ICT and Science: Some Characteristics of Scientific Networks and How They Apply Information Technology

Simone Belli[1(✉)] and Ernesto Ponsot[2(✉)]

[1] Universidad Complutense de Madrid, Madrid, Spain
sbelli@ucm.es
[2] Yachay Tech, Urcuquí, Ecuador
ernesto.pb@gmail.com
https://www.ucm.es/dep-antsocypssoc/cv-simone-belli

Abstract. In every discipline, we observed the so-called "digital turn" or the digital transformation in scientific collaboration. A survey was designed and applied to researchers within the framework of the H2020 project EULAC Focus. The researchers consulted embrace different disciplines and are located in different universities and research institutes. There are 305 different interviews and 159 variables or observed responses. The research explores how information and communication technologies in this specific professional setting have affected the way in which research teams are related. In particular, this investigation explores the extent to which scientific networks are composed and how they collaborate thanks to the applied informatics, observing the digital tools used by researchers to communicate and collaborate.

Keywords: Scientific collaborations · Digital transformation · Research groups · Scientific publications · Scientific networks

1 Introduction

Unlike previous generations, researchers today have a seemingly endless variety of potential scientific collaborations and research networks available through digital tools based on applied informatics. Thanks to the Internet, less time and efforts are required to begin and manage a scientific collaboration. Some studies have shown that Internet-mediated collaboration is generally thought to increase scientific productivity [1,2].

This article explores how information and communication technologies in this specific professional setting have affected the way research teams are related. A research team or group is conceived as any contact network integrated by at least 2 researchers, with a common purpose, regardless of whether or not they belong to the same institution, different institutions or even different countries. In particular, this investigation explores the extent to which scientific networks are

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composed and how they obtain and manage information thanks to digital transformation. Observing the ways of communication and collaboration of research teams, information search and access to the knowledge, and the major trends and changes they have perceived in the last years.

In this paper, we are interested in identifying which are the digital mechanisms that account for success in scientific collaborations and the principles of co-evolution of the digital infrastructures in scientific communities. For this purpose, a survey was designed and applied to researchers within the framework of the EULAC Focus project. The researchers consulted embrace different disciplines and are located in different countries. The objective was to study how the new information and communication technologies have affected the way research groups are related. The first response was recorded on 12/16/2016 and the last on 2/13/2018. Members belong to both European and American countries. There are 305 different interviews and 159 variables or observed responses. As to date there is limited research specifically on digital tools based on applied informatics, this study aims to be an exploratory investigation that identifies the various affordances and transformations provided by the technologies, with the intent of also highlighting areas in need of further research.

These are the two hypotheses that have guided this research:

– *Hypothesis 1.* Scientists working in local research teams tend to have less scientific collaborations/publications.
– *Hypothesis 2.* Scientists tend to use online tools for the production of scientific collaborations/publications.

To test these hypotheses, we will observe the size of the networks of the researchers, its structure (local or global), the frequency of interactions and the modality (analogical or digital tool) in relation to the number of publications.

What follows is a brief review of the existing literature and the study's methodology, and then a more in-depth exploration of emerging patterns of usage and their professional consequences.

2 Methodology

2.1 Design and Measurements of the Survey

This is a quantitative research consisting of an online survey sent to a multistage random sample of European and Latin America and Caribbean university researchers in all disciplines via email from the accounts of the members of the EULAC Focus project (10 scientific institution in Latin American and Caribbean countries, and 9 in European Union) to their scientific networks connection and institutional colleagues.

The invitation was then subsequently shared via email and social networks (Twitter, Facebook, LinkedIn, ResearchGate, Academia.edu) by willing network connections in a 'snowballing' fashion [3]. While the 'snowball method' can have epistemological limitations with regards to generating statistically significant representative samples, the research method is nevertheless capable of collecting data indicative of broader social patterns and trends, especially when the survey reaches a broad cohort of participants [3–6].

