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Dissemination practices in the Spanish research system: scientists trapped in a golden cage

Cristóbal Torres-Albero, Manuel Fernández-Esquinas, Jesús Rey-Rocha and María José Martín-Sempere[†]

The aim of this paper is twofold. On the one hand, it offers a systematic analysis of the data available regarding Spanish scientists' dissemination activities; on the other, it seeks to shed light on their behaviour and motivations. To do this, we consider the context of Spanish society and the conditions affecting the work and professional promotion of scientists. We present evidence from two surveys of CSIC researchers and of participants in Spain's main science fair, with the caveat that the data were obtained in a methodologically favourable scenario. A contrast exists between scientists' vocation to disseminate and the limitations derived from a low degree of interest in science in Spanish society, together with professional promotion policies that do not give priority to dissemination activities. This leads us to conclude that Spanish scientists are trapped between dissemination activities governed by moral values and a scarcely favourable social and professional context.

Keywords: public communication of science and technology, role of scientists, science popularization, science profession, Spain

1. Introduction

Little attention has been paid to the empirical study of scientists' participation in the dissemination of science in Spain. The few studies carried out to date have addressed dissemination mainly through theoretical or qualitative approaches, or else have focused on the role of professionals who promote science from within the fields of journalism, museums or education (González-Alcaide et al., 2009). Science dissemination has rarely been approached from the perspective of the practices of researchers themselves. There is currently no institutionalized procedure in Spain for gathering data regarding behaviours, attitudes and motivations of scientists in the communication of science to society.

The aim of this paper is twofold. On the one hand, it offers a systematic analysis of the data available regarding Spanish scientists' dissemination activities; on the other hand, it seeks to provide an explanation of their behaviour and motivations. To do so, we consider the situation of scientific culture in Spanish society and the conditions that affect the work and professional promotion of researchers.

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The paper is structured in three sections. Firstly, we consider the interest of Spanish society in science, showing the low degree of receptivity towards scientists' dissemination activities. Secondly, we analyse the policies and management procedures in the Spanish research and development (R&D) system. We highlight the focus of science policies on international convergence, the recent endeavours to establish infrastructures for promoting science culture, and the scarce encouragement of scientists' dissemination activities. Lastly, we present the existing empirical evidence, which allows us to estimate the number of scientists engaged in dissemination and their main social, demographic and attitudinal features.

For this purpose two empirical sources are used. First, a survey of CSIC (Spanish Council for Scientific Research) researchers provides an overview of the level of engagement of Spanish scientists in different kinds of activities. Second, a survey of participants in a major science event – the Madrid Science Fair – is used to observe behaviours, attitudes and motivations. The results show that a significant portion of scientists regularly take part in scientific dissemination activities, although they run up against two important limitations: Spanish society's low degree of interest in science and the scientific policies and professional promotion patterns that do not give priority to scientific diffusion. Thus our use of Max Weber's pessimistic "iron cage" metaphor, referring to the trend of modern society toward rationalization against action grounded in moral values. A parallel with the scientific institution can be found: the sense of entrapment between the set of strict meritocratic rules that govern scientific policies and organizations and the vocation of scientists to disseminate knowledge in order to improve a society's public scientific culture. However, given scientists' freedom to choose science as a profession, together with the vocational facet of science and the middle class social status of scientists, we have preferred to replace the cold iron bars with warmer golden bars.

2. Spanish society's lack of interest in science

Historically, Spanish society has provided scarce support and given low social relevance to scientific activity. The so-called "controversy of Spanish science" (García-Camarero and García-Camarero, 1970) is a long-lasting debate (stretching from the end of the 18th century to the first third of the 20th century) regarding the causes behind Spain's poor contribution to modern science. The most popular expression arising from this debate is the famous "Let *them* invent!" ("*¡Que inventen ellos!*"). This expression has served as a sort of cliché to defend the supremacy of Spanish humanistic culture over foreign scientific innovation. It points to the historically marginal position of science in Spain, evident from its meagre contribution to the process of modernization, the scarce public and private resources and organizational support, and Spanish society's lack of support for science (González-Blasco et al., 1979).

The data from the first monographic survey devoted to science and technology issues in Spain, carried out in 1982, which explicitly enquired whether citizens were interested in the quantity and quality of scientific research in Spain, are therefore hardly surprising. Only 25% of Spaniards answered affirmatively, whereas 54% said they were not interested and 21% did not have an opinion about it. A similar questionnaire sent to Spanish members of parliament recorded that 81% answered negatively to the same question (García-Ferrando, 1987: 163).

