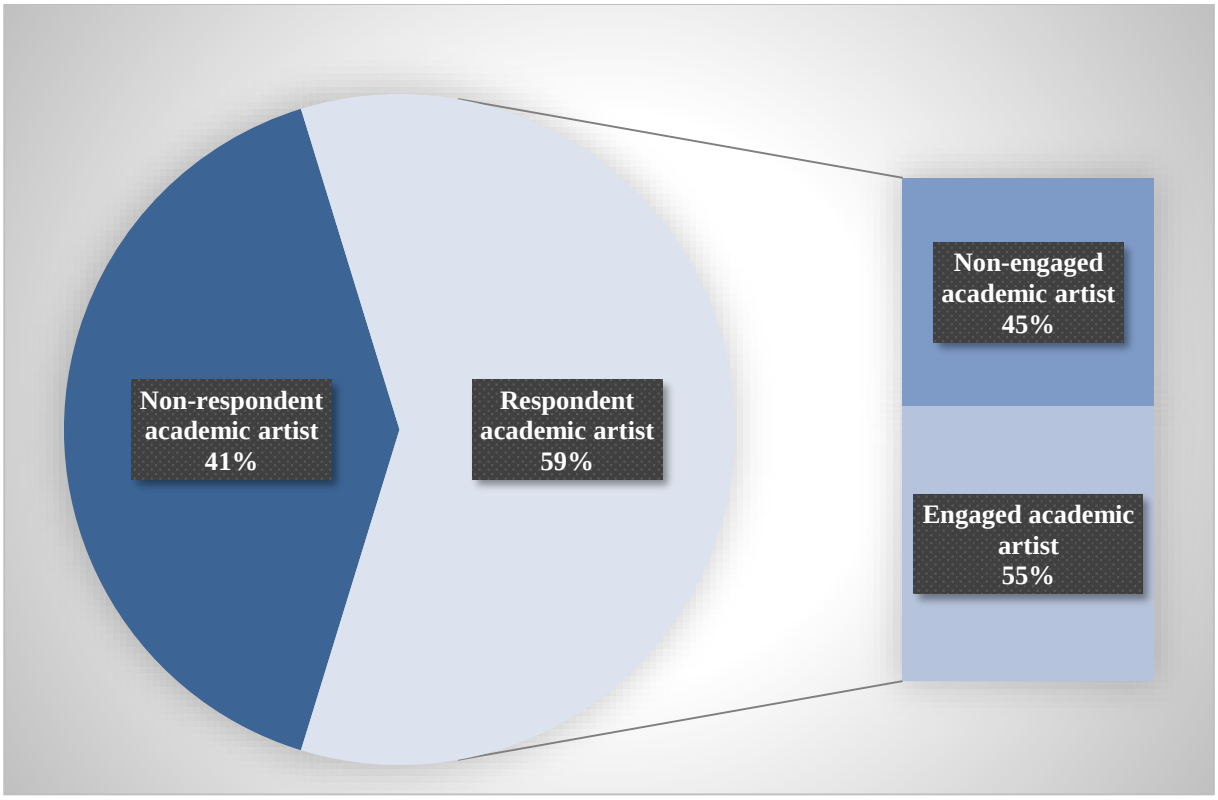

Fig. 2. Distribution of respondent academic artists (n=4,288)

Among our independent variables, the first two are *woman researcher*, equal to 1 if the researcher is a woman, 0 if not,[3] which addresses Research Question 1, and *age*, which addresses Research Question 2;. 43% of the researchers were women with a mean age of 47 years.

