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NÚMERO MONOGRÁFICO
Las Tecnologías de la
Información y de la
Comunicación (TIC)
y los nuevos contextos
de aprendizaje

ESTUDIOS SOBRE EDUCACIÓN

JUNIO

ESE

REVISTA SEMESTRAL DEL
DEPARTAMENTO DE EDUCACIÓN
FACULTAD DE FILOSOFÍA Y LETRAS



Universidad
de Navarra

ESE ESTUDIOS SOBRE EDUCACIÓN

REVISTA SEMESTRAL DEL DEPARTAMENTO DE EDUCACIÓN
DE LA FACULTAD DE FILOSOFÍA Y LETRAS DE LA UNIVERSIDAD DE NAVARRA
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Effect of Background, Attitudinal and Social Network Variables on PhD Students' Academic Performance. A Multimethod Approach¹

Efecto de las variables personales, actitudinales y de red social en el rendimiento académico de los estudiantes de doctorado. Un enfoque multimétodo

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Abstract:

INTRODUCTION: The aim of this paper is to predict the academic performance of PhD students understood as publications and presentations at conferences.

MATERIALS AND METHODS: We use a multimethod approach, a quantitative web survey of PhD students and their supervisors and in-depth interviews. We surveyed all PhD students at the University of Girona (Spain) in their 4th and 5th year, who held either a PhD grant or a teaching position at the university.

RESULTS: The explanatory variables of PhD performance are of three types: characteristics of the PhD students' research groups understood as social networks, back-

ground variables and attitudinal characteristics. The quantitative analyses show the importance of some background and attitudinal variables like supervisor performance, having a grant, or motivation. The qualitative results show networking to be also important. Policy implications are drawn at country and university level.

DISCUSSION: Policy implications are drawn at country and university level.

Keywords: academic performance, PhD students, multimethod approach, social networks.

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Resumen:

INTRODUCCIÓN: El objetivo de este artículo es predecir el rendimiento académico de los estudiantes de doctorado entendido como publicaciones y presentaciones en congresos.

MATERIALES Y MÉTODOS: Usamos un enfoque multimétodo, una encuesta cuantitativa por internet de los estudiantes de doctorado y sus directores y entrevistas en profundidad. Encuestamos a todos los estudiantes de doctorado en la Universidad de Girona (España) en su cuarto o quinto año que tenían o bien una beca o tareas docentes en la universidad.

RESULTADOS: Las variables explicativas del rendimiento son de tres tipos: características de los grupos de in-

vestigación de los estudiantes, entendidos como redes sociales, y características personales y de actitud. Los resultados cuantitativos muestran la importancia de variables personales y de actitud, como rendimiento de los directores, tener beca o motivaciones. Los resultados cualitativos muestran la importancia de las redes.

DISCUSIÓN: Se explican las implicaciones en política académica a nivel estatal y de universidad.

Palabras clave: rendimiento académico, estudiantes de doctorado, enfoque multimétodo, redes sociales.

INTRODUCTION

In our society it is extremely important to produce quality in any professional sector. At the highest level of education, which is the PhD level, academic quality should be given strong emphasis if society is interested in higher quality researchers at university and industry level. Research shows that PhD programmes are generally ill adapted to the changing and increasing demands that future PhDs will have to face (see Austin, 2002 and references therein). This is even more important in countries such as Spain, where the labour market is not particularly favourable to PhD's holders (Jacobsson and Gillström, 2006).

A key point for the academic quality of PhD's programmes is that their future PhDs achieve high academic performance. In the long run PhDs' performance is evaluated by the broader scientific community by means of the papers presented at conferences and published in journals (Green and Bauer, 1995). Our choice in this article is thus to assess performance by these same means. Understanding which variables influence PhD's performance is also relevant for research groups at universities in order to select the best PhD students and promote working conditions that foster a better performance.