From the mid 1980s until the present day, Spain has undergone a significant economic and social modernization process that has included its national R&D system (see section below). However, current data do not suggest a greater level of interest in science, in Spanish public opinion. The surveys of the Spanish Foundation for Science and Technology (FECYT, 2005, 2007, 2009) show a low and stable degree of unprompted, rather than prompted, interest

in science. Only 6.9% of Spaniards mentioned it in 2004, whereas in 2006 and 2008 the figure stayed put at 9.6%. In the last two surveys, science and technology occupied position thirteen of eighteen (2006) and seventeen (2008) issues mentioned without prompting by at least 1% of the respondents. In the 2008 survey, an index of suggested interest in eight different issues was created (ranging from +2 to –2). Medicine and health issues scored the highest (0.78). Science and technology issues scored an interest index of 0.07, and occupied position six, ahead of only the interest shown in politics issues (–0.50) and economy and business issues (–0.02), which occupied the last two positions (Torres-Albero, 2009: 155).

These data are consistent with those provided by the Eurobarometers. For instance, the Eurobarometer *Scientific Research in the Media* (European Commission, 2007: 83) places Spain below the European Union average, in a position far from that corresponding to the country in terms of its economic, social or scientific relevance. Specifically, only 8% of respondents say they are very interested in scientific research (rank eighteen of a total of twenty-seven countries), whereas the response "fairly interested" is chosen by 40% (rank seventeen). In total, the percentage of interested respondents is 48%, with Spain occupying position seventeen of the twenty-seven European Union countries as regards the degree of interest in scientific research.

In conclusion, current interest in science among Spanish citizens is significantly lower than interest in other issues of daily life or the mass media agenda. Spain is in the group of European nations whose public pays less attention to these issues (Torres-Albero, 2005a). The segment of the population that is genuinely interested in science and technology does not exceed, in the best of cases, a tenth of the total, although a significantly larger proportion could be receptive to media stimulus. However, Spanish media devotes meagre space to science and technology content (Moreno-Castro, 2009).

In our view, the scarce interest and attention shown by current Spanish society toward science and technology is related to the convergence of a set of circumstances: the persistence of the historical conditioning factors described above, especially the weak link between technoscience and economic and social modernization (Álvarez and Molero, 2005); the relatively low interest in science shown by European modernized societies (Durant et al., 2000); and the existence within Spanish citizenship of significant levels of social representation ambivalent towards science and technology (Torres-Albero, 2005b). Therefore, considering the scenario of the Spanish society outlined here it can be said that the social context for Spanish scientists is not especially motivating or attractive for science dissemination activities.

3. Dissemination in public policies and scientific organizations

The conditions that affect Spanish scientists' dissemination activities are examined considering three essential components that shape the R&D system: the orientation of science policies, the reward system governing scientists' careers and the scarce institutionalization of science dissemination in the academic sector.

Dissemination and science policy

The orientation of recent science policy needs to be framed within the recent development of the R&D system. Until the end of the 20th century, Spanish science was lagging considerably behind compared to OECD countries. During the dictatorship scientific activities were scarce and research organizations were isolated from international standards such as peer review processes and meritocratic careers. At the time of entering the European Union (1986), gross

domestic expenditure on R&D (GERD) was 0.5% of gross domestic product (GDP). Policies launched in the 1980s were aimed at expanding research while introducing into universities and public research organizations (PROs) the practices of modern science that were commonplace in Western democracies (Muñoz, 2001). Growth has been constant since then, although the main figures are still in the middle range of the EU27 countries' (GERD of 1.27% and 9.9 researchers per thousand people). Spain's can be characterized as a "catch up" system geared to achieving convergence with the leading countries in science and technology. The public sector has a particularly strong presence (Spain is the sixth country in the world in terms of public investment). The main actors are the universities, although there is an important presence of PROs, with the Spanish Council for Scientific Research (CSIC) in a dominant position (ICONO, 2008).

In this context public policies have had the specific goal of levelling with the scientific production of the most developed countries. The focus of the main science policy tool, the National Plan for Research, Development and Innovation (RDI Plan), has been to increase international publications and participation in transnational projects and networks. Grants aimed at promoting dissemination had a residual role during the 1980s and 1990s. In 2000 the RDI Plan itself stated that "in Spain there is scarce interest among researchers and research centres to disseminate to society the result of their research activities and show its importance, thereby raising the level of scientific and technological culture" (CICYT, 2000: 51).

