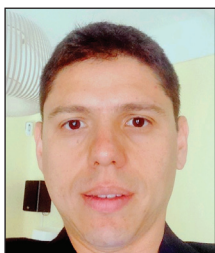# ADOPTION OF ICTS BY COMMUNICATION RESEARCHERS FOR SCIENTIFIC DIFFUSION AND DATA ANALYSIS

Adopción de TIC por investigadores en comunicación para la difusión científica y el análisis de datos

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Abstract

This study examines the actual use of ICTs by communication and media researchers for scientific diffusion and data analysis. Survey data were collected from members of the *International Communication Association* (*ICA*) (n=295). Adoption rate averages of most of the tools were close to the median, except for *Twitter*, grids, and simulation software. Consistent with

past research and the *Unified theory of acceptance and use of technology* (*Utaut*), we found that *performance expectancy* is a predictor of adoption, though this relation was not moderated by *age* or *gender*. In the case of scholarly environments, we found that *scientific collaboration* is a stronger predictor of actual use. Theoretical and practical implications of the findings are discussed.

Keywords

ICT; Adoption of technology; Communication and media; Researchers; Performance expectancy; Scientific collaboration.

Resumen

Este estudio examina el uso que los investigadores en comunicación dan a las TIC para la difusión científica y el análisis de datos. Se reportan los datos de una encuesta a investigadores de la *International Communication Association* (*ICA*) (n=295). Las tasas de adopción de la mayoría de las herramientas consultadas se aproximaron a la mediana, salvo en los casos de *Twitter*, grids y software de simulación. Consistente con la investigación anterior y con la *Teoría unificada de aceptación y uso de tecnologías* (*Utaut*), encontramos que la *expectativa de rendimiento* es un predictor significativo de la adopción de TIC, aunque esta relación no está moderada ni por la *edad* ni por el *género*. En el caso de los contextos académicos, encontramos que la *colaboración científica* es el predictor más fuerte del uso de las TIC. Se discuten implicaciones teóricas y prácticas de los resultados.

Palabras clave

TIC; Adopción de tecnología; Comunicación; Investigadores; Expectativa de rendimiento; Colaboración científica.

Introduction

Contemporary science has increased the use of computers for knowledge discovery, but also for scientific diffusion and collaboration. In this context of e-Science (**Hey**; **Trefethen**, 2005; **Nielsen**, 2012) or e-research (**Hey**; **Tansley**; **Tolle**, 2009), the incorporation of information and communication technologies (ICTs) in scientific routines has affected the way scientists do their work (**Borgman**, 2007; **Dutton**, 2010). Scholars from fields such as physics have used e-tools intensively (**Gentil-Beccott** *et al.*, 2009), but in the case of social sciences and the humanities this adoption process has been more heterogeneous and difficult (**Arcila-Calderón**; **Said**, 2012), even when in the last few years a set of techniques, tools and, dynamics have emerged within the so called digital humanities (**Dutton**; **Jeffeys**, eds., 2010; **Sánchez**; **Romero**, eds., 2014).

Commercial and non-commercial companies currently offer a wide range of e-tools that can be used in academic work (from specialized software and hardware to social media), and benefits from these ICTs can be related with the quantity and quality of research. In the first case, ICTs allow the production, analysis, curation, and sharing of huge amounts of information (known as *big data*) that may reconfigure the whole scientific activity (**Hey**; **Tansley**; **Tolle**, 2009). In the second case, these technologies permit an extraordinary capacity for collaboration, which has been related to the quality of the research processes (**Liao**, 2010; **Rigby**; **Edler**, 2005).

The e-tools may have an extensive number of specific uses, but in research environments these uses are focused on (i) scientific diffusion and (ii) scientific data analysis. Scientific diffusion refers to all messages created to communicate, facilitate, and articulate the scientific process. The way scientists communicate has been extensively studied and special attention has been paid to the influence of the Internet in this process (**Gibbons** *et al.*, 1994; **Briceño**, 2014) in which non-specialized audiences have begun to participate (**Waldrop**, 2008; **Neylon**; **Wu**, 2009). On the other hand, data analysis includes all procedures used to gather, manage, compute, and store scientific information. In the era of *big data*, scientists are adopting software and platforms by which they are automatically obtaining millions of records, processing them, and then getting new knowledge directly from data (**Zikopoulos** *et al.*, 2013; **Kosciejew**, 2013; **Gobble**, 2013; **Mayer-Schonberger**; **Cukier**, 2013). For example, the use of many computer-based methods to analyze content has been relevant in the field of social sciences and media studies (**Leetaru**, 2011; **Verbeke** *et al.*, 2014; **Pang**; **Lee**, 2008; **Lewis**, **Zamith**; **Hermida**, 2013). Additionally, supported by universities and R&D centers, scholars must deal with complex repositories, where they store, compute, and retrieve data.