The third independent variable, *science quality*, which addresses Research Question 3, is more complex. We measured it as Field Normalized Citation Score (FNCS). In a first step, for each paper, we divide the number of forward citations (2-year window: publication year and the following two years) by the average number of forward citations received by all Spanish papers in that thematic category and that year. For example, a paper published in 2016 received one citation in 2016, 2017 and 2018; this paper belongs to two categories: 'Mathematics, Applied' and 'Mathematics'; all Spanish papers published in 2016 in those two categories received, respectively, an average of 1.25 and 0.97; the FNCS would be ((1/1.25) + (1/0.97))/ 2 = 0.91. In a second step, we grouped all the papers for every corresponding author and averaged the FNCS. Finally, because the distribution was unbalanced, we transformed it into quartiles, so the final variable ranges between 1 and 4.

We included science quality squared, to account for non-linearities in the effects of science quality.

The final independent variable is *university researcher*, which equals 1 if the respondent works at a university and 0 otherwise, and addresses Research Question 4; 55% of the researchers worked at a university.

[3] The questionnaire included intersexual as an option, but only 0.1% of respondents chose it and differentiating it in the regressions did not yield any insights. It is now subsumed in *man*, the reference category.

The interactions between *university researcher* and *science quality* allows us to address Research Question 5, based on their effects on *academic artist*.

We use the effect of the independent and interaction variables on *commercial academic artist* and *engaged academic artist* to address Research Questions 6 and 7.

For the full sample of researchers, we control for a wide range of institutional (science field, country and region of residence), sociodemographic (nationality, language, education, civil status, number of children), occupational (employment situation and type) and organisational (number of organisations, ownership regime, directive positions) variables. Table 1 presents the descriptive statistics.

Table 1. Academic researchers: Descriptive statistics of variables

Sample	Variable role	Level	Variable name	Description/Explanation	Mean	Std. Dev.	Min.	Max.
Full sample (n=7,324)	Dependent variables	Individual	Academic artist	A researcher who publishes in academic journals and creates artistic work	0.58	0.49	0.00	1.00
			Commercial	An academic artist whose creative work is paid or commercially exploited	0.11	0.31	0.00	1.00
			Engaged *	An academic artist whose creative work diffuses scientific knowledge or is a source of scientific ideas	0.54	0.50	0.00	1.00
	Independent variables		Woman researcher (RQ1)	Sex of the researcher	0.43	0.49	0.00	1.00
			Age (RQ2)	Number of years	46.76	10.24	18.00	97.00
			Science quality (RQ3)	Average Field Normalized Citation Score of the researcher's publications, grouped in 4 quartiles	2.50	1.12	1.00	4.00
			Science quality squared (RQ3)		7.50	5.68	1.00	16.00
			University researcher (RQ4)	At least one university affiliation	0.55	0.50	0.00	1.00
	Control variables	Institutional	Multidisciplinarity	Number of science fields	1.28	0.45	1.00	2.00
			Science field	Medicine	0.22	0.40	0.00	1.00
				Life Sciences	0.13	0.31	0.00	1.00
				Other Natural Sciences	0.21	0.38	0.00	1.00
				Engineering	0.12	0.30	0.00	1.00
				Art and Literature (Social Sciences and Humanities is the benchmark)	0.03	0.16	0.00	1.00
			Region of residence	Madrid	0.22	0.42	0.00	1.00
				Barcelona	0.10	0.31	0.00	1.00
				Valencia ('other Spanish regions' is the benchmark)	0.08	0.28	0.00	1.00
			Foreign residence	Non-Spanish residence	0.06	0.24	0.00	1.00
		Sociodemographic	Foreign nationality	'Spanish only' is the benchmark	0.08	0.28	0.00	1.00
			Non-Spanish first language	'Spanish only' is the benchmark	0.23	0.42	0.00	1.00
			PhD	PhD title	0.89	0.31	0.00	1.00
			Married or domestic partner	'Couple or single' is the benchmark)	0.64	0.48	0.00	1.00
			Number of children under age	Father/motherhood	0.79	0.99	0.00	5.00
		Professional	Employed	Yes/no (unemployed)	0.96	0.19	0.00	1.00
Employed (n=7,064)			Working for others or for others and self	'Working for self only' is the benchmark)	0.98	0.26	0.00	1.00
Working for others or for others and self (n=6,908)		Organisational	Number of organisations	Multiple affiliation	1.20	0.50	1.00	5.00
			Directive position	Yes/no	0.28	0.43	0.00	1.00
			Public organisation	Yes/no	0.84	0.34	0.00	1.00

* n=2,543

However, not all variables apply to all types of respondents: only employed researchers can have an occupational status, and only those working for others can have organisational characteristics. This defines different subsamples and we discuss them all in the results.