Measures to improve science culture started to develop when the public sector reached a higher growth rate. From the year 2000 stable programmes were established, although the main turning point was 2007 thanks to its official declaration as the "Year of Science." As a support tool for this celebration, the "Programme for Science Communication and Dissemination" was established. This gave rise to the largest set of grants to date for funding educational projects, science fairs, science weeks and scientific culture units, in addition to support for museums and collaborative projects with regional governments. The current RDI Plan (CICYT, 2008) establishes more clearly the promotion of science culture as one of its goals. It is defined as a "horizontal aim," which implies incorporating dissemination as a regular component of the other traditional science policy tools, such as R&D projects, infrastructures and research training. Nevertheless, there is still no specialized organizational and management structure that makes it possible to carry out and evaluate compliance with this goal.

Finally, the emergence of regional governments as key actors in the promotion of R&D is particularly relevant. Some important science culture events are held by autonomous regions, such as fairs and educational programmes, although usually they are also detached from the main functions of regional plans aimed at improving firm innovation (Buesa et al., 2006).

Dissemination, evaluation and the professional promotion of scientists

The organizations distributing resources and evaluating research performance also respond to the political goal of increasing standards of excellence and international convergence, especially through publications. The logic of this system can be seen in the practice of the three national evaluation agencies established specifically to incorporate the rational practices of science into universities and PROs (Jiménez-Contreras et al., 2003: 1). The National Agency for Evaluation and Prospective Studies (ANEP), which evaluates projects and scholarships in the RDI Plan, does not consider dissemination in assessing grant proposals. Publications and, lately, knowledge transfer, are the main criteria. 2) The agency for rewarding tenured professors (CNEAI) bases itself, again, on publications obtained every 6 years. Impact factors, together with patents in some specialties, are usually the performance indicators. 3) Finally,

the agency for university accreditation (ANECA), which grants access to university positions, combines teaching experience and scientific publications.

The results obtained by individual scientists before these bodies are used as the criteria for professional promotion at universities and PROs. The reward system in Spanish science is based especially on the evaluation by recognized members of the scientific communities acting as gatekeepers at the agencies (Fernández-Esquinas et al., 2006). Any activity that cannot be assessed on the basis of these parameters (except teaching in the case of ANECA) tends to be deemed as less relevant. Thus, dissemination is not an important element in the criteria to fund projects competitively nor in the evaluation of scientists' work, nor in the careers of researchers and professors, which are closely related to the performances certified by those bodies.

Scarce visibility and absence of information make it difficult to include dissemination in evaluation procedures. On the one hand, scientists do not usually report these activities to their work centres or include them in their curriculum vitae. On the other hand, they are difficult to assess and quantify because of the lack of accessible data sources. All this poses many obstacles for dissemination to start playing a role in evaluation systems, which do however have easy access to standardized indicators. Moreover, the rise of innovation policies is leading to the use of technology transfer activities together with impact factors. While policies and agencies use publications and patents as effective tools for gearing science toward excellence and innovation, knowledge transfer of a social nature remains hidden.

In sum, although in recent years dissemination activities have increased in Spain and some of them are promoted by the national RDI Plan, they still work as a set of grants with a low degree of integration with the management of science and the professional promotion of scientists. This is one of the main barriers for the institutionalization of dissemination activities.

Dissemination in universities and PROs

In the absence of stable science policy structures and reward procedures, science dissemination carried out by universities and PROs in Spain is characterized by amateurism. Researchers engage in these activities voluntarily, with institutional support that is at best short-term and sporadic. The difference is set by a small group of organizations, who have incorporated science culture in their agenda through specialized programmes and units. Here we shall focus on those with a higher degree of professionalization.

The CSIC is the most active organization owing to its size. It also has accumulated experience in dissemination given that it holds the oldest science museums in the country. Since 2004 it has had a scientific culture vice-presidency office that carries out a strategic action line seeking to engage the active participation of researchers (CSIC, 2005, 2008).

The most dynamic universities are the largest and those with the longest scientific tradition, given that they have more resources to establish their own programmes. On the other hand, some more recently created universities have adopted dissemination as a strategic element and have created scientific journalism and culture units. Lastly, we should mention the emergence of new science museums (generally financed by regional governments in collaboration with universities and PROs) and the consolidation of annual events that are host to a substantial amount of the public, especially science weeks and science fairs (Martín-Sempere et al., 2006).