Scholars of different fields adopt e-tools to a different degree and with different purposes. These differences may be caused by the specific dynamics, methods, and constraints of each discipline. The goal of this paper is to analyze how researchers in the field of communication and media studies adopt ICTs for their scientific work in special scientific diffusion and data analysis. In the sections that follow, we first provide an overview of past research and theoretical framework to address our research questions (RQ) and hypotheses (H). Then, we describe our method and report our findings.

Adoption of ICTs by researchers

There is an increasing interest in studying the adoption and use of ICTs by researchers in various disciplines (**Pearce**, 2010; **Procter** *et al.*, 2010; **Ponte**; **Simon**, 2011; **Dutton**; **Meyer**, 2008; **Briceño**, **Arcila-Calderón**; **Said**, 2012; **Arcila-Calderón**,

Piñuel; Calderín, 2013), given the consensus about the impact of these technologies on scientific methods and practices (Dutton, 2010; Hey; Trefethen, 2005; Borgman, 2007; Nielsen, 2012). Special attention has been paid to the adoption of web 2.0 tools given their current diffusion. Procter *et al.* (2010) collected information from 1,321 academics and doctoral students in the United Kingdom with the goal of detecting usage patterns of web 2.0 in the production and sharing of scientific content. According to the results, almost half of this sample (45%) was classified as an *occasional* user, while *frequent* users only represented 13% of the sample and *non-users* reached 39%. The data suggests that there is a significant correlation between the rate of adoption of these tools and the age, gender, and academic position of the researcher. Specifically, older males with higher-level academic posts were more inclined to use web 2.0 tools for research (i.e. *Google Scholar*, *Wikipedia*, *Facebook*, etc.). This study didn't find that young people or digital natives (Prensky, 2001) were the most extensive users of social tools in academic environments. On the contrary, it supports the results of the *Education for change report* (2012) that concludes that the new generation of researchers doesn't use digital technologies to their full potential.

> There are differences between the parameters that regulate the adoption of ICTs orientated to data analysis and ICTs for scientific diffusion

But the fast spread of web 2.0 tools for scientific diffusion and interest towards ICTs for research is not consistent in all fields. Briceño; Arcila-Calderón; Said (2012) examined the habits of a community of high-energy particle physicists in Latin America. The results of their survey confirmed a trend of using traditional tools of electronic academic publication (*arXiv* and *Spires*) and other shared data management systems, but found a low level of interest in the use of web 2.0 tools (that are commercial, for mass and popular use) such as *Facebook*, blogs and *Twitter*, which serves as a reminder that each scientific discipline maintains distinct habits in the areas of scientific collaboration and communication. Nevertheless, Dutton and Meyer (2008) analyzed the attitudes of British social scientists towards e-research and technologies for scientific work through an online survey and found that within the different fields and methodological orientations that make up social sciences, there were no significant differences regarding interest towards e-research and ICTs.

Some studies suggest that there may be differences between the parameters that regulate the adoption of ICTs orientated to data analysis and ICTs for scientific diffusion (Pearce, 2010; Arcila-Calderón; Piñuel; Calderín, 2013). Pearce (2010) contributes empirical evidence of widespread use of web 2.0 tools for scientific diffusion (up to 43%) among scholars in one British university (instant messengers, wikis, blogs). In the case of chats (instant messengers), there was a significant negative correlation in relation to age, which highlighted that older users demonstrated a

lower probability of using chats. Similarly, even though not at a significant level, the same trend was identified in the use of blogs and wikis. On the other hand, the study found that gender could be positively correlated with the rate of adoption and knowledge of other advanced tools more orientated to data analysis and preservation (grids, repositories). That is, male researchers were more likely to discover and adopt tools such as the *Access Grid* (awareness of the existence of *Access Grid* nodes) and repositories (deposit any outputs in a repository such as *ePrints*). Thus, age might be related to the adoption of scientific diffusion tools and gender to the adoption of data analysis tools.

> *Performance expectancy* predicts *behavioral intention* of using and adopting ICTs

To the best of our knowledge, there is no previous research that describes the way in which the international community of researchers in the area of communication and media studies adopts ICTs for their scientific work. However, a regional study demonstrated that Latin American scholars in this field have a positive attitude towards e-research and *frequently* use at least one basic e-tool, but there was evidence of a very limited use of advanced technologies (Arcila-Calderón; Piñuel; Calderín, 2013). According to these findings, adoption rates of ICTs for scientific diffusion were significant and about half of the researchers used tools such as chats (41.14%), blogs (48.1%), and social networks like *Facebook* and *Twitter* (62.34%). The adoption of ICT orientated to data analysis was more heterogeneous. Some tools like simulation or web analysis software (8.23%) and grids or clusters (11.08%) had a low rate of adoption, and tools such as content analysis software (25.32%), online survey software (38.92%), tools for graphic visualization, management and creation (43.35%), spreadsheets (44.62%), and databases (57.91%) were more spread among scholars. In order to extend this previous knowledge, we posed the following research question:

> RQ1: To what extent does the international community of communication researchers adopt ICTs for scientific diffusion and data analysis?