4. Results

4.1. Academic artists

Table 2 presents the results for estimating the probability of being an academic artist. Columns 1-3 progressively include more control variables depending on the subsample. Women researchers and older researchers are less likely to be artists. Science quality conflicts with being an artist, without non-linearities. University researchers are less likely than other researchers to be artists. Column 4 includes the interaction terms between university researchers and the other dependent variables. None is significant.

Among control variables, in the case of the multidisciplinarity, Art and Literature, living in the national capital, living abroad, being young, not having Spanish as a first language, working in several organisations and holding a directive position are all beneficial conditions for being an artist. However, being married, having several children and working for an employer (i.e., not being self-employed) are unfavourable to being an artist. Public or private ownership of the organisation is not important.

Table 2. Probit regression of academic artist

	1 Full sample	2 Employed	3 Working for others	4 With moderations
Woman researcher (RQ1)	-0.17***	-0.16***	-0.15***	-0.15***
	(0.03)	(0.03)	(0.03)	(0.03)
Age (RQ2)	-0.01***	-0.01***	-0.01***	-0.01***
	(0.00)	(0.00)	(0.00)	(0.00)
Science quality (RQ3)	-0.03**	-0.03**	-0.03**	-0.03**
	(0.01)	(0.01)	(0.01)	(0.01)
Science quality squared (RQ3)	0.01	0.00	0.00	0.00
	(0.02)	(0.02)	(0.02)	(0.02)
University researcher (RQ4)	-0.09***	-0.07**	-0.08**	-0.13**
	(0.03)	(0.03)	(0.04)	(0.05)
Uni. res. * Science quality (RQ5)				-0.01
				(0.03)
Uni. res. * Science quality sq. (RQ5)				0.04
				(0.03)
Multidisciplinarity	0.11***	0.11***	0.10***	0.10***
	(0.04)	(0.04)	(0.04)	(0.04)
Medicine	-0.17***	-0.17***	-0.18***	-0.18***
	(0.05)	(0.06)	(0.06)	(0.06)
Life Sciences	0.03	0.03	0.04	0.05
	(0.06)	(0.06)	(0.06)	(0.06)
Other Natural Sciences	-0.22***	-0.22***	-0.18***	-0.18***
	(0.05)	(0.05)	(0.06)	(0.06)
Engineering	-0.23***	-0.22***	-0.20***	-0.20***
	(0.06)	(0.06)	(0.06)	(0.06)
Art and Literature	0.32***	0.32***	0.33***	0.31***
	(0.11)	(0.11)	(0.11)	(0.11)
Madrid	0.12***	0.14***	0.13***	0.13***
	(0.04)	(0.04)	(0.04)	(0.04)
Barcelona	-0.00	0.01	-0.01	-0.01
	(0.05)	(0.05)	(0.05)	(0.05)
Valencia	-0.03	-0.03	-0.03	-0.03
	(0.06)	(0.06)	(0.06)	(0.06)
Foreign residence	0.21***	0.23***	0.24***	0.24***
	(0.07)	(0.07)	(0.07)	(0.07)
Foreign nationality	0.10	0.07	0.08	0.07
	(0.06)	(0.06)	(0.06)	(0.06)
Non-Spanish first language	0.09**	0.10**	0.09**	0.09**
	(0.04)	(0.04)	(0.04)	(0.04)
PhD	-0.06	-0.07	-0.09*	-0.10*
	(0.05)	(0.06)	(0.06)	(0.06)
Married or Domestic Partner	-0.07*	-0.07*	-0.07*	-0.07*
	(0.04)	(0.04)	(0.04)	(0.04)
Number of children under age	-0.04**	-0.04**	-0.04**	-0.04**
	(0.02)	(0.02)	(0.02)	(0.02)
Employed	-0.14			
	(0.09)			
Working for others only		-0.23**		
		(0.11)		
Number of organisations			0.14***	0.14***
			(0.03)	(0.03)
Directive position			0.09**	0.09**
			(0.04)	(0.04)
Public organisation			-0.07	-0.07
			(0.05)	(0.05)
Constant	0.80***	0.89***	0.55***	0.55***
	(0.14)	(0.16)	(0.13)	(0.13)
Observations	7324	7064	6908	6908
χ^2	210	190	200	203
p	0.00	0.00	0.00	0.00