The availability of public grants and the growing involvement of institutions, together with the existence of museums and events, give rise to an emerging space that channels

and provides professional support to scientists motivated by dissemination. Nevertheless, researchers are subject to a variety of simultaneous pressures to comply with various institutional "missions," such as publication, teaching and technology transfer. That is, scientists wishing to engage in dissemination work, as well as the incipient scientific culture units at universities and PROs, are trapped between the mechanisms for evaluating grants and publication performance, the growing teaching burden and the increasing incentives for commercialization.

4. Scientists' dissemination work in Spain

Two empirical sources regarding specific dissemination practices of scientists in Spain are available. The first of them (PCST-CSIC study) is a quantitative approach to the dissemination practices of the population of researchers of the CSIC (Martín-Sempere et al., 2006). The second study (PCST-Madrid Fair study) was designed in order to analyse the group of scientists that took part in a science fair. The target population for this study was the set of scientists of the CSIC and of the universities participating in the Madrid Science Fair from the years 2001 to 2004 (Rey-Rocha et al., 2006; Martín-Sempere et al., 2008). The main methodological aspects of both studies are summarized in Table 1.

We use both studies as complementary strategic sources for empirically substantiating our baseline argument. Firstly, with the CSIC study we obtain a descriptive overview from a representative sample that allows us to assess the specific activities that scientists carry out, together with their professional profile.[1] Given that CSIC is subjected to some of the management and promotion procedures of professors, and given its extensive network of associated units and collaboration agreements with universities (CSIC, 2008), we consider these data as a proxy for the dissemination activities of tenured researchers in the public sector. Secondly, with the Madrid Fair sample we obtain more detailed observations of behaviours, motivations and expectations from a group of scientists who have been engaged at least in this popular activity. The background hypothesis that underlines the design of the study is the hidden orientation of scientists toward science culture in contrast with institutionalized practices. This contrast can be addressed when specific answers are obtained using a strategic sample.

Scientists' dissemination practices

Both studies coincide in showing that most researchers take part in dissemination activities, even if sporadically. 85.1% of CSIC researchers surveyed stated they had carried out some dissemination work during the period analysed (1998–2002). In the case of the participants in the Fair, 95.6% of the CSIC researchers and 84% of the university professors[2] said they took part regularly or occasionally in a dissemination activity in addition to the Fair. This suggests a high degree of participation which we shall nevertheless qualify when we analyse what we define as regular dissemination work, that is, the proportion of researchers who carry out scientific dissemination activities on a regular basis.

With this goal in mind we have designed a "dissemination activity index (DAI)" from the data of the PCST-Madrid Fair study. To calculate the index, each of the items or dissemination activities the respondents[3] were asked about was assigned the following weighted value:

$$In = 1 \times \text{Regularly} + 0.5 \times \text{Occasionally} + 0 \times \text{Never}$$

Table 1. Main methodological aspects of the studies regarding scientists' dissemination practices in Spain

Research project	
PCST-CSIC	PCST-Madrid Fair
Population	
CSIC research personnel ($N = 2161$)	Personnel of the CSIC and public universities of the Region of Madrid taking part in the Madrid Science Fair (years 2001 to 2004) ■ CSI C personnel ($N = 220$) ■ University professors ($N = 263$)
Methodology	
Survey through online questionnaire	Face-to-face interview with structured questionnaire
Mainly closed questions	
Sample	
No sampling was carried out. The entire population was surveyed/interviewed	
Response rate	
34.1% ($n = 736$)	CSIC: 75.9% ($n = 167$) Universities: 77.2% ($n = 203$)
Field work	
February–May 2003	CSIC: December 2003–May 2004 Universities: February–June 2005
Scientific dissemination variables considered	
Number of scientific dissemination activities (see Table 3)	Participation in other scientific dissemination activities, other than the Fair Availability to take part in dissemination activities at schools Opinion regarding the following aspects: ■ Motivations for participation in the Madrid Science Fair ■ Interest caused in the public by their participation ■ Usefulness of their participation: for the public, for themselves, for their team, for their institutions and for their field ■ Benefits obtained from their participation ■ Main problems and limitations faced in their participation ■ Different initiatives to foster regular participation in scientific dissemination activities
Social, demographic and professional variables	
Age Gender Seniority Background Professional category Scientific field Consolidation of research groups Perception of the integration within the group	Age Gender Professional category Scientific field
Statistical analysis	
Chi-square (qualitative variables) Mann-Whitney U-test (quantitative variables)	Categorical principal components analysis (CATPCA)

in such a way that the value of the index for each individual is calculated as the sum of the weighted values of the different items, that is:

$$DAI = \Sigma\, In$$

Once the index was calculated, the following categories were defined:

– Individuals with DAI zero: those who have never carried out any dissemination activity.
– Individuals with high, average or low dissemination efforts: those whose DAI is, respectively, in the first, second or third percentiles.