Performance expectancy through ICTs

Previous studies have found a wide range of factors that might be related to ICT adoption (Williams *et al.*, 2009; Zhang; Sun, 2009; Zhang; Aikman; Sun, 2008; Kaba; Osei-Bryson, 2013; Weber; Kauffman, 2011; Lal, 2008; Giunta; Trivieri, 2007) and several theoretical frameworks have been used to understand this process (Diffusion of innovations, Theory of reasoned action, Technological acceptance model – TAM, Motivational model, Planned behavior theory, PC use model, Social cognitive theory, etc.). To formulate the *Unified theory of acceptance and use of technology* (*Utaut*), Venkatesh; Morris; Davis; Davis (2003) reviewed eight theoretical models, which explained between 17 and 53 percent of the variance in user intentions to use information technology, and found that for every model construct

related to *performance expectancy* (perceived usefulness, extrinsic motivation, relative advantage, job-fit, and outcome expectations) were always significant and also had the strongest influence. In *Utaut performance expectancy* is moderated by *gender* and *age* (the effect is stronger for younger individuals and for men) and is defined as the "degree to which an individual believes that using the system will help him or her to attain gains in job performance" (**Venkatesh** *et al.*, 2003, p. 447). In a later revision of the model (*Utaut2*), **Venkatesh**; **Thong**; **Xu** (2012) kept *performance expectancy* as the strongest predictor of user intentions.

> There is not previous research that describes the way in which international community of researchers in the area of communication and media studies adopts ICTs for their scientific work.

Close constructs such as *attitude toward using technology* are also significant and relevant predictors in some models, but are not included either in *Utaut* or in *Utaut2*. In fact, there is no clear consensus whether attitudes act as determining factors in the adoption of the ICTs. According to **Zhang**, **Aikman** and **Sun** (2008) this controversy is due to the imprecision that has existed in studies in defining what an attitude is, for example without separating attitudes towards using ICT as an *object* (ATO) or towards using ICT as a *behavior* (ATB). In addition, the authors stated that it is necessary to include attitudes towards previous or similar versions of ICTs in the analysis, given that these are ultimately related to the intention of the behavior. Specifically, **Zhang**, **Aikman** and **Sun** (2008) carried out a survey of students from a North American university to evaluate their use and acceptance of a virtual learning environment (*WebCT 6.0*), and found that the ATB was a better predictor of the intention of the use of ICTs than the ATO. They also found that the effect of ATO was completely mediated by ATB. This operational distinction was maintained in later studies (**Zhang**; **Sun**, 2009), as well as other specific considerations in the structure of attitudes (if they incorporated experiential or instrumental aspects), which allowed for a better understanding and a predictive capacity of the models in which attitudes are considered as factors in the use and acceptance of the ICTs. However, the lack of consensus suggests that *attitude towards using technology* may be a problematic predictor.

In line with *Utaut* and *Utaut2* we posit that *performance expectancy* predicts adoption of ICTs for scientific work such that:

> H1. *Performance expectancy* has a significant influence on *actual use of ICTs.*

And given the importance of variables *gender* and *age* we propose (as in *Utaut* and *Utaut2*) that they moderate the influence of *performance expectancy* on the adoption of ICTs for scientific work.

> H2.1 The effect of *performance expectancy* on *actual use of ICTs* is moderated by *age*, such that the effect will be stronger for younger researchers.

> H2.2 The effect of *performance expectancy* on *actual use of ICTs* is moderated by *gender*, such that the effect will be stronger for male researchers.

Scientific collaboration

Acknowledging the limitations of certain models, **Weber**; **Kauffman** (2011) state that the range of determinants is much wider (economic, social, and other factors), which is why it is evident that there isn't a clear consensus on the topic in scientific literature on ICT adoption. For instance, the analysis of **Kaba**; **Osei-Bryson** (2013), based on the results of a survey on the adoption and use of mobile telephones in Canada (Quebec) and Guinea (both French-speaking regions but with distinct cultural patterns), found factors that apparently determine the adoption of a technological innovation lose their effects in some environments. According to the data, in Canada the validity of models such as TAM (Technology acceptance model) was confirmed in which previous attitudes and perceptions (regarding usefulness and ease of use) are determinants in the adoption of ICTs. However in Guinea, these factors weren't significant.