The main goal of this article is thus to find the variables that make a difference in the performance of PhD students. The creation of new knowledge, which later turns into the PhD's academic performance, is an extremely difficult task (Delamont and Atkinson, 2001), and requires a necessary knowledge base (back-

ground variables) and the necessary motivation (attitudinal variables) to share (network variables) this new knowledge with mentors, in the group and in other relevant networks. In this article, these three types of variables are analysed simultaneously, namely characteristics of the research group understood as social network; and background and attitudinal characteristics of the PhD students and their supervisors.

Performance in creative teams or working groups has been approached from both managerial/innovation and education perspectives and even from both disciplines simultaneously, as some key variables like mentoring operate in a similar fashion (Paglis, Green and Bauer, 2006). A first group of authors stress the role of personal background. For instance, under the managerial perspective Cohen and Levinthal (1990) found that higher education and experience in learning tasks (i.e., seniority) influence knowledge creation and absorption of new information.

Another group of authors focused on the role of attitudinal variables such as group atmosphere, job satisfaction or motivation. Ivankova and Stick (2007) found that self-motivation and an online learning environment were predictive variables of PhD's performance. A meta-synthesis of the research on doctoral studies attrition and persistence (Bair and Haworth, 2004) shows motivation to be strongly related to doctoral degree completion, the lack of motivation being cited as the most important factor related to attrition. Similar findings are also found in the managerial literature (e.g. Nonaka and Takeuchi, 1995).

A third group of authors worked on the role of social network relationships within groups, including trust and communication among social network members (Wasserman and Faust, 1994). The basic idea behind this perspective is that an individual's success is strongly dependent on the relations with relevant others inside and outside the organisation (Burt, 2000). The importance of social relations in the network structure for individual performance can be captured by the concept social capital. The key points are the relationship between students and supervisor (Cryer, 2006), with the research group as a whole (Gulbrandsen, 2004) and socialization (Austin, 2002). On the other hand, being isolated in a research group can be one of the main problems for a PhD student (Rudd, 1984).

Several authors criticized that these three types of variables have rarely been used together for predicting performance in knowledge intensive jobs. In the managerial field, several authors (Harvey, Pettigrew and Ferlie, 2002; Smith, Collins, and Clark, 2005) included background and network factors, while Hargadon and Fanelli (2002) did include all three types.

In the academic literature, the importance of the three types of variables to explain the success of PhD students was suggested by Delamont, Atkinson and Parry

(1997, pp. 178-188; 2000), who criticised that the sometimes only criterion that universities use for recruiting PhD students is the possession of undergraduate studies. Other studies (Green and Bauer, 1995; Paglis, *et al.*, 2006) used the three types of variables empirically but restricted the network part to relationships with the supervisor only.

Our aim in this article is to empirically explain academic performance of PhD students by focusing on all these types of variables together and, unlike previous research, to include the research group networks. Our hypotheses draw directly from the above summary review of findings regarding each type of variable and boil down to:

A combination of background (H1), attitudinal (H2) and social network (H3) variables will better predict PhD students' academic performance than using a single type of variables only.

We use quantitative and qualitative data from PhD students and their supervisors in the University of Girona, located in the region of Catalonia in Spain. Tashakkori and Teddlie (2003) give strong arguments for combining quantitative and qualitative methods in studying complex phenomena that require data from different perspectives, and also to use the strengths of one method to enhance the other (Morgan, 1998). The use of the second method may be planned to elicit information that the prime method cannot achieve or to inform in greater detail about some results. In this article the quantitative is the core method, and the qualitative analysis is carried out afterwards to supplement the former.

The goal of the quantitative study is to operationalize a set of relevant attitudinal, background and network variables and combine them into a single regression model predicting performance. We collected the data through a web survey of PhD students and their supervisors. The goal of the supplementary qualitative study is to understand the PhD students' point of view and to know what or who fostered or hindered their research performance, especially with respect to hypotheses that are supported by the literature but failed to be confirmed by the quantitative study. In the qualitative study we conducted in-depth interviews with a subset of students that were identified either as extreme or as typical in the quantitative study.