* p<0.10, ** p<0.05, *** p<0.01. Robust standard errors in brackets. No multicollineartiy according to VIF. Main effects of variables with interaction terms are centered.

4.2. Comercial academic artists

Table 3 reports the difference between commercial and not commercial academic artists. We could have modelled this on the full sample, but this might have caused biased estimations if commercial academic artists were not representative of all academic researchers. Instead, we considered, first, that researchers choose to be artists or not (Step 1), and then to be commercial or not (Step 2). The first decision was modelled in section 4.1 (probability of being an academic artist). Here, we present the results for the second decision based on a Heckman selection model. A Wald test indicates that the two decisions are not independent, therefore, accounting for sample selection bias is appropriate.

Women and older researchers are less likely to be commercial academic artists. Science quality is at odds with art commercialisation, and has a linear effect. Working at a university also has a negative effect on being a commercial artist, but when the interaction terms are included, it has a strong impact. Sample selection bias means that these effects are net of the similar effects of these variables on the probability of being an academic artist. Hence, we can interpret them as *additive*, that is, the detrimental effects of being a woman, science quality and university work on academic art are more pronounced for commercial than non-commercial academic artists.

The negative linear interaction of science quality on art commercialisation is no different for university and non-university researchers, but there is a positive curvilinear effect of science quality. Hence, art commercialisation has a positive relationship with science quality after a certain threshold, but only for university researchers, not other researchers. This is the most specific characteristic of university researchers confirmed so far.

Table 3. Probit model with sample selection of commercial academic artist (RQ6)