It is therefore possible that certain specific factors are emerging. The study by **Giunta** and **Trivieri** (2007) showed that collaboration between companies (together with the size of the company, its geographical location, the functional composition of the workforce, the activities of R&D, subcontracting and exports) was a highly significant determinant in the adoption of ICTs. In this sense, **Lal** (2008) found that among small and medium-sized companies in Malaysia with international technological collaboration there was a tendency to adopt more advanced ICTs. In academic contexts, *scientific collaboration* may affect scholarly practices (**Cummings**; **Kiesler**, 2005; **Hara** *et al.*, 2003; **Rigby**; **Edler**, 2005; **Liao**, 2010). This is the case with the study previously mentioned by **Procter** *et al*. (2010), which found that greater scientific collaboration resulted from greater adoption of web 2.0 tools. **Arcila-Calderón** (2013) confirmed these results and found scientific collaboration was positively correlated with the adoption of ICTs by Latin American social researchers. Also, **Bargak** *et al.* (2010) found collaboration (together with funding and contribution to interesting research) was a catalyst that drove e-infrastructure adoption. These three previous studies suggested that in academic contexts the degree of *scientific collaboration* predicts ICT adoption. Thus our last hypothesis is:

> H3. *Scientific collaboration* has a significant influence on *actual use of ICTs.*

Adoption of ICTs by researchers for scientific work

As we have seen in the previous sections, factors explaining ICT adoption are not always consistent. Nevertheless, *Utaut* and *Utaut2* clearly show that *performance expectancy* is the strongest predictor of *behavioral intention* of ICT adoption in general contexts. In the case of academic and scientific environments, other relevant variables such as *scientific collaboration* should also be considered. Thus we suggest the sum of these two factors may explain the *actual use* of ICT for scientific work. Given their importance, we include *gender* and *age*
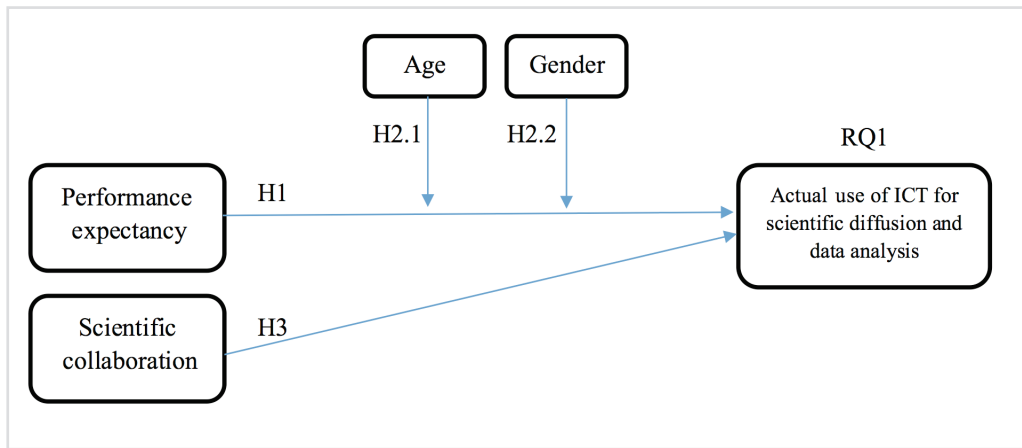
Figure 1. Theoretical model of adoption of ICTs for scientific work

as moderators of the influence of *performance expectancy* as they were included in *Utaut* and *Utaut2*. It is important to notice that although these models considered that *performance expectancy* predicts *behavioral intention,* we suggest this variable may directly predict *actual use*, which means there would not be a mediation process. Figure 1 shows our theoretical model, which includes *performance expectancy* (moderated by *gender* and *age*) and *scientific collaboration* as predictors of *actual use* of ICT for scientific work.

Method

Participants and procedures

Data were obtained from surveys administered to researchers affiliated to the *International Communication Association* (*ICA*), which is an international academic association for scholars in the field of communications and media studies. *ICA* is a prestigious well-known worldwide organization that promotes scientific diffusion and discussion in communication research, and active members are supposed to conduct and participate in investigations.

We randomly chose 400 *ICA* members (from a population of 1,812 active members openly registered by January 2013) and invited them to participate in the online survey from March 1 to July 31, 2013. A total of 348 answers were received, from which 295 were valid answers. The response rate was at 73,75%, which represents a good rate but implies a self-selection bias. This limitation does not affect our findings since the goal was to describe processes rather than generalize our results (**Shapiro**, 2002). Although members belonged to more than 80 countries, the final version of the questionnaire was presented in English (translated from Spanish by authors and proofread by two experts). The survey was developed and executed using *LimeSurvey* software (hosted in university servers) and was designed to be completed in about 20 minutes.

Measures

The questionnaire was based on past research (**Dutton**; **Meyer**, 2008; **Arcila-Calderón**, 2013) and measures included: the type of e-tool used for sharing knowledge (*actual use of ICT for scientific diffusion*), the type of e-tool used for data analysis (*actual use of ICT for data analysis*), the benefits

of ICTs for scientific tasks (*performance expectancy*), and the habits of collaborative work practices (*scientific collaboration*). Each item for *actual use of ICT* was measured with a dichotomous answer (0. No / 1. Yes) and constructs were summative (0-4 for *actual use of ICT for scientific diffusion*, 0-8 for *actual use of ICT for data analysis* and the sum of these two scales, 0-12 for *actual use of ICT for scientific work*). A 5-point Lickert scale, ranging from *completely disagree* (1) to *completely agree* (5), was used to measure items for *performance expectancy* (5-25 summative scale), and a 4-point scale, ranging from *never* (1) to *very often* (4), was used for *scientific collaboration* (4-16 summative scale).