PHD STUDIES IN SPAIN AT THE TIME OF CONDUCTING THE STUDY

At the time the study was conducted, PhD studies in Spain were not yet adapted to the Bologna reform with the objective of creating the European Higher Education Area. University master's degree programmes did not yet exist, and students who had completed a degree programme called "licenciatura" (about 300 credits) could

enrol in a PhD's programme. No other requirement was generally enforced, and individual PhD's programmes, often organized by single departments, were autonomous to decide which students to admit. See Jacobsson and Gillström (2006) for details.

PhD programmes were divided into three distinct stages. The first academic year involved attendance to about 200 hours of courses and seminars; during the second academic year the student wrote one or more research projects, and during the third year the student was asked to submit the proposal for the PhD's thesis. Thesis supervisors were not asked to fulfil any particular requirement, apart from having a PhD and having either permanent or temporary links with the department or institution coordinating the doctoral programme. It was not even required for them to have authored or co-authored any publication. (Jacobsson and Gillström, 2006). Therefore, this resulted in a high diversity of publication performances of supervisors.

Formally, there was no time limit for delivering the thesis. Depending on the field of study, the median time needed to complete it ranged between three and six years at the University of Girona. This made the whole PhD's programme last between five and eight years. It needs to be taken into account that grants only lasted four years and thus only supported students during their first two years of thesis writing.

Admittance to a PhD's programme did not automatically imply a grant or that the student would belong to the university academic staff. Some students, thus, earned a living in the private sector while doing their PhD. However, a substantial number of PhD students did belong to the university staff. Two main types of PhD students were in this latter situation.

- Some students already belonged to the university staff prior to starting their PhD. In fact, the lowest categories of teaching staff did not require candidates holding a PhD. The members of these categories of course needed a PhD if they were to get promoted. There was no requirement of these PhD students to belong to a research group although in practice it was so in most cases. Teaching was usually their main job.
- In the University of Girona roughly 50% of PhD students had obtained grants from the Spanish government, from the regional government, from the university itself or from a particular research project. These grants implied that the awarded PhD students had to be members of a research group. These PhD students had to teach no more than 60 hours a year and, therefore, research was their main job. The grant never implied that the students

would later get a permanent position at the university and thus most of them would end up doing a career in the private sector, even though some had wrongly hoped for a tenured position at the university (Jacobsson and Gillström, 2006).

QUANTITATIVE RESEARCH DESIGN

Instrument Development and Data Collection

Our population is made up of PhD students at the University of Girona who were either at the beginning of their 4th or their 5th year at the time the quantitative research was conducted between November 2003 and February 2004. We selected only PhD students having either a grant or a teaching position at the university. This choice was made because external PhD students for the most part do not belong to a research group and, thus, we would not be able to use the research group as a social network variable predicting the PhDs' performance. The quantitative research was part of a wider research project of the INSOC group (International Network on Social Capital and Performance), also carried out at the universities of Ghent (Belgium), Ljubljana (Slovenia) and Giessen (Germany).

The design of the questionnaire was a complex process including several focus groups and pre-tests (De Lange, 2005). The fact that we had to produce comparable versions in four languages and that different university systems were involved lengthened the process even further and implied two independent translations, a pre-test of the translated questionnaires and further discussions and modifications. In this paper we only focus on the results from the University of Girona. Two different web questionnaires were designed, for PhD students and supervisors (for further details see Coenders, Ferligoj, Coromina and Capó, 2007).

Web questionnaires simplify the administration of some complex questions (Tourangeau and Yan, 2007). For example, the software can retain the names of network members given in previous answers and supply them into later questions. Moreover, web questionnaires are self administered and thus improve data quality for sensitive questions such as those dealing with personal relationships (Dillman, 2007). Reliability and validity of our web network questions were reported to be high by Coromina and Coenders (2006). The average reliability over all contact frequency questions was 0.885 and the average validity 0.963.