	1 Full sample	2 Employed	3 Working for others	4 With moderations
Woman researcher	-0.18***	-0.19***	-0.19***	-0.19***
	(0.04)	(0.04)	(0.04)	(0.04)
Age	-0.01***	-0.01***	-0.01**	-0.01**
	(0.00)	(0.00)	(0.00)	(0.00)
Science quality	-0.08***	-0.08***	-0.07***	-0.07***
	(0.02)	(0.02)	(0.02)	(0.02)
Science quality squared	0.03	0.03	0.03	0.03
	(0.02)	(0.02)	(0.02)	(0.02)
University researcher	-0.08*	-0.02	-0.01	-0.17**
	(0.05)	(0.05)	(0.05)	(0.07)
Uni. res. * Science quality				-0.03
				(0.04)
Uni. res. * Science quality sq.				0.12***
				(0.04)
Multidisciplinarity	0.06	0.07	0.06	0.06
	(0.05)	(0.05)	(0.05)	(0.05)
Medicine	-0.49***	-0.47***	-0.47***	-0.46***
	(0.07)	(0.07)	(0.08)	(0.08)
Life Sciences	-0.25***	-0.24***	-0.23***	-0.22***
	(0.08)	(0.08)	(0.08)	(0.08)
Other Natural Sciences	-0.31***	-0.28***	-0.23***	-0.22***
	(0.07)	(0.07)	(0.07)	(0.07)
Engineering	-0.28***	-0.25***	-0.23***	-0.21**
	(0.08)	(0.08)	(0.08)	(0.08)
Art and Literature	0.38***	0.38***	0.42***	0.39***
	(0.11)	(0.11)	(0.12)	(0.12)
Madrid	0.20***	0.21***	0.20***	0.19***
	(0.05)	(0.05)	(0.05)	(0.05)
Barcelona	-0.01	0.02	-0.02	-0.03
	(0.07)	(0.07)	(0.07)	(0.07)
Valencia	0.05	0.06	0.08	0.08
	(0.07)	(0.07)	(0.08)	(0.08)
Foreign residence	0.08	0.07	0.06	0.07
	(0.09)	(0.09)	(0.09)	(0.09)
Foreign nationality	-0.08	-0.09	-0.10	-0.11
	(0.07)	(0.08)	(0.08)	(0.08)
Non-Spanish first language	0.15***	0.13**	0.12**	0.12**
	(0.05)	(0.05)	(0.05)	(0.05)
PhD	-0.01	-0.02	-0.06	-0.09
	(0.07)	(0.07)	(0.07)	(0.07)
Married or Domestic Partner	-0.10**	-0.10**	-0.11**	-0.11**
	(0.05)	(0.05)	(0.05)	(0.05)
Number of children under age	0.00	0.00	-0.00	-0.00
	(0.02)	(0.02)	(0.02)	(0.02)
Employed	0.09			
	(0.11)			
Working for others only		-0.67***		
		(0.11)		
Number of organisations			0.16***	0.16***
			(0.04)	(0.04)
Directive position			0.08	0.08
			(0.05)	(0.05)
Public organisation			-0.17***	-0.17***
			(0.06)	(0.06)
Constant	-0.89***	-0.13	-0.85***	-0.85***
	(0.17)	(0.18)	(0.16)	(0.16)
Observations	7324	7064	6908	6908
Censored observations	3055	2976	2929	2929
χ^2	182	213	193	201
p	0.00	0.00	0.00	0.00

* p<0.10, ** p<0.05, *** p<0.01. Robust standard errors in brackets. No multicollineartiy according to VIF. Main effects of variables with interaction terms are centered. Step 2 of the sample selection model. Step 1 produces almost identical results to Table 2.

4.3. Engaged academic artists

We have shown that engagement in knowledge diffusion through art is the norm rather than the exception among academic artists. Table 4 presents the estimations for the probability of being an engaged academic artist. Similar to commercial academic artists, we consider the possibility of sample selection and whether the decision to become an academic artist precedes the decision to being an engaged academic artist. The Wald test following the Heckman model rejects this possibility. We accounted for the possibility that commercialisation and engagement decisions are correlated by running a bivariate probit regression. In this case, the Wald test supports the modelling strategy (see Table 4).

Being a woman has a detrimental effect on academic engagement through art, while age has a beneficial effect. Science quality is initially negatively related to academic engagement through art but this relationship becomes positive beyond a certain threshold. After the inclusion of the control variables, working at a university and its interaction with science quality have no distinguishable effects.

Academic artists' engagement is affected negatively by being a woman researcher with three differences compared to commercialisation: age has the opposite impact (positive on commercialisation, negative on engagement); working at a university has different importance (significant for commercialisation, not for engagement); and the positive curvilinear influence of science quality on engagement applies to all researchers (not only to university researchers). These aspects are discussed in Section 4.4.