The study population contains researchers, including Ph.D. students and postdoctoral researchers. The questionnaire contained items relating to digital transformation in science, detailed questions about digital communication and scientific production, in addition to questions about their research activities. In terms of statistics, the methodology includes a combination of descriptive and inferential analyses based on the data collected. For the inferences, the Poisson regression model [7] is used, in its variant that corrects the over dispersion present in the data, quasi Poisson. This model, a member of the family of generalized linear models [8], has a clear application when the response variable is the product of case counting and seeks to determine rates associated with a period of time (here, number of publications per year). All data processing was done in R Statistical Software [9].

The objective was to study how the new information and communication technologies have affected the way in which work teams are related through 159 variables or observed responses. The survey consisted of a combination of open-ended, multiple-choice and Likert-scale questions and took approximately 15–20 min to complete.

Only a subset of the variables collected in the survey are used for current analysis. There are three variables that are constructed from others:

- PubTotal: contains the total number of publications reported in the survey.
- PubScience: contains only the number of publications considered as scientific.
- Loc: Contains the grouping of locations of reported team members.

2.2 Data Collection

The first response to the survey was recorded on 12/16/2016 and the last on 2/13/2018. Members belong to both European countries and American countries, for a total of 18 countries. The survey had a total of 305 respondents, of whom most, but not all, answered all questions under consideration. In addition, for this research, the responses of those interviewed who indicated that they worked alone were not considered, only those who indicated that they were working as a team or both. In terms of gender, 4 people preferred not to inform (1%), 101 are female (34%) and 200 are male (66%). This leaves a total of 264 interviews to consider. Figure 1 shows the demographic pyramid of the surveyed.

The figure shows that those responding to the survey are mostly male, with ages between 33 and 45 years old. Moreover, female scientists face 'patrifocal' constraints in some developing world cultures that limit their access to new technologies and the ability to network outside the domestic arena [10]. Age is also a social factor that differentiates access to social networks (generally favoring experience and tenure) and technology adoption and use (generally favoring youth). In combination, unequal access to network and technology resources

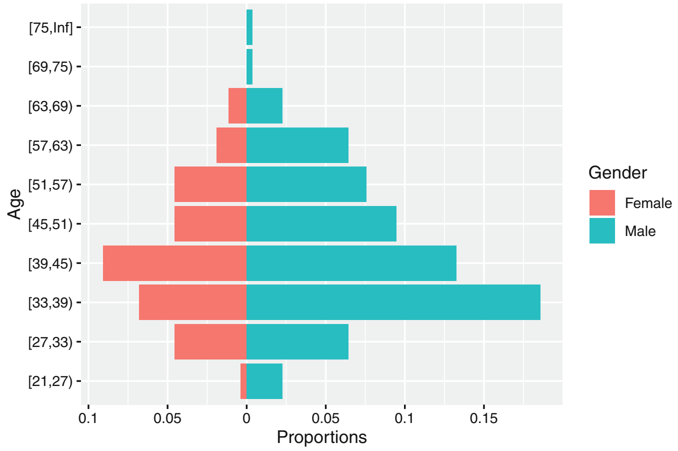

Fig. 1. Demographic pyramid of the sample

along regional, gender and age dimensions can be grouped together under the phrase 'geo-social asymmetries' [1].

Detailed demographic information was collected from the research participants, because it is one of the main objective of the EULAC Focus project. Researchers from 18 different countries were surveyed, 67% of the respondents work in an Ecuadorian university, followed by Mexican universities (14%) and Spanish universities (5%). There is an obvious bias towards Ecuador, because the principal researcher is based in this country. All other countries represent 13% of the sample. For regions, we have 1% from USA, 9% from European Union, and 90% from Latin American and Caribbean Countries.

The majority of participants work in universities (92%), where they are professors (68%), graduate students (13%), and post docs (5%). There is a balance between the surveyed who embrace scientific or technical careers and humanistic or artistic careers.

3 Results

3.1 Scientific Production

In this first section of our results, we will focus on the production of the researchers that have answered all the questions of the survey. Two response variables were constructed, considering the sum of the total (PubTotal) and the scientific production (PubScience) measured in publications count terms. Both are counting variables, suggesting the use of the Poisson distribution. In the data set the estimated mean for the total production is 10.06 and its estimated variance is 86.93. For scientific production, the estimated mean and variance are 7.99, 53.49, respectively. So, we note over-dispersion problems. For this reason, quasi-Poisson regression models are proposed for its analysis.