Web surveys also have their drawbacks; the main of which being coverage and non-response errors. In our case, coverage error is absent because our popu-

lation has universal internet access. We reduced non-response by using personalized invitations, confidentiality assurance, clear instructions and short wording, by avoiding visual effects that might lengthen download, and by implementing several mixed mode follow-ups of non respondents by e-mail, letter and telephone (see De Lange, 2005).

Our population size was 86 PhD students and their supervisors. High response rates of 78% for PhD students and 71% for supervisors were obtained and after an exploratory analysis and data cleaning, 50 out of all 86 student-supervisor pairs had available data from both. The average response time was 31 minutes for students and 32 minutes for supervisors.

Operationalization of Variables

Dependent variable. Academic performance is operationalized as a sum of different types of academic publications and conference papers, both published and accepted at the time of data collection, and weighted according to their relevance as shown in Table 1.

Table 1. Academic outputs to measure PhD student's performance

Type of research output	Weight
Article in any international journal or in any journal with peer review	2
Book, book chapter or proceedings chapter with peer review	2
Article in a national journal without peer review	1
Book, book chapter or proceedings chapter without peer review	1
Internal research paper	1
Oral presentation or poster at a conference	1

We are aware that the operationalization of PhD student performance in terms of academic output and particularly of publications can have its limitations. However, the choice is not unreasonable given the fact that publications are taken more and more into account by the governmental agencies providing accreditations for jobs at universities.

The weights given to the different types of research output are more uniform than what is usual in the aforementioned agencies (for instance, in our scale an article in an international journal with a high impact factor counts only twice as much as a conference paper). We also considered using less uniform weights but any at-

tempt to increase the relevance of high impact publications nearly doubled the skewness of the performance distribution and made it too much affected by the field of study, as certain fields tend to favour certain types of output. Besides, at early stages of the academic career, a large number of outputs fall into the lower categories: internal working papers and conference presentations.

Background variables (H1). The variables used for the prediction of PhD students' performance are related to personal characteristics (age, gender and having children), previous education and academic achievement (the "licenciatura" gradings and the year in which students obtained their "licenciatura"), experience (the seniority at the department and the current PhD academic year) and knowledge diversity (belonging to the teaching staff or having a grant, and supervisor's performance, obtained in the same way as student's performance from the supervisor's questionnaire).

Attitudinal variables (H2). Since the small sample size prevented the use of structural equation models, we opted for a simpler and yet consistent method to deal with measurement error bias in attitudinal variables, which is disattenuated regression using summated rating scales or SRS (Lord and Novick, 1968). The steps taken were the following:

- The sets of unidimensional items from which to compute the SRS were identified by means of exploratory factor analysis.
- The SRS reliability was computed by means of Ω (Heise and Bohrnstedt, 1970). Unlike Cronbach's α , Ω does not assume items to be tau-equivalent.
- The disattenuated correlation between SRS_i and SRS_j was computed as:

$$\hat{\rho}_{dij} = \frac{\hat{\rho}_{ij}}{\sqrt{\Omega_i \Omega_j}}$$

- The regression model was estimated by ordinary least squares from the disattenuated correlations.

A first group of SRS relates to the reasons or motivations to start a PhD such as motivation for autonomy or for the research job; a second group relates to the social atmosphere in the research group; a third group to the integration of the PhD thesis within the research group; a fourth group to PhD students' relationships with supervisors; and a fifth group to the attitudes towards publishing and towards work. The SRS names and their Ω reliabilities are shown in Table 2.