Descriptive values of the index, expressed as mean ± standard deviation (range; median), were 3.7 ± 2.7 (0–11; 3.5) for university professors and 5.2 ± 2.7 (0–10.5; 5.5) for CSIC researchers. Those who regularly partake in dissemination activities (high dissemination effort) are one fourth (27.1%) of the university professors and half (55.6%) of the CSIC researchers. To understand the significant difference between both groups we must take into account that university professors have a mixed teaching and research position. Likewise, these data should be taken with caution, as they come from a sample of individuals who participated in the Madrid Science Fair, and who are therefore prone to take part in dissemination activities. Taking into account this condition, we may point to the higher number of university professors who have either never carried out any other dissemination activity (16%), or have a low (22.9%) or average dissemination level (34%). These values for CSIC researchers are 4.4%, 4.4% and 35.6%, respectively.

We shall now identify the most common dissemination practices among the Spanish scientists that make up the samples studied (Table 2). In both cases the most common activities are writings in popular science books and magazines, followed by conferences and round tables and, occasionally, mass media activities and open doors events. Comparison of the two samples of CSIC researchers shows a higher dissemination activity (both regular and occasional) among those who took part in the Madrid Science Fair. The figures regarding the activities carried out regularly show some differences. On the one hand the population of

Table 2. Scientists' dissemination practices

	PCST-CSIC project		PCST-Madrid Fair project			
	CSIC researchers (n = 736)		CSIC researchers (n = 45)		University professors (n = 144)	
	Reg + Oc *	Reg	Reg + Oc	Reg	Reg + Oc	Reg
Popular science books and magazines	66.6	35.1	82.2	33.3	54.2	19.4
Articles in the press	37.8	13.3	53.3	8.9	34.7	3.4
Scientific cinema/video	7.1	0.3	35.5	4.4	13.9	0.7
Dissemination websites	Not asked		33.4	17.8	36.8	26.4
Conferences/Round tables	56.1	23.9	86.7	40.0	67.4	23.6
Seminars/Congresses	Not asked		55.6	17.8	41.7	19.4
Workshops	8.3	1.4	28.8	4.4	28.5	10.4
Radio/TV programmes	31.8	6.8	68.9	13.3	38.2	8.3
Courses for primary and secondary school teachers	Not asked		46.7	20.0	29.2	13.2
Scientific routes	2.2	0.5	11.1	8.9	7.6	0.7
Science Week	Not asked		84.5	57.8	56.9	34.7
Open doors events	38.2	4.5	71.1	46.7	60.4	34.0
Exhibitions	13.7	1.0	42.3	15.6	29.9	6.9
Other science fairs	13.9	1.1	33.4	15.6	15.3	4.2

The cells indicate the percentage of individuals.
* Reg = regularly; Oc = occasionally. In the case of the PCST-CSIC study, occasional has been applied to activities carried out at least once, and regular has been applied to those in which they have taken part at least once a year.

CSIC researchers focuses on the publication of contributions both in books and popular science magazines and in the press, together with participation in conferences and round tables. On their part, the participants in the Fair show a more uniform distribution among the different activities. They stand out for their high level of commitment to institutional activities, mainly open doors events and activities carried out within the framework of science weeks. The university professors of the PCST-Madrid Fair study sample are characterized by dissemination practices similar to those of their colleagues at CSIC, although the intensity, measured in terms of the percentage of individuals who take part, whether regularly or occasionally, is lower.

Profile of disseminating scientists

In this section we outline the profile of disseminating scientists. Table 3 shows the profile of CSIC scientists who participated in some of the most relevant dissemination activities.

In the case of the scientists who published articles in the press, no significant differences were found with regard to the social, demographic and professional profile of researchers. On its part, participation in open doors events is related with the level of consolidation of the group to which the researcher belongs and the degree of identification of each scientist with their research group of reference. Participation in radio and television is related with the social and demographic characteristics of the individual, specifically gender, professional category and age group. This is an activity carried out mainly by males, over the age of 40, in the highest professional category in the CSIC scale (i.e. research professor).