Demographic variables were also included:
- *age*,
- *gender* (0=male, 1=female),
- *region* (1=Europe, 2=United States and Canada, 3=Latin America, 4=Africa, Asia the rest of the world),
- *academic level* (1=Bachelor's degree, 2=Master's, 3=Doctorate),
- *main employment status* (1=permanent teaching or researching, 2=postgraduate student, 3=non permanent teaching or researching), and
- *specific area of research* (*ICA* Division or Interest group).

> *Scientific collaboration* was the strongest predictor of the model, being significant for both cases: *actual use of ICTs for scientific diffusion* and *actual use of ICTs for scientific data analysis*

Before the application of the questionnaire, we conducted a focus group of a *panel of experts* in order to assure content validity. Two independent researchers (not related with the study) assessed the instrument and made qualitative comments, which were considered to improve the questionnaire. Straightaway, we estimated test-retest reliability through the application of the survey to a group of 30 researchers in two different moments (with a gap of one week) to measure the correlations between the answers given on each occasion. Items that did not reach an intraclass correlation coefficient (ICC) of 0.70 were deleted or reconsidered[1].

Once the data were collected, we assessed the validity of the constructs included in the questionnaire through an exploratory factorial analysis (EFA), which allows for the identification of underlying factors in a series of variables (**Pérez-Gil**; **Chacón**; **Moreno**, 2000; **Macía**, 2010; **Igartua**, 2006).

Items for each construct were factor analyzed with Varimax (orthogonal) rotation and EFA suggested a latent structure of four dimensions (table 1), explaining 52.93% of the variance for the set of 21 items and an examination of the Kaiser-Meyer Olkin measure of sampling adequacy suggested the sample was factorable (KMO=0.793). *Performance expectancy* (Factor 1) had an Eigen value of 4.371 and explained 20.82% of variance. *Actual use of ICTs for scientific diffusion* (Factor 2) had an Eigen value of 1.808 and explained 8.61% of variance. *Actual use of ICTs for data analysis* (Factor 3) had an Eigen value of 1.509 and explained 7.19% of variance. And *Scientific Collaboration* (Factor 4) had an Eigen value of 1.328 and explained 6.32% of variance.

According to internal consistency reliability, *Performance expectancy* obtained α0.755, *Actual use of ICTs for scientific diffusion* was at α0.674, *Actual use of ICTs for data analysis* was at α0.646, and *Scientific collaboration* reached α0.550.

Although these last indicators didn't reach the ideal score of 0.70 (**Cronbach**, 1951; **Hayes**, 2005) in this *ad hoc* instrument, we decided to continue with their presence in the proposal given that they were very close to the minimum of 0.60 required for exploratory studies (**Hair** *et al.*, 2000; **Robinson**; **Shaver**; **Wrightsman**, 1991).

Analysis

To address RQ1 we conducted descriptive analysis of data. In the case of H1 and H3, multiple linear regression analysis estimated by ordinary least squares (OLS) was carried out. We performed multicollinearity tests to check OLS assumptions and results showed tolerance values close to 1 and VIF values under 2, which indicates the absence of multicollinearity (**Cohen** *et al.*, 2003). To address H2.1 and H2.2, we ran a moderation analysis with *SPSS Macro process* (Model 2), developed by **Hayes** (2013).

Table 1. Loadings for exploratory factorial analysis (EFA) with Varimax rotation.
Note: Factor loadings > 0.400 are in boldface.

Item	1	2	3	4
Performance expectancy				
The use of digital technology in research is beneficial	**0.592**	0.008	0.172	0.127
e-Research (research based on ICT) positively affects my productivity and the productivity of my research group	**0.702**	0.007	0.147	0.206
Reusing data and information from other scientists to produce new findings is an advantage of collaborative work	**0.674**	0.158	0.087	-0.048
The publication of content on free and open platforms increases the possibilities for collaboration between peers and / or research groups	**0.703**	0.254	-0.134	0.025
e-Research (research based on ICT) facilitates the development of responses to the new scientific questions that are appearing in my field of study	**0.697**	0.191	0.050	0.173
Actual use of ICTs for scientific diffusion				
I use chats	0.223	**0.469**	0.158	0.124
I use *Facebook*	0.068	**0.746**	0.087	-0.002
I use *Twitter*	0.091	**0.736**	0.149	0.017
I use blogs	0.175	**0.673**	0.026	0.310
Actual use of ICTs for scientific data analysis				
I use software for online surveys	0.073	-0.032	**0.600**	-0.006
I use content analysis software (e.g. *Atlas.ti*)	0.092	0.202	**0.462**	-0.202
I use simulation or web analysis software (e.g. *Netlogo*)	-0.043	0.177	**0.526**	-0.011
I use distributed computing systems (e.g. grid; cluster; cloud)	0.123	0.361	**0.420**	0.091
I use digital storage sites	0.140	0.311	**0.477**	0.147
I use databases	0.138	0.063	**0.424**	0.310
I use tools for visualization, management and creation of graphics	0.140	0.029	**0.586**	0.085
I use spreadsheets	-0.086	-0.009	**0.542**	0.194
Scientific collaboration				
I have applied for national or international funding for a research project with peers that belong to an institution that is different to me	0.113	-0.056	-0.001	**0.682**
I have sent my articles to a pre-print platform (an online platform where authors send and publish articles before being published in a scientific journal)	0.075	0.041	-0.007	**0.643**
I have used digital platforms to make public and share the raw data from my research (databases, code books, procedure manuals, etc.) with the goal of third parties using them	0.077	0.195	0.186	**0.624**
I have participated in a virtual research community (working group or research network with members based in a range of geographic locations with a method of working that mainly takes place using the internet)	0.103	0.228	0.122	**0.530**