Table 4. Bivariate probit regression of engaged academic artist (RQ7)

	1 Full sample	2 Employed	3 Working for others	4 With moderations
Woman researcher	-0.21***	-0.20***	-0.20***	-0.20***
	(0.05)	(0.06)	(0.06)	(0.06)
Age	0.01***	0.01***	0.01***	0.01***
	(0.00)	(0.00)	(0.00)	(0.00)
Science quality	-0.06**	-0.06**	-0.05**	-0.05**
	(0.02)	(0.03)	(0.03)	(0.03)
Science quality squared	0.07***	0.08***	0.07**	0.07**
	(0.03)	(0.03)	(0.03)	(0.03)
University researcher	0.05	0.11*	0.09	0.07
	(0.06)	(0.06)	(0.06)	(0.09)
Uni. res. * Science quality				0.00
				(0.05)
Uni. res. * Science quality sq.				0.02
				(0.05)
Multidisciplinarity	0.01	0.04	0.01	0.02
	(0.06)	(0.06)	(0.07)	(0.07)
Medicine	-0.58***	-0.55***	-0.58***	-0.57***
	(0.09)	(0.10)	(0.10)	(0.10)
Life Sciences	-0.18*	-0.17	-0.17	-0.16
	(0.10)	(0.10)	(0.11)	(0.11)
Other Natural Sciences	-0.49***	-0.44***	-0.43***	-0.42***
	(0.09)	(0.10)	(0.10)	(0.10)
Engineering	-0.62***	-0.62***	-0.61***	-0.60***
	(0.11)	(0.11)	(0.11)	(0.12)
Art and Literature	0.18	0.13	0.12	0.11
	(0.16)	(0.17)	(0.17)	(0.17)
Madrid	-0.02	-0.02	-0.04	-0.04
	(0.06)	(0.07)	(0.07)	(0.07)
Barcelona	-0.10	-0.10	-0.14	-0.14
	(0.09)	(0.09)	(0.10)	(0.10)
Valencia	0.02	0.02	0.06	0.06
	(0.10)	(0.10)	(0.10)	(0.10)
Foreign residence	0.18*	0.18	0.20*	0.21*
	(0.10)	(0.11)	(0.11)	(0.11)
Foreign nationality	-0.09	-0.16	-0.13	-0.13
	(0.09)	(0.10)	(0.10)	(0.10)
Non-Spanish first language	0.04	0.03	0.03	0.03
	(0.06)	(0.07)	(0.07)	(0.07)
PhD	0.13	0.12	0.09	0.09
	(0.08)	(0.09)	(0.09)	(0.09)
Married or Domestic Partner	-0.05	-0.06	-0.07	-0.07
	(0.06)	(0.06)	(0.06)	(0.06)
Number of children under age	-0.00	-0.01	-0.01	-0.01
	(0.03)	(0.03)	(0.03)	(0.03)
Employed	-0.01			
	(0.13)			
Working for others only		-0.78***		
		(0.17)		
Number of organisations			0.15***	0.15***
			(0.05)	(0.05)
Directive position			0.18***	0.18***
			(0.06)	(0.06)
Public organisation			-0.08	-0.08
			(0.08)	(0.08)
Constant	-0.22	0.51**	-0.35	-0.35*
	(0.22)	(0.25)	(0.21)	(0.21)
Observations	2543	2423	2347	2347
χ^2	238	255	238	242
p	0.00	0.00	0.00	0.00

* p<0.10, ** p<0.05, *** p<0.01. Robust standard errors in parenthesis. No multicollineartiy according to VIF. Main effects centered in regressions with interaction terms. The bivariate estimation of 'Commercialisation' produces almost identical results to Table 3.

4.4. Cross-table comparison and discussion

According to our findings, women researchers are less likely to be either commercial or engaged artists. Working at a university conflicts with being an academic artist and commercialising art, but does not affect engagement through art. Up to a certain threshold, science quality is detrimental to being either a commercial or engaged academic artist. After that threshold, the relationship between quality and art becomes positive for *university* commercial researchers and for *all* engaged researchers.