Participation in open doors events is particularly relevant among scientists in the fields of Physics Science and Technology, and Natural Resources. On the other hand, there is a relatively low percentage of scientists from the fields of Biology and Biomedicine, and Humanities and the Social Sciences. As to radio and television programmes, they attract a high number of researchers working in the fields of Natural Resources, Humanities and the Social Sciences, and Physics Science and Technology. They show a lower than expected degree of participation among scientists in the areas of Materials Science and Technology, and Chemistry Science and Technology.

Lastly, individuals who have not taken part in any dissemination activity are characterized by a profile very similar to that of the general sample, although they are slightly older. They are particularly relevant in the field of Biology and Biomedicine.

The PCST-Madrid Fair data allow us to outline the profile of university professors (Table 4), on the basis of their dissemination activity index. There is a significant relationship between this index and professional category, so that full professors make considerably more dissemination efforts than tenured professors. The index is also related with performance in other participative activities. Thus, those who are most involved in dissemination activities show a significantly higher rate of participation in other participative activities. Although no relation was found between the index and the research field, the standardized residual values show a higher presence of individuals who make significant dissemination efforts in the field of Social and Human Sciences.

Attitudes and motivations towards scientific dissemination

The PCST-Madrid Fair study analyses the attitudes and motivations of scientists behind their participation in a science fair. The results show that their decision to take part in this event was influenced by an ensemble of motivations related significantly more frequently to altruistic reasons than to reasons of professional promotion or personal reward.

Table 3. Profile of CSIC disseminating scientists

	% CSIC researchers who have taken part in …				
	Articles in the press	Radio/TV	Open doors events	No dissemination activity	Total CSIC
	(*n* = 278; 37.8%)	(*n* = 234; 31.8%)	(*n* = 281; 38.2%)	(*n* = 110; 14.9%)	**(*n* = 736)**
Gender		$\chi^2 = 10.2$ α = *0.002*			
M	63.7	73.5 [3.2]	66.9	68.2	66.0
F	36.3	26.5 [–3.2]	33.1	31.8	34.0
Age		$\chi^2 = 20.04$ α = *0.0*			
31–40	28.1	19.7 [–3.7]	26.0	21.8	27.3
41–50	40.3	45.3	44.5	38.2	40.6
> 50	31.7	35.0	29.5	40.0	32.1
Average ± EstDev	46.7±8.2	47.7±7.8	46.2±7.8	48.4±9.0	46.6±8.3
(Min–Max) Median	(32–68) 45	(32–68) 47	(32–68) 45	(33–68) 47 U Mann-Whitney = 26796.5; *p*-value = 0.02	(32–68) 45
Professional category		$\chi^2 = 19.3$ α = *0.0*			
Research professor	17.3	22.2 [3.8]	17.1	14.5	15.1
Scientific researcher	21.6	24.4	20.6	22.7	21.7
Tenured scientist	61.2	53.4 [–3.9]	62.3	62.7	63.2
Group consolidation			$\chi^2 = 8.8$ α = *0.014*		
Consolidated group	72.7	67.5	75.1 [3.0]	68.2	68.9
Non-consolidated group	19.1	20.5	17.4 [–2.3]	21.8	21.7
No group	8.3	12.0	7.5	10.0	9.4
Level of identification with group			$\chi^2 = 17.2$ α = *0.0*		
High	54.3	54.7	60.5 [4.1]	48.2	51.0
Average	20.9	20.5	18.9 [–2.1]	15.5	21.6
Low or Nil	17.3	17.5	16.4 [–1.9]	22.7	20.2
DK/NA	7.6	7.3	4.3	13.6	7.2
*Area**		$\chi^2 = 43.4$ α = *0.0*	$\chi^2 = 32.02$ α = *0.0*	$\chi^2 = 26.1$ α = *0.0*	
Biology and biomedicine	16.9	15.0	10.0 [–2.8]	30.0 [4.1]	16.7
Food science and technology	10.8	6.8	8.5	3.6	7.7
Materials science and technology	11.2	7.7 [–2.4]	12.8	6.4	10.9
Physics science and technology	12.6	17.9 [2.2]	18.1 [2.7]	12.7	13.9
Chemistry science and technology	10.4	6.0 [–3.9]	13.2	15.5	13.2
Agricultural sciences	11.5	9.4	10.9	9.1	11.8
Humanities and social sciences	7.2	11.1 [2.8]	3.2 [–3.6]	11.8	8.0
Natural resources	19.4	26.1 [3.5]	23.5 [2.6]	10.9 [–2.0]	17.8

Source: PCST-CSIC study.
Cell values indicate column percentages. In those contingency tables where a relationship between both variables exists (significant chi-square values), the standardized residual value, when significant (i.e. < –1.96 or > 1.96), is displayed for each cell between square brackets. These values identify the cells that explain the association between the variables.
* Scientific and technical areas in which the CSIC institutes are grouped.