Results

Preliminary and descriptive results showed that researchers that answered the survey (n=295) had an average age of 43.71 years (SD= 11,88) and in this sample there was a slightly higher percentage of men (54.1%). Most of the individuals had completed a doctorate (76.6%) and already had a permanent teaching or research position (72.9%), which means that they are concentrated in scholarly contexts. Respondents were from all regions (Europe=40.68%, United States and Canada=25.42%, Latin America=8.14% and Africa, Asia the rest of the world=25.76%) and from all *ICA* Divisions and Interest groups, especially from Mass communication (14.9%), Political communication (14.2%), Communication and technology (12.2%) and Journalism studies (9.5%).

RQ1 was focused on the adoption rate of *ICTs for scientific work* by researchers. As exposed in the EFA, tools were classified into *ICTs for scientific diffusion* and *ICTs for scientific data analysis.* The rates of adoption (figure 2) for *scientific diffusion* among communication scholars were considerably more homogeneous (chats=41%, *Facebook*=42%, *Twitter*=28%, blogs=26%) than those for *scientific data analysis* (software for online surveys=70%, content analysis software=45%, simulation or web analysis software=7%, distributed computing systems=27%, digital store sites=44%, databases=44%, tools for visualization, management and creation of graphics=40%, spreadsheets=57%). It is clear that researchers were familiar with *ICTs for scientific diffusion*, even when their adoption rates did not reach the 50%. We can consider that, except for *Twitter*, all of these tools went through the take-off point, that is the point where it is difficult to stop the diffusion process (**Rogers**, 2003). In the case of *ICTs for scientific data analysis*, we found that simulation or web analysis software and distributed computing systems did not reach this take-off point, but tools such as software for online surveys and databases were widely spread.

On average, respondents had an *actual use* of almost half of the questioned *ICTs for scientific work* (0-12 scale, M=5.28, SD=2.83). Both *actual use of ICTs for scientific diffusion* (0-4 scale, M=1.54, SD=1.39) and *actual use of ICTs for scientific data analysis* (0-8 scale, M=3.75, SD=1.96), had averages below the median but close to it. This implies that researchers have a *medium* level of adoption of ICTs and that there are not differences between the actual use for *scientific diffusion* and *scientific data analysis* [t(266)= -0.114, >0.05] (using z-scores).

To test our model we carried out regression and moderation analyses (table 2). The regression was significant [F (6, 221) = 12.32, p <0.001] and included predictors in the model which explained 25% (R^2=0.25) of the variance (f^2=0.33; *medium* effect size, according to **Cohen**, 1988) of *actual use of ICT for scientific work* (23% in the case of *actual use of ICTs for scientific diffusion* and 15% in the case of *actual use of ICTs for scientific data analyis*). We found that *performance expectancy* (5-25 scale, M=16.43, SD=2.33) was a significant predictor on *actual use of ICT for scientific work* (b=0.31, <0.001) which clearly supports H1. This predictor was significant with *actual use of ICTs for scientific diffusion* (b=0.16, <0.001) as well as *actual use of ICTs for scientific data analyis* (b=0.15, <0.01). Instead, we found that *age* (b=0.00, >0.05) and *gender* (b=0.27, >0.05) did not moderate the influence of *performance expectancy* on *actual use of ICT for scientific work*, thus H2.1 and H2.2 were not supported, as suggested by *Utaut*[2]. However, the analysis revealed that *age* was a predictor for *actual use of ICTs for scientific diffusion* (b=-0.02, <0.01) but was not for *actual use of ICTs for scientific data analyis* (b=-0.01, >0.05), which means that younger researchers will adopt more tools such as chats, *Facebook*, *Twitter,* and blogs.

Scientific collaboration (4-16 scale, M=4.52, SD=1.45) was the strongest predictor of the model (b=0.69, <0.001), being significant for both cases: *actual use of ICTs for scientific diffusion* (b=0.30, <0.001) and *actual use of ICTs for scientific data analyis* (b=0.38, >0.01). This result fully supports H3 and suggests that in academic contexts collaboration practices are determinants in the adoption of ICTs for both *scientific diffusion* and *data analysis*.