Table 2. Scale names, reliabilities and attitudinal variables

SRS name	Ω	Attitudinal variables
Motivation to start PhD: Autonomy (3 items).	.799	Reasons to start A PhD
Motivation to start PhD: Academic career (3 items).	.720	
Motivation to start PhD: Research interest (3 items)	.709	
Motivation to start PhD: Career advantages (3 items)	.703	
Atmosphere in the research group (5 items)	.916	Social atmosphere in the research group
Integration of the PhD thesis within the research group tradition (3 items)	.672	Integration of the PhD thesis within the research group tradition
Guidance of supervisor during PhD (3 items)	.790	Relationships with the supervisor
Too close supervision by supervisor (2 items)	.802	
Promotion of student's external contacts by the supervisor (3 items)	.830	
Job involvement (4 items)	.764	Attitudes towards publishing and towards work
Attitude towards publishing (5 items)	.823	
Meaninglessness feeling at work (3 items)	.708	
Loneliness feeling at work (3 items)	.700	
Satisfaction at work (6 items)	.794	

Attitudinal questions were asked using 7-point Likert or semantic differential formats.

Social capital and social network variables (H3). Social networks refer to the PhD students' research group relational structure. Despite the fact that the University of Girona had an official list of research groups, in some cases they were not a good reflection of the actual working networks. Many groups were unrealistically large, with members that were not particularly active or with fairly independent sub-groups working on diverging topics.

Instead of these official lists, we were more interested in the active members of the research groups connected to the research topic of the PhD student. Prior to the quantitative data collection, we carried out focus groups with leading researchers of different fields, where we defined a set of questions to be asked to supervisors of PhD students in order to obtain the research group member names:

- Name all the teaching assistants (or doctoral assistants) whose research is mainly under your supervision.
- Name all the researchers of whom you are formally the mentor and who work on or participate in a research project.
- Name your colleague professors, senior researchers, junior researchers or people working in the private sector with whom you substantially work together on those research projects in which PhD student [name] is involved.

After the supervisors had been interviewed to get the composition of the research groups, the names of the group members were introduced in the network questions of the web survey. One example of these questions (concerning collaboration in the research group) is shown in Figure 1. This personalized way of delivering the questionnaire made the response to the questions much easier.

Figure 1. Example of social network question about collaboration

Consider all situations in the past year (namely since 1 november 2002) in which you collaborated with your colleagues concerning research, e.g. working on the same project, solving problems together, etc. The occasional piece of advice does not belong to this type of collaboration. How often have you collaborated with each of your colleagues concerning research in the past year?

	<i>Not in the past year</i>	<i>Once in the past year</i>	<i>Several times a year</i>	<i>About monthly</i>	<i>Several times a month</i>	<i>Weekly</i>	<i>Several times a week</i>	<i>Daily</i>
Name 1	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Name 2	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
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Name 4	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

The type of social networks considered were drawn from the literature (De Lange, 2005; Sparrowe, Liden, Wayne and Kraimer, 2001).

- *Collaboration*: measured with question in Figure 2.
- *Scientific Advice*: frequency of asking colleagues for scientific advice about work-related problems.
- *Crucial information*: frequency of asking colleagues for information/data/software.
- *Emotional Support*: extent to which respondents discuss about serious problems at work with colleagues.

- *Trust*: extent to which respondents trust or distrust their colleagues regarding work related matters (e.g. theft of ideas, order of coauthorship).
- *Getting on well*: how respondents get along with each of their colleagues.
- *Socialising*: frequency of engaging in social activities with colleagues outside work.

The social network measures used in the quantitative analysis are:

- Average contact intensities between the PhD student and the remaining group members for each network separately, assigning scores from 0 (not in the past year) to 7 (daily) to the categories in Figure 2.
- Research group size.
- Number of different institutions which the members of the research group belong to.
- Count of researchers external to the research group that have advice or collaboration relationships with the PhD student (for these two networks, respondents were asked to include also contacts outside the research group).
- Frequency of supervisor advice.