The following is the list of variables and its levels, in case it is not of a numerical type. The first level is the reference level and is written in italic letters.

- **Country**: *Argentina*, Brazil, Chile, Colombia, Cuba, Czech Republic, Ecuador, France, Germany, Italy, Mexico, Netherlands, Peru, Portugal, Spain, UK, USA, Venezuela.
- **Gender**: *Female*, Male, Prefer not to say.
- **Position**: *Academic technician*, Associate Professor/Reader, Director, Doctoral student, Head of Hospital Teaching, Lecturer/Fellow, Master, Masters student, Occasional Professor, Official Radiation Protection, Post Doc/Assistant, Private company worker, Professor, Project Manager, Research Assistant, Research technician, Researcher, Scientific Director, Senior Lecturer/Senior Fellow, Senior Researcher, Student.
- **InsType**: *Government*, Private Sector, Public Research Institute, University.
- **Discipline**: *Agricultural Sciences*, Astronomy And Astrophysis, Chemistry, Earth Sciences, Economic Sciences, Geography, History, Legal Sciences And Law, Life Sciences, Linguistics, Mathematics, Medical Sciences, Other, Pedagogy, Physics, Politic Science, Psychology, Science (Field Not Defined), Science Of Arts And Letters, Science of Earth And Space, Sociology, Technological Science.
- **AloneTeam**: *Alone*, Both, Team.
- **LocSameIns**: *FALSE*, TRUE.
- **LocDiffIns**: *FALSE*, TRUE.
- **LocDiffCou**: *FALSE*, TRUE.
- **FreqInt**: *Bi-weekly*, Daily, Less often, Monthly, No answer, Twice a week, Weekly.
- **ContactLetter**: *Essential*, No answer, Not Used, Used.
- **ContactPhone**: *Essential*, No answer, Not Used, Used.
- **ContactEmail**: *Essential*, No answer, Not Used, Used.
- **ContactList**: *Essential*, No answer, Not Used, Used.
- **ContactInsMess**: *Essential*, No answer, Not Used, Used.
- **ContactVideoC**: *Essential*, No answer, Not Used, Used.
- **Age**: (Numeric).
- **pubTotal**: (Numeric).
- **pubScience**: (Numeric).
- **TeamSize**: (Numeric).
- **Loc**: *DiffIns*, DiffIns/DiffCou, SameIns, SameIns/DiffCou, SameIns/DiffIns, SameIns/DiffIns/DiffCou.

A first, purely additive, quasi-Poisson regression model to study the association between the response variable (pubTotal) and the remaining explanatory variables is as follows:

$$\begin{aligned}\log(\lambda_1) = {} & Country + Gender + InsType + Position \\ & + AloneTeam + Discipline + Loc + FreqInt + ContactLetter \\ & + ContactPhone + ContactEmail + ContactList + ContactInsMess \\ & + ContactVideoC + Age + TeamSize\end{aligned} \tag{1}$$

where λ_1 is the rate of total publications per year.

Tables 1 and 2 contains the analysis of deviance of the model factors, with terms added sequentially (first to last). The reference level in each case is the first. In bold type are indicated the factors that are significant at $\alpha = 0.1$ (that is, with 90% confidence)[1].

Table 1. Analysis of deviance for total production (1).

	Df	Deviance	Resid. Df	Resid. Dev	Pr(>Chi)
NULL			263	1731.06	
Country	17	171.41	246	1559.66	**0.0228**
Gender	1	2.41	245	1557.25	0.5124
InsType	3	7.38	242	1549.87	0.7258
Position	18	201.36	224	1348.51	**0.0074**
AloneTeam	1	1.99	223	1346.52	0.5515
Discipline	19	230.27	204	1116.25	**0.0024**
Loc	5	51.75	199	1064.50	0.1008
FreqInt	5	29.72	194	1034.79	0.3813
ContactLetter	2	2.56	192	1032.23	0.7963
ContactPhone	2	43.90	190	988.33	**0.0201**
ContactEmail	2	1.61	188	986.71	0.8662
ContactList	2	39.29	186	947.42	**0.0302**
ContactInsMess	2	29.25	184	918.17	**0.0739**
ContactVideoC	2	51.21	182	866.96	**0.0105**
Age	1	10.11	181	856.85	0.1798
TeamSize	1	20.65	180	836.20	**0.0552**