Discussion and conclusion

The goal of this study was to describe the actual use of ICTs by communication and media researchers. Consistent with past research (**Procter** *et al.*, 2010; **Pearce**, 2010; **Arcila-Calderón**; **Piñuel**; **Calderín**, 2013), we found that, except for *Twitter*, communication scholars have an adoption rate of chats, *Facebook* and blogs close to 50%. This indicates that web 2.0 tools for scientific diffusion are commonly used or at least there is a medium level of adoption. The case of *Twitter* is particular since only 28% of researches have adopted it.
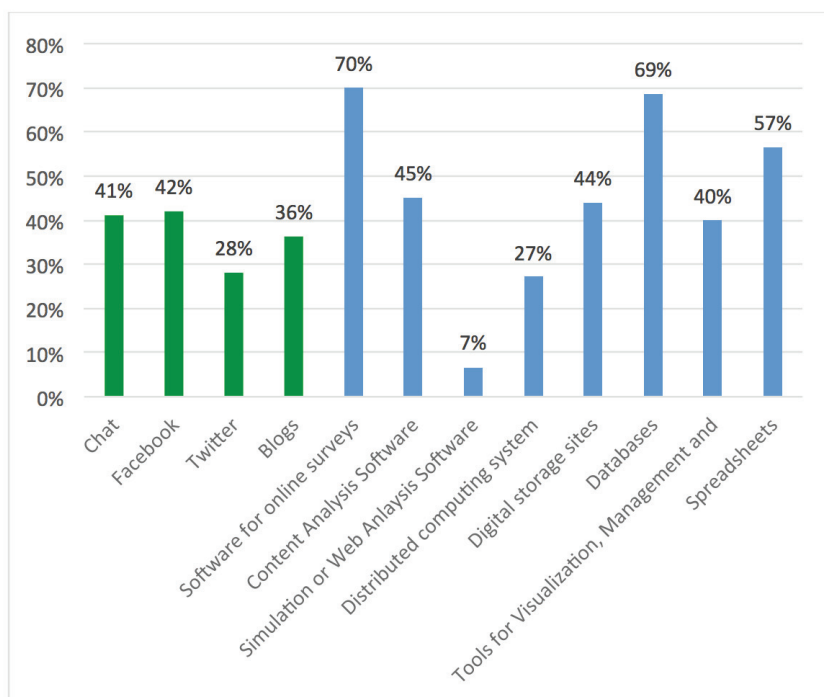

Figure 2. Rate of adoption of ICTs for *scientific diffusion* (green) and *scientific data analysis* (blue)

Table 2. Multiple linear regression and moderation analysis to test H1, H2.1, H2.2 and H3

	ICT adoption by communication researchers		
	Actual use of ICT for scientific diffusion	Actual use of ICT for scientific data analysis	Actual use of ICT for scientific work (diffusion + data analysis)
	b	b	b
Performance expectancy	0.16***	0.15**	0.31***
Scientific collaboration	0.30***	0.38**	0.69***
Gender	0.07	-0.04	0.09
Age	-0.02**	-0.01	-0.03*
Performance expectancy x Gender	0.10	0.19	0.27
Performance expectancy x Age	-0.00	0.00	0.00
Adjusted R^2	0.23	0.15	0.25
Anova	$F_{(6, 230)} = 11.67$***	$F_{(6, 225)} = 6.43$***	$F_{(6, 221)} = 12.32$***

*$p<0.05$; **$p<0.01$; ***$p<0.001$.

In contrast with recent reports (*Education for change report*, 2012), data also shows that scientific diffusion through ICTs is becoming important for younger researchers, which suggests that it is still necessary to promote these tools among more experienced scholars. On the other hand, age was not a predictor of actual use of ICTs for scientific data analysis, meaning that researchers of all ages adopt these tools to the same extent. Within this set of tools, ICTs such as simulation software or grids did not reach the take-off point. These tools are probably much more frequent in natural and experimental sciences because of their approaches. For the case of distributed computing systems we infer that communication research has not sufficiently adopted "big science" dynamics, which includes computing big data and articulating huge research teams, for which grids are ideal platforms. Nonetheless, other ICTs for scientific data analysis seem to have spread (>40%), which would mean that researchers are related to computer-based discovery.

Because of the self-selection bias in the sample, we cannot draw conclusive remarks or generalize adoption rates. However, our data clearly shows that many researchers are aware of transformations in scientific practices based on ICT. This is crucial since early adopters and local experts finally motivate others within the same field to use technologies (**Stewart**, 2007). Further research is needed to compare actual use of ICT among different scientific communities and also among divisions within a community. In our study we did not analyze differences among *ICA* divisions or interest groups (or between qualitative and quantitative researchers), but there might be disparities.