QUANTITATIVE RESEARCH RESULTS

Of the 50 complete student-supervisor pairs, 12% belonged to social science fields, 46% to natural and physical sciences, 28% to technical studies and 14% to arts and humanities. 10% of the students had children, 66% were male, and 58% had a grant. Average student's seniority at the department was 4.6 years (SD 1.9), average student's age was 29.9 (SD 6.3), average research group size was 7.4 members (SD 2.7), average performances were 14.4 (students, with SD 12.8) and 33.0 (supervisors, with SD 22,7).

Seven regression models were estimated with PhD students' academic performance as the dependent variable. Each regression model contained one combination of the variable types described above. The adjusted R^2 for each of them are shown in the upper part of Table 3.

The procedure used to select the relevant variables in these regression models consisted of, first, checking for high correlations among variables in order to prevent collinearity and, then, remove from the regression model one by one variables with a non-interpretable effect sign or with a p-value larger than 0.10.

Table 3. Combination of regression models and final regression model for predicting PhD students' performance

Model Summary	Adjusted R ²
Background regression model	.469
Attitudinal regression model	.045
Network regression model	.035
Network - attitudinal regression model	.084
Background - network regression model	.456
Background - attitudinal regression model	.496
Background -network- attitudinal regression model	.486

Model detail: Background - attitudinal regression model	$\hat{\beta}$	t-value	VIF
Supervisor performance	.444	3.950	1.154
Seniority at the department (years)	.725	5.026	1.901
Having a grant (dummy: 1=yes)	.253	1.867	1.683
Having children (dummy: 1=yes)	-.317	-2.599	1.355
Motivation to start PhD: Autonomy	.193	1.818	1.028

By comparing the adjusted R² we can decide which sets of variables add on predictive power provided by other sets. We can see that network variables do not bring in any additional predictive power for PhD students' performance in the quantitative analysis (hypothesis H3 is not supported). The best model is thus the one containing background and attitudinal variables (H1 and H2 are supported).

The lower part of Table 3 shows the information on the final background-attitudinal regression model, the standardized regression coefficients, $\hat{\beta}$, the t-values and the variance inflation factors (VIF), which show collinearity to be very low.

Supervisors' performance and students' seniority at the department seem to be the most decisive predictors of students' performance. Also we found that PhD students holding PhD grants publish more than students who do their PhD while being teaching staff. Finally, PhD students who have children publish less. The only attitudinal variable from the model shows that students who are more motivated for autonomy in research when enrolling in the PhD (which included the items "possibility to steer my own research", "independence at work" and "intellectual freedom") publish more. No significant variable is found from the network set, although supervisor's performance can also be understood from a network's perspective, the supervisor being an important member of the student's network.

QUALITATIVE RESEARCH DESIGN

The reason to embark on a qualitative follow-up study was that network variables had failed to predict performance in the quantitative study (hypothesis H3), despite the empirical evidence both in the management and academic literature. The goal of the qualitative study is to understand the PhD students' point of view, their feelings and perspectives about publishing and to know what or who helped them in their research performance and what or who made their research performance difficult. From the qualitative research we expected to get support for H3 from interviewees linking the opinions on their networks with opinions on academic achievement.

We collected data using in-depth interviews. The questions were formulated as generally and openly as possible, in order to give respondents the freedom to express their views and not restricting responses to just the network variables which were of interest to us. The interview contained only three questions, though respondents were encouraged to provide additional details through extensive probing by the interviewer. The three questions were:

- Could you explain your experience of doing your PhD at the University of Girona?
- Everybody says that publishing is very important for PhD students. Could you explain me your publishing experience?
- Could you tell me what advice would you give to a new PhD student?

The interviews were conducted by one of the authors of this article between July 2007 and May 2008. We used two purposive sampling techniques in order to select a subset of the cases in the quantitative study that might best illuminate the research question. *Extreme/deviant case sampling* involves seeking out the most extreme successes and failures, so as to learn as much as possible about the outliers. *Typical case sampling* seeks those cases that are the most average or representative.