As shown in Table 5, the main motivations of the scientists to take part in the Fair were related with the desire to arouse or increase the public's interest in and enthusiasm for science (4.4 for CSIC researchers and 4.2 for university professors), to increase the public's scientific

Table 4. Profile of university professors participating in the Madrid Science Fair

	Dissemination activity index (DAI)				
	High (n = 39; 27.1%)	Intermediate (n = 49; 34.0%)	Low (n = 33; 22.9%)	Nil (n = 23; 16.0%)	Total (n = 144)
Gender					
M	89.2[2.6]	67.3	66.7	73.9	74.5
F	10.3[–2.6]	32.7	33.3	26.1	25.5
Age					
≤ 40	25.6	28.6	27.3	34.8	28.5
41–50	51.3 [2.3]	32.7	30.3	26.1	36.1
> 50	23.1 [–1.9]	38.8	42.4	39.1	35.4
Average ± SD	45.6±6.6	47.6±9.4	47.4±7.9	45.9±8.8	46.7±8.2
(range; median)	(32–58; 46)	(26–78; 47)	(34–63; 49)	(31–61; 48)	(26–78; 47.5)
Professional category *					
Full Professor	28.2	36.7 [2.3]	18.2	4.3 [–2.5]	25.0
Tenured Professor	53.8	40.8 [–2.7]	66.7	78.3 [2.3]	56.3
University School Professor	17.9	22.4	15.2	17.4	18.7
Partakes in other participative activities **					
Yes	59.0 [2.1]	46.9	45.5	13.0 [–3.3]	44.4
No	38.5 [–2.0]	46.9	54.5	82.6 [3.2]	52.1
DK/NA	2.6	6.1	0.0	4.3	3.5
Field (university learning branches defined by the Ministry of Education)					
Health sciences	15.4	26.5	33.3	30.4	25.7
Experimental sciences	15.4	26.5	30.3	13.0	22.2
Social and human sciences	17.9 [2.3]	10.2	0.0 [–2.1]	4.3	9.0
Technical subjects	51.3	36.2	36.4	52.2	43.1

* $\chi^2 = 12.571$, $\alpha = 0.046$; ** $\chi^2 = 15.103$, $\alpha = 0.017$.
Cell values indicate column percentages. In those contingency tables where a relationship between both variables exists (significant chi-square values), the standardized residual value, when significant (i.e. < –1.96 or > 1.96), is displayed for each cell between square brackets.

culture (4.3 and 3.9, respectively), as well as to increase public appreciation of the scientist's work (4.0 and 3.7, respectively). In contrast, the scientists interviewed gave little importance to the likely effect on their motivation of the possibilities of professional promotion (1.4 and 1.6, respectively), or economic reward (1.0 and 1.1, respectively).

In brief, the motivations expressed by the scientists are coherent with the context in which dissemination work is carried out by scientists in Spain. This context is characterized, as we have already pointed out, by a low degree of social interest in issues related to science and technology and by an evaluation system which credits researchers' careers mainly through publications in mainstream journals and recognition obtained from the most prestigious peers. Consequently, the results reveal how the decision of the scientists to take part in an event such as the Madrid Science Fair is not motivated by reasons of professional promotion or recognition but mainly by moral considerations regarding the improvement of public interest towards science and, ultimately, the scientific culture of citizens.

5. Conclusions

The social context of Spanish society does not seem, at least a priori, attractive or motivating for science dissemination practices. Nevertheless, there is a significant potential sector (approximately 40% of the population) that could be receptive towards the stimulus of scientific

Table 5. Distribution of responses (expressed as percentage of respondents) to the question "please indicate to what extent the following motivations influenced your decision to take part in the Fair"