The negative effects of most determinants of being an academic artist are intensified in relation to commercialisation and engagement. This is in line with our interpretation that both represent different dimensions of depth of researchers' artistic commitment. The exception is the results for age: younger researchers are more likely to be artists and are more likely to be commercial artists, but are less likely to be engaged artists. This positive association between age and engagement implies that engagement represents not depth of artistic commitment, but alignment to the traditional research mission. Hence, our construct of engagement is ambiguous and, while some forces (gender, scientific quality and organizational logic), point to one interpretation, others (age) do not. The reason for this uncertainty caused by age is likely related to dynamics not discussed before the formulation of Research Question 2, which refers to openness of young researchers to relatively recent commercialisation activities and diffusion. However, we may have underestimated that the older researchers in the sample are representative of the generation that experienced the Franco dictatorship and Spain's transition to democracy in May 1968 and the emergence of left-wing, anti-capitalism movements which were prominent in universities (Powell, 2001). This might explain the relation between age and art commercialisation and engagement, since older respondents may have considered diffusion a service to the public, before institutions and organisations formalised this

activity. Whether this adds to the theory or is a context-dependent explanation, is left to future research.

Apart from age, our theory explains well why some effects are significant in a particular direction. However, it does not justify why science quality-university affiliation works differently for artistic commercialisation and engagement. It might be that commercialisation is more difficult in universities compared to other organisations, whereas diffusion is not, so even if a negative effect of university affiliation is expected on both aspects, it is plausible that it is more significant for the former than for the latter.

However, why the U-shaped relation between scientific quality and art applies to all researchers in the case of engagement, but only to university researchers in the case of commercialisation needs to be addressed. It is possible that polarisation between university researchers may be stronger than among other academic researchers. It is clear that there is a high level of polarisation in universities in terms of scientific prestige, along the dimensions of research productivity, income and internationalisation (Kwiek, 2019). If commercialisation is more difficult in universities, it might be that only the most prestigious individuals become involved, whereas the differences (and the related curvilinear effect) are attenuated in other organisations. If engagement is less problematic for university researchers, the need for prestige to overcome the related barriers may be similar to other organisations (thus, producing the same curvilinear effect for university and other researchers). Future research could further examine the differences in the significance of the determinants of art commercialisation and engagement, perhaps using mediation analysis.

5. Conclusions

Art can diffuse scientific knowledge and academics may engage in artistic production to that end. This helps universities to contribute to the cultural life of cities, and valorises research in arts and humanities. Not only this research often translates into art, but also improves the tools for artistic production in other scientific fields. Artistic production could be considered as one of the mechanisms of university-industry knowledge diffusion in studies that typically include patents, spin-offs, contract research, informal contacts, etc. Its inclusion seems especially important given that universities are increasingly using copyrights to protect their intellectual property (Rooksby and Hayter, 2019). Academic knowledge diffusion through art could achieve more weight in evaluations of researchers' curricula. Appropriate rewards to researchers could increase task significance, and employees' organisational commitment (Fernández-Mesa et al., 2020), and retain valuable writing, performing, filming and visualisation skills. Acknowledging new types of research impact through art could improve understanding and narratives about the benefits of researchers' involvement in society (Hayter et al., 2020; Azagra-Caro et al., 2020b), especially in regions where research excellence and industry needs may not match (Bonaccorsi, 2017).

An analysis of academic artists requires a redefinition of the concept of 'academic'. The usual organisational perspective considers universities and sometimes public research organisations as academic, and other organisations as non-academic. This is not sufficient to provide an understanding of the relationship between researchers' individual characteristics, such as gender, age and science quality, and academic art. Female, young and more influential researchers find it more difficult to create art due to the context of academic science (open system of peer-reviewed publications), not because of belonging to one organisation type or another. Thus, an institutional approach that considers

researchers that publish in a scientific journal as academics, even if they do not belong to universities or public research organisations, is more appropriate for academic artists. Consequently, following the idea that entrepreneurship training should apply to both university and non-university actors (Giones, 2019), artistic training as a means of research valorisation could also cover both groups.