Now, scientific production refers to the number of publications per year that take into account only those considered as scientific production, so that if λ_2 is the rate of annual scientific publications (pubScience), a second purely additive model proposed is:

$$\begin{aligned}\log(\lambda_2) = & \, Country + Gender + InsType + Position \\ & + AloneTeam + Discipline + Loc + FreqInt + ContactLetter \\ & + ContactPhone + ContactEmail + ContactList + ContactInsMess \\ & + ContactVideoC + Age + TeamSize\end{aligned} \tag{2}$$

Comparing the results of Tables 1 and 2, it is important that the "Loc" factor is not significant when explaining the total publications, but it explains

[1] Hereafter, Df: Degrees of freedom. Resid: Residual. Dev: Deviance. Pr(>Chi) [or Pr(> $|t|$)]: p-value.

the scientific production. It is clear that the location of researchers in a team work has an impact on scientific production and not on all the publications. This activity can be done individually for the researcher with local and national means. Consequently, we will concentrate on scientific publications exclusively to analyze how liquid science is distributed in the scientific networks.

Table 2. Analysis of deviance for scientific production (2).

	Df	Deviance	Resid. Df	Resid. Dev	Pr(>Chi)
NULL			263	1325.94	
Country	17	118.50	246	1207.44	**0.0546**
Gender	1	0.43	245	1207.01	0.7534
InsType	3	8.46	242	1198.56	0.5839
Position	18	164.67	224	1033.88	**0.0040**
AloneTeam	1	3.31	223	1030.57	0.3827
Discipline	19	159.59	204	870.98	**0.0087**
Loc	5	43.12	199	827.86	**0.0777**
FreqInt	5	18.53	194	809.33	0.5126
ContactLetter	2	2.62	192	806.71	0.7399
ContactPhone	2	29.38	190	777.33	**0.0341**
ContactEmail	2	3.71	188	773.62	0.6527
ContactList	2	35.49	186	738.13	**0.0169**
ContactInsMess	2	16.60	184	721.53	0.1483
ContactVideoC	2	37.42	182	684.11	**0.0135**
Age	1	9.28	181	674.83	0.1442
TeamSize	1	22.79	180	652.04	**0.0221**

On the other hand, in Table 2, Gender, InsType, AloneTeam, FreqInt, ContactLetter, ContactEmail, ContactInsMess and Age factors are not significant, and will be excluded in the search for a more parsimonious model. This does not mean that they are not important, but that nowadays they do not seem to make a difference in scientific production, e.g. male or female essentially produce in the same way, and email and other forms of contacts excluded are valued by all of them in similar ways. Then the new model for pubScience is:

$$\log(\lambda_3) = Country + Position + Discipline + Loc + ContactPhone \\ + ContactList + ContactVideoC + TeamSize \quad (3)$$

Table 3 contains the analysis of variance of the model, now considering the levels of the factors versus the reference level. For space reasons the table include only levels that were significant for factors Country, Position and Discipline.

Table 3. ANOVA for scientific production (3).

	Estimate	Std. Error	t value	Pr(> $\|t\|$)	Exp
(Intercept)	1.97	1.03	1.92	**0.06**	7.20
CountryPeru	1.57	0.70	2.24	**0.03**	4.79
PositionResearch technician	−3.28	1.56	−2.10	**0.04**	0.04
DisciplineOther	0.74	0.40	1.86	**0.06**	2.09
LocDiffIns/DiffCou	0.09	0.21	0.41	0.68	1.09
LocSameIns	−0.03	0.16	−0.17	0.86	0.97
LocSameIns/DiffCou	−0.19	0.31	−0.62	0.53	0.82
LocSameIns/DiffIns	−0.39	0.22	−1.77	**0.08**	0.68
LocSameIns/DiffIns/DiffCou	−0.06	0.16	−0.39	0.70	0.94
ContactPhoneNot Used	−0.36	0.19	−1.91	**0.06**	0.70
ContactPhoneUsed	−0.27	0.13	−2.13	**0.03**	0.76
ContactListNot Used	0.11	0.18	0.59	0.56	1.11
ContactListUsed	0.34	0.17	2.03	**0.04**	1.40
ContactVideoCNot Used	−0.55	0.19	−2.85	**0.00**	0.58
ContactVideoCUsed	−0.19	0.12	−1.61	0.11	0.83
TeamSize	0.02	0.01	2.44	**0.02**	1.02