	CSIC researchers * (n = 45)			University professors ** (n = 144)		
Motivations	1+2	4+5	Average	1+2	4+5	Average
Arousing or increasing public's interest in and enthusiasm for science	4.4	88.9	*4.4*	7.0	78.5	*4.2*
Increasing public's scientific culture	6.7	82.2	*4.3*	10.5	70.9	*3.9*
Sense of duty	4.4	82.2	*4.2*	17.4	65.3	*3.6*
Increasing public's appreciation of scientist's work	8.9	77.8	*4.0*	15.2	66.0	*3.7*
Make my centre better known or more visible	17.7	68.9	*3.8*	9.8	72.2	*3.9*
Personal satisfaction	28.9	48.9	*3.2*	18.7	52.8	*3.4*
Told to by somebody else	60.0	28.9	*2.3*	40.3	45.1	*3.0*
Personal commitment	55.5	26.6	*2.3*	48.6	29.8	*2.5*
Enjoyment	60.0	20.0	*2.2*	54.9	18.1	*2.3*
Professional relationships	66.7	11.1	*2.0*	66.0	15.3	*2.1*
Professional promotion	88.9	4.4	*1.4*	85.4	7.7	*1.6*
Economic reward	100	0.0	*1.0*	98.6	0	1.1

* *Source*: Martín-Sempere et al. (2008). ** *Source*: Rey-Rocha et al. (2006).
Scale: 1 = Not important at all; 2 = Slightly important; 3 = Moderately important *(not shown)*; 4 = Fairly important; 5 = Very important.
The complete expression of correlations among these motivations can be found in Martín-Sempere et al. (2008) for the case of CSIC researchers, and in Rey-Rocha et al. (2006) for CSIC professors.

dissemination, which implies a potential field for the development of dissemination activities in the future.

In this scenario, the public policies that govern the Spanish R&D system have concentrated their efforts on achieving convergence with the main leading countries in science and technology. It was not until 2007, when the system had reached most of its goals of international convergence, that there was a turning point in the establishment of stable infrastructures and resources for scientific dissemination. But given the low degree of continuity, amateurism is still the general pattern in the institutional promotion of scientific dissemination. On the other hand, for the professional promotion of scientists, priority is still given to scientific publishing, peer recognition, teaching or, more recently, technology transfer. Dissemination has a very low degree of integration in the procedures of professional promotion of scientists. Scientists who carry out dissemination activities must add this task to the considerable workload required to achieve simultaneously the other activities mentioned, which are usually considered more important for the evaluation and funding procedures of the Spanish R&D system and, therefore, for the promotion of their career as scientists.

Despite all these rather unfavourable conditions, in light of our data, a significant part of Spanish scientists can been considered to be regularly engaged in dissemination: specifically, half of the CSIC researchers and a fourth of the university professors. Nevertheless, these data should be taken with caution, as one of the sources for this study consists of participants in the Madrid Science Fair – a universe of scientists prone to taking part in scientific dissemination activities. The main motivation to engage in these activities is to improve the interest in science of Spanish citizens and, with this, to favour the improvement of the public's scientific culture.

Thus, there is a clear contrast between scientists' vocation to disseminate (an action guided by moral values) and the orientation of scientific policies and organizations that affect the recognition and professional career of scientists (guided by strict bureaucratic and rationalizing

norms of a productive nature). That is, there is a parallel with the metaphor of the iron cage formulated by Weber to understand the trends of modern society.

Departing from our diagnosis of the situation, when it comes to suggesting best practices to encourage scientific dissemination activities, one possibility is to look directly at the opinions of the researchers themselves. In the PCST-Madrid Fair study, respondents were asked to value a series of possible initiatives to promote scientists' participation in science dissemination. The answers leave no room for doubt. The interviewed scientists value, above all, the consideration of dissemination as a merit when it comes to evaluating their professional activity. This initiative receives an average of 4.2 points (in a range from 1 to 5), both from CSIC researchers and from university professors. The next most valued opinion is that there should be explicit recognition by their institutions of the dissemination activity (3.8 and 3.7, respectively). Lastly, as a third point to take into account, they request an increase in funding for these activities (3.7 in both groups). In our view, addressing this triple request could prove to be a decisive stimulus for Spanish scientists to leave their "golden cage" once and for all.

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Notes

1 The 34% response rate shows differences of less than 5% with the population in the distributions of science areas and academic categories. We assumed that the bias is acceptable for the whole population.

2 We refer only to CSIC researchers and university professors with permanent positions (Spanish equivalent of tenure). The rest of the staff have very heterogeneous professional profiles, none of them very propitious for dissemination.

3 No numeric periodicity was established for an activity to be deemed regular, leaving this to the consideration of the scientists themselves. The options given were: regularly, occasionally and never.

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