The analytical 'academic engagement' framework characterises a set of university interaction channels as largely compatible with the university's traditional research mission. The term, 'academic commercialisation', refers to university interaction channels that tend to jeopardize university research. The study of academic artists challenges the use of this taxonomy for clusters of channels: we propose that the same channel can be used for commercial and engagement purposes. Academic researchers who create art for more than hobby purposes, can try to commercialise it or not, and to engage into scientific diffusion or not. Hence, a single channel (art) brings together both commercialisation and engagement. Future research could examine how much engagement is involved in a typical commercialisation channel, such as spin-off foundation, or how much commercialisation is involved in an emblematic engagement channel such as joint research.

Our work provides what, to the best of our knowledge, is a new concept - 'academic artist' and offers some analogies to and contrasts with the related concept of 'academic entrepreneur'. It provides a conceptualisation of the relationship with the constructs of academic commercialisation and engagement found in the university-industry interaction literature. It suggests new theories related to some of antecedents to academic art: sex, age, scientific quality and organisational logic. The empirical results suggest that academic artists may be trapped in arguable dynamics, some of which are context-dependent, that have implications for research evaluation.

The normative interpretation of our findings depends to some extent on the reader's ideology. A supporter of reducing the barriers to women's participation in science will identify with the fewer opportunities for women to become artists and engage in science diffusion through art. Targeted policies and initiatives to enable women to use art for scientific purposes could increase equality in academic science.

Finally, the positive curvilinear relationship between science quality and art suggests the existence of power differences. Artistic commercialisation and engagement are compatible with better quality science only after a certain threshold, which implies that much academic prestige, and relational and social capital are necessary to counterbalance the time costs involved in adding art to science. If the aim were to implicate researchers in art, this would require initiatives to allow participation of less powerful academics. This might be achieved by reducing the weight of curricula in the evaluation of funding proposals, including research projects and PhD grant applications, that is, allowing ideas and content to weigh higher than the individual.

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Appendix: questionnaires

Table A1. Artistic Creativity Achievement Questionnaire (ACAQ)

Have you created any artistic work in these domains?
Plastic Arts (Drawing, Painting, Sculpture…)
Photography
New Media Arts (Digital, Computer, Multimedia Art…)
Music
Performing Arts (Dance, Theatre or Film Acting, Opera…)
Architecture
Creative Writing: Fiction (Poetry, Novel, Story, Playwriting, Scriptwriting…)
Creative Writing: Non-Fiction (Essay, Journalism, Biography… It excludes scientific publishing)
Websites (Blog, Archive, Chat, Databases…)
Theatre Direction or Production
Film Direction or Production
Other artistic areas (specify)

Inspired by Carson et al. (2005). Three mutually exclusive possible replies: "No", "Yes, I have created some artistic work, unpaid and not commercially exploited" and "Yes, I have created some artistic work, paid or commercially exploited".

Table A2. Science Through Art Questionnaire (STAQ)

(a) Through your artistic facet, do you diffuse scientific knowledge?

Yes, from my field of knowledge
Yes, from my speciality within my field of knowledge
Yes, from my publications in the ISI's JCR, with impact factor
Yes, from knowledge fields other than mine

(b) Does your artistic work let you contact with people outside your professional sphere like this?

I talk about my scientific research with entrepreneurs or managers from the artistic world (editors, producers…)
I talk about my scientific research with professional artists (painters, sculptors, writers, filmmakers…)
I talk about my scientific research with the public of my artistic work (readers, spectators…)
After having known my artistic work, entrepreneurs or managers from the artistic world have contracted me to develop my research facet
Entrepreneurs or managers from the artistic world that produced my artistic work exhibit my research facet as a plus for the promotion
Entrepreneurs or managers from the artistic world have given me research ideas that I have developed in my research facet
Professional artists have given me research ideas that I have developed in my research facet
The public of my artistic work has given me research ideas that I have developed in my research facet

Answers in a 5-point Likert scale from 0 (Never) to 5 (Very frequently).