Table 3 is produced by fitting a quasi-Poisson regression model, since we assume that there is over dispersion in the sample. We add a column Exp with the exponentiation of the parameters estimates. The dispersion parameter Φ is estimated in 4.31, so the estimated variance is $7.99 \times 4.31 = 34.44$, near that one estimated directly from the data (53.49). The model goodness of fit is poor, as can be seen from the residual deviance (715.12) and residual degrees of freedom (197). Nevertheless, this is to be expected since only a very small subset of all the variables that would explain the variability is used.

All the factors in Table 3 are significant because at least one of its levels is significant. Then, we can interpret the estimators obtained from the model. Because the model fits in a logarithmic scale, the explanation is clearer by returning to the linear scale. Then, in mathematical terms the model (3) is:

$$\log(\lambda_3) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \beta_5 x_5 + \beta_6 x_6 + \beta_7 x_7 + \beta_8 x_8$$

where the estimated parameters are the $\beta_i, (i = 0, 1, \cdots, 8)$, β_0 is the intercept, and the values of the variables, x_i. The β_i are really vectors, because they accompany categorical variables that have one parameter for each level of the factor (minus the reference), except β_8 because TeamSize is a numerical variable and β_0. Then

$$\lambda_3 = \exp(\beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \beta_5 x_5 + \beta_6 x_6 + \beta_7 x_7 + \beta_8 x_8)$$

and if the other variables remain constant, the effect of the i-th variable on the mean λ_3 is $\exp(\beta_i x_i) = (e^{\beta_i})^{x_i}$ and every unit of increment in the variable x_i produces a multiplicative effect of e^{β_i} in the response λ_3.

In the next sub-sections we analyze each of the significant factors (levels) in relation to scientific publications productivity.

The Country: Figure 2 shows the box plot of pubScience by country. The highest median values in the sample correspond to Peru, Spain, and Venezuela, however, only the number of scientific publications in Peru is significantly different from the rest according to our model (3). This is because the reported with respect to Spain and Venezuela has a high variance.

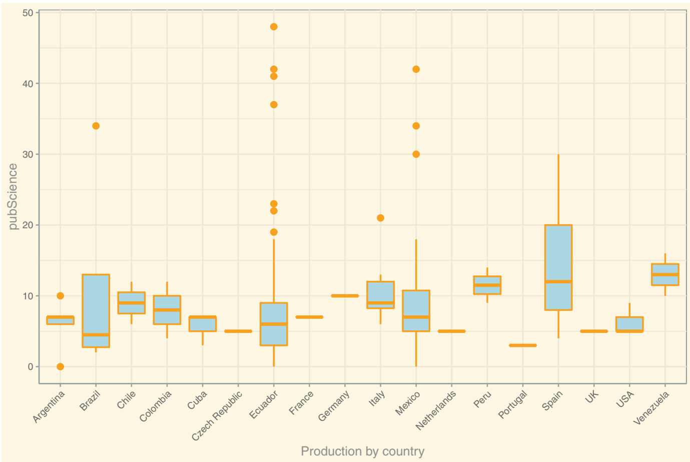

Fig. 2. Box plot of scientific publications by country

According to Table 3, the coefficient associated with Peru is 1.57, exponentiating 4.79, then a researcher from Peru has an estimated 4.8 times more scientific publications than a researcher from Argentina (reference level).

Position: The only significant level with respect to the position is Research technician. Its estimated coefficient is negative (−3.28), exponentiating 0.04, then research technicians have 0.04 times the number of publications that academic technicians (the reference level) and also that the rest of positions.