Our results provide support to the finding that *performance expectancy* predicts actual use of ICT (**Venkatesh** *et al.*, 2003; **Venkatesh**, **Thong**; **Xu**, 2012). This perceived usefulness (**Davis**, **Bagozzi**; **Warshaw**, 1992; **Davis**, 1989) is a clear determinant in ICT adoption, which means that individual beliefs about technologies have a strong importance in the decision process. In our case, these expectancies are especially related to the future scientific productivity and the generation of new findings, thus researchers believing new technologies may help with scientific discovery will be more likely to adopt them. Our findings also suggest that *age* and *gender* do not moderate the effect of *performance expec-*

tancy on *actual use of ICTs*. This fact has some theoretical implications. First, our study differs from *Utuat* (**Venkatesh** *et al.*, 2003) and *Utaut2* (**Venkatesh, Thong**; **Xu**, 2012), meaning that in an academic context these variables may not moderate this relationship, due to the specific dynamics of research processes. Instead, as discussed earlier, age could have a direct effect on actual use of some social ICTs. On the other hand, our proposed model shall eliminate these two moderation variables, and include age as a predictor.

> We suggest that specific models must be explored to understand ICT adoption for scientific work, due to the particular constraints of scholar contexts

Scientific collaboration was the strongest predictor of our model, which is consistent with past research focused on ICT adoption by researchers (**Procter** *et al.*, 2010; **Bargak** *et al.*, 2010; **Arcila-Calderón**, 2013). It is evident that collaboration actions and dynamics require appropriated tools and sometimes advanced digital platforms. A good example of this is the *Large Hadron Collider*, for which more than 3,000 physicists work and collaborate using sophisticated grids to store, share and compute data. But this project is also a good example of ICT adoption for scientific diffusion since some experiments (i.e. *Atlas*) can be followed through *Twitter* or *Facebook*. The average collaboration index in our sample of communication scholars was low, which can explain why the grids also had a low adoption rate. Therefore, the inclusion of collaboration as a predictor of ICT adoption in scientific environments may help to increase the explained variance of theoretical models in future research. We need to point out some limitations concerning this variable. First, the internal consistency of this construct was modest (α0.550), which can be caused by the few number of items in this scale. Second, other indicators that were not included in this study (such as co-authorship) might be considered in order to measure collaboration.

Utaut2 explained up to 52% of the variance for *actual use* and up to 74% of the variance for *behavioral intention*

(**Venkatesh**, **Thong**; **Xu**, 2012). Our proposed model only explained 25% of variance for *actual use of ICT*, thus other predictors might be included. These determinants may be in line with *Utaut2* (effort expectancy, social influence, facilitating conditions, hedonic motivation, price value, habit), but we consider that other specific predictors should arise for scientific and scholarly contexts (institution size, research approach, cultural dynamics). To some extent, our findings suggest that specific models must be explored to understand ICT adoption for scientific work, due to the particular constraints of scholar contexts.

In summary, this study describes actual use of ICT for scientific work of communication scholars and gives some insight about the determinants that influence the adoption decision. This study provides empirical evidence to support *performance expectancy* as an important predictor in ICT adoption but proposes to include *scientific collaboration* as a determinant in scientific and scholarly environments. Future research may replicate this survey in other disciplines and contexts with larger samples. However, in our study power analysis indicated that sample size was adequate. Specifically, *sensitivity analysis* using G*Power 3.1.9.2 (**Faul**, **Erdfelder**, **Lang**; **Buchner**, 2007; **Faul**, **Erdfelder**, **Buchner**; **Lang**, 2009), determined the magnitude of effect that could be detected with 295 individuals (assuming 1-B=0.80), finding that our sample was large enough to identify a *small* effect size of 0.03 (**Cohen**, 1988).

In terms of practical implications, our study suggests that sensitization campaigns might be appropriated to increase *performance expectancies* among researchers, informing the benefits of ICT use in research. Campaigns can be accompanied by direct education to local experts and leaders in computed-based discovery, thus they can promote ICT use within the particular field. In addition, funding programs and scholarly accreditations might promote scientific collaboration through international calls and co-authorship recognition, respectively. As earlier discussed, this kind of collaboration significantly increases ICT use for scientific discovery and diffusion.

Notes

1. Inconsistencies were found in answers on the use of commercial video conferencing tools (*Skype*) and advanced video conferencing tools (e.g. Internet2), which is why they were deleted from items. In the case of social media, the original variable asked about the use of "*Facebook* and *Twitter*" jointly, but after inconsistencies occurred, the research team decided to separate these items and measure them independently.

2. To expand these findings we ran a *moderated moderation* analysis (**Hayes**, 2013) to test *three-way interaction* within *Performance expectancy* x *Age* x *Gender*. This analysis allows determining whether the moderation of *Performance expectancy*'s effect on *Actual use of ICTs for scientific work* moderated by *age* is itself moderated by *gender*. Using *SPSS Macro process* (Model 3) we found that the regression was significant [F (8, 219) = 9.20, p<0.001] explainig 25% of the variance, but without any moderation interactions. When running this analysis the only significant predictor was *Scientific collaboration* (*b*=0.70, <0.001) and *Performance expectancy* did not show a clear influence (*b*=0.15, >0.05).

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