Discipline (Specialty): According to Table 3, the only significant level for discipline is Other. The scientific production is greater than the rest, but surely this is because in this category there are several different disciplines together. Consequently, the only interesting conclusion in this case is that there do not seem to be significant differences in the scientific production of the disciplines explicitly considered.

Location: In Fig. 3 the proportions of the research teams are shown, according to whether their members belong to the same institution (SameInst), to a different institution (DiffInst), to institutions of other countries (OtherCountry) or its combinations. The majority of their networks is located in the same institution (36%), 24% of the participants have colleagues in the same or in different institutions of the same country or in different countries. 20% of the sample report colleagues only from different institutions. The rest has similar interpretations. These proportions are useful to know the distribution of the research teams, and to know if the group is international or not.

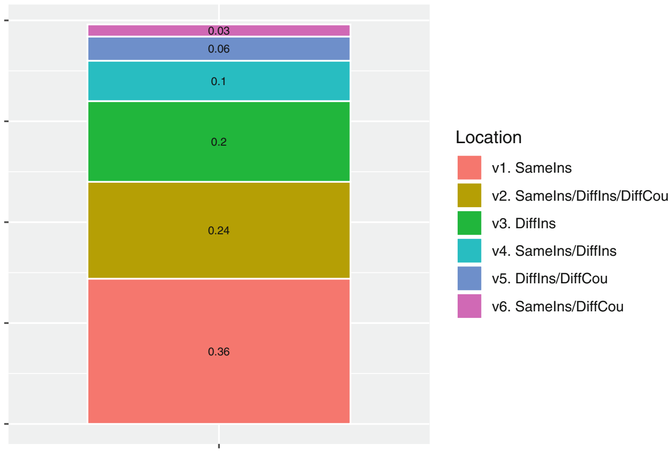

Fig. 3. Location of team members (proportions)

Figure 4 shows the box graphs for pubScience of each location level. The medians and variability displayed in figure do not show many differences for each level of location, however it is clear that those researchers who reported working mainly alone have the lowest productivity of the sample, while those who reported work both alone and with other institutions and other countries show the highest productivity.

According to our model, SameIns/DiffIns is the only factor that is significant. Its coefficient is -0.39, exponentiating 0.68, then the team that includes colleagues from the same institution and different institutions, has 0.68 times the scientific production than those teams that include colleagues from different institutions only (the reference level). Given the importance of these variables for the study, Table 4 contains similar explanations for the rest of the Location levels.

Then, it is interesting that the sample consulted reports a higher productivity if working in teams with different institutions only or different institutions and different countries. This result confirms Hypothesis 1 in the sense that productivity is estimated to increase when the research teams include members from

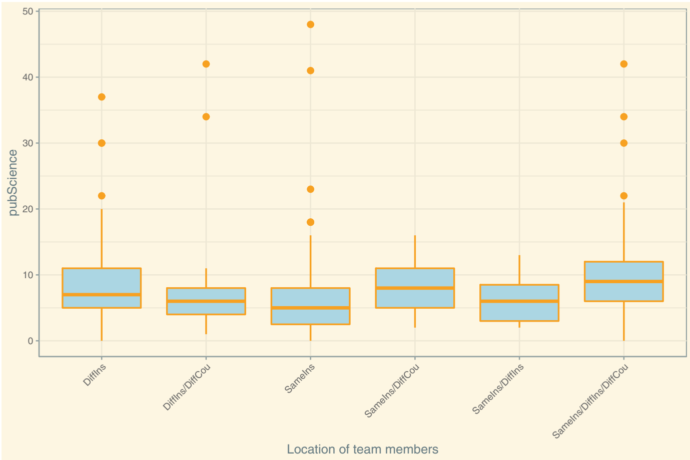

Fig. 4. Location of team members (boxplot)

Table 4. Location of the team members' analysis.

Level	exp(Est.)	Comment
DiffIns/ DiffCou	1.09	Teams that includes colleagues from different institutions and countries, has 1.091 times the scientific production that those teams that includes colleagues from different institutions only
SameIns	0.97	Teams that includes colleagues from the same institution only, has 0.97 times the number of scientific publications that those teams that includes colleagues from different institutions only
SameIns/ DiffCou	0.82	Teams that includes colleagues from the same institution and different countries, has 0.82 times the scientific production that those that includes colleagues from different institutions only
SameIns/ DiffIns/ DiffCou	0.94	Teams that includes colleagues from the same institution, different institutions and countries, has 0.94 times the scientific production that those teams that includes colleagues from different institutions only

different countries, and not just locals. This increase is slight but appreciable, as indicated by the first row of the Table 4.

Contact Means: The way we propose to analyze the scientific networks and how these networks work is to examine the construction of the links between researchers and the use of different technologies, analogical and digital. Researchers and analogical-or-digital devices constitute this network of a scientific community where everything is constantly under mediation and cooperation.

By focusing on the tools to communicate with the colleagues, we can observe how these have changed in the last years. Researchers have passed from analogical to digital tools to communicate with the rest of colleagues. The form to communicate in professional settings, and not, have changed strongly with the increase of the numbers of national and international networks. In Fig. 5, it can be possible to observe how researchers communicate with the rest of the nodes of their networks using analogical tools (Letters, Phone Calls) and digital tools based on applied informatics (Emails, Mailing Lists, Instant messaging, Video conference).

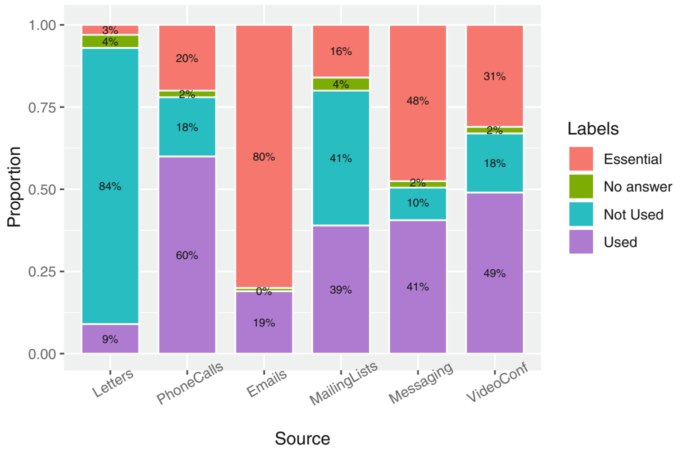

Fig. 5. All the mechanisms of contact the team members.

In Fig. 5, it can be observed how letters are not used by 84% (n = 256) of the researchers, converting it in an obsolete tool. A majority of researchers (80%, n = 244) agree that emails are essential in their professional tasks. This great agreement among the interviewees explains why these factors are not significant in our model.

In the last years messaging services via mobile have increased their impact to communicate between colleagues. For researchers, this service is considered essential and useful (89%, n = 269). Among the factors that are significant (see Table 3. The reference level is "essential"), we have:

- Phone: Respondents who say they have not used it have 0.7 times the scientific production than those who consider it essential. And those who say they have (but is not essential) has 0.76 times the scientific production than those who consider it essential. Clearly the use of the telephone is essential.
- Lists: Interviewees who say they have not used them have 1.11 times the scientific production than those who consider it essential. And who say they

have (but are not essential) have 1.4 times the scientific production than those who consider it essential. The use of lists is necessary but not essential.
- Video: Respondents who say they have not used them have 0.58 times the scientific production than those who consider it essential. And those who say they have (but is not essential) have 0.83 times the scientific production than those who consider it essential. Clearly the use of the video conference must be considered essential.

So, considering the use of the telephone and video conferencing as essential, as well as using the lists as a means of communication, increases the scientific productivity of the team. This affirms Hypothesis 2, since these mechanisms are characteristic of the digital era in communications.

The Size of the Network: One important question of the analysis is to understand if the researcher works in a collective way, if they prefer to work in a research team or alone. Only a small number of researchers, 6% (n = 19) work alone, and are excluded from this analysis. The size of their research groups is between 3 and 6 persons (63%), 34% of the researchers work in groups that have more than 6 researchers (see Fig. 6).

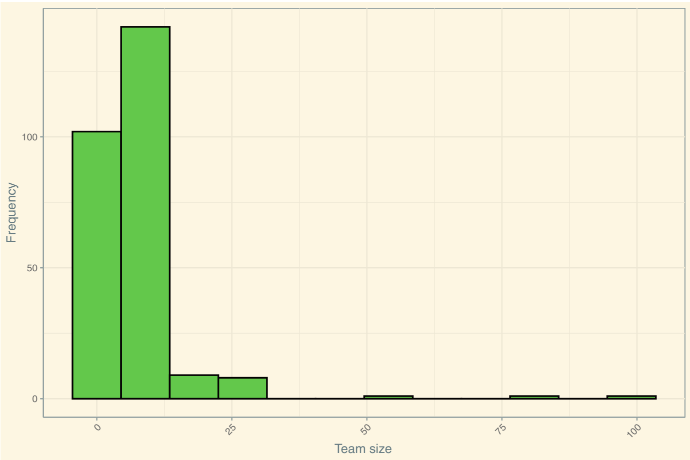

Fig. 6. Size of the research groups.

According to our model, each member that is added to the team increases 1.02 times the number of scientific publications. The importance of working in a team is evident.

4 Discussion

We have observed that more productive researchers work in medium and big research groups to achieve important results, and in consequence, to increase the number of scientific publications. Members of these research groups must come from different institutions and different countries to have advances in science. Heterogeneity of a research group is a determining variable to observe if the team can have a positive record or not.

It is surprising that in a digital era where the communication is instant and run to the screens, personal telephone conversations are considered essential to have great professional relations with the colleagues. Of course that emails and instant messaging are considered essential too, but phone conversations are needed to negotiate and to be clear between partners in order not to incur in misunderstandings caused by a text message. The use of this type of communication increases the number of scientific publications and scientific collaborations.

Video conferences are an evolution of phone conversations, where the body and facial expressions help to add more details to the voice, and for this it is considered essential to be more productive in science. This digital infrastructure based on applied informatics helps researchers to share and distribute scientific facilities regardless of their type and location in the world. Liquid science has increased collaborations between researchers, institutions and countries, creating a digital scientific infrastructure. In this new era, the effective and multimodal communication in teamwork is essential.

5 Conclusions

The most representative changes that digital communication in scientific networks has provided to the scientific community are mainly two: (1) The efficiency related to communication, and, (2) The information and knowledge flow.

The exploratory and explanatory findings offered by this study suggest that researchers view the digital transformation of science as welcome intermediaries to create and manage scientific networks. The majority of this study's participants believed that technology merely enhanced their abilities to work in scientific networks, increasing the number of their scientific publications.

Hypotheses 1 is confirmed since teams that include different institutions and countries show greater scientific productivity than teams composed only of local researchers. Hypothesis 2 is also confirmed as communications through digital media such as telephone, video conferencing or electronic lists are used and considered essential by those teams that show greater scientific productivity. A very clear recommendation is then that the research teams try to include among their members, researchers from different countries and get ready to use intensive media of the contemporary era.

Somewhat superficial and not specific, traditional views on the difference between analogic and digital tools is still largely prevalent. However, the conclusions that can be drawn from our analysis should be limited for three reasons. First, the lack of representatives of different countries; the research was carried out mainly in only three of them for the survey (Ecuador, Mexico, and Spain). Although, we have chosen these countries according to the availability of researchers that collaborate with the members of EULAC Focus project.

Thus, further research is needed. Second, the analysis related only to the uses of researchers from different disciplines and at different stages of their careers. These researchers can adopt and shape not shared perceptions of the digital tools that they use. Finally, data do not allow to test if these scientific networks generate some positive results to the research, or they are not competitive like other scientific networks, for example not build on digital technology. The project has bias that can conduct the researcher to respond in a positive way to the introduction of digital technology in their scientific activities and networks.

In the future, it is expected to improve the planning of the survey, seeking the prior construction of a specific sample framework. This, although difficult on a world scale, is worth it because it would allow to represent countries and different configurations of work teams in a better way.

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