Table 4. Typical and extreme cases regarding networking and performance

		Research group networking potential		
		Low	Average	High
Performance	Lower than expected	Extreme		Extreme
	As expected		Typical	
	Higher than expected	Extreme		Extreme

In order to sample a few cases in each shaded cell in Table 4, we needed to construct a measure of networking potential and a measure of meeting the expectations regarding performance for all cases in the quantitative sample. The former was computed with a principal component analysis of all network variables and the latter from the studentized residuals in the regression model in Table 3. The qualitative sample size was 16.

The interviews were tape recorded, transcribed verbatim and coded by one of the authors by using the Atlas.ti software. Another of the authors reviewed the codes and the assignment of paragraphs to codes. We, then, classified the items reported by PhD students either as triggers or hindrances to publishing, and either as related to the student's network or not

QUALITATIVE RESEARCH RESULTS

The fact that 112 out of the 165 instances mentioned by the students had to do with their networks suggests networks to be more important than shown by the quantitative analysis and clearly supports H3.

The network items mentioned as being relevant for the publication performance are related to the supervisor, to the research group and to external researchers. As regards the supervisor, many students told that the supervisor advice was helpful, specially in the initial stages to get a broad strategic orientation "*at some point my supervisors advised me to leave a specific part of the project and move on to another thing, (...) «You're going astray, this is not the way to go»*". Most of the interviews mentioned the quality of the supervisor advice rather than its frequency, as measured in the quantitative study. Many raised the point that a good supervisor should be interested in the student's PhD thesis, which was not considered in the quantitative questionnaire either. Many students considered that supervisors specifically taught them how to publish, for instance, how to organize the articles and correct the language, "*the first two articles were written almost entirely by my supervisor, I mean, I provided the tables, the figures, all the information, but the writing itself was practically done by my supervisor, and he showed me how it should be done*".

As regards the research group as a whole, most of the students pointed at colleagues as the main source of support for research. Easily meeting research group members was most often mentioned, even the fact of sharing an office or laboratory. "*We have a room for students to work in and which functions as well as a library, a meeting room*". PhD students can, then, get valuable help from group members because of their availability to ask questions at any moment, which makes it easier than asking the supervisor "*You have many doubts, especially at the beginning, (...) you*

can't go to your supervisor, say, with a thousand doubts". Many also mentioned that having other PhD students in the research group helped them as they could best understand each other's problems *"having contact with people who have the same problems as you helps you find better solutions faster"*. Belonging to a research group which pushes students into publishing was also helpful. If students felt that their articles were important within the research group, they were more motivated *"it's been so thanks to this policy, the policy of publishing the results you get when you do some research work"*. The quantitative questionnaire did not include such items as sharing physical spaces or the presence of other PhD students in the group.

Meeting researchers outside the research group was very frequently mentioned as a positive factor as well, related both to contact diversity and to possible future external collaboration.

Non-network related aspects which helped students to publish were of a rather attitudinal nature. The most mentioned were to have a high motivation for research as a whole, for the research topic and for self planning. Working conditions were also mentioned, particularly having the time to concentrate on the thesis as a main task *"during the four years of my PhD I wasn't burdened with additional tasks... for example classes, so I could devote my time to researching"*. Working conditions and time use were absent from the quantitative questionnaire, although implicitly, they were likely to emerge in the quantitative results by means of the 'having-a-grant' variable. In fact, favourable working conditions were mostly mentioned by students with a grant. Students with a grant also mentioned much more often visiting other universities. *"In Amsterdam I met... this thesis supervisor. He's top in my field of research. He is one of the most influential people in the world"*.

As regards hindrances related to network issues, the interviews showed that a lack of network contacts hindered students from publishing. This included small group size *"if you're in a small group and you're the one who knows the most about a certain subject, then you can't consult things"*, loneliness *"most days I'm alone at home or at the archive, also alone"*, few meetings or group seminars, lack of other PhD students in the group, and lack of supervisor advice for a variety of reasons such as distance, lack of time or of supervisor's knowledge in the topic.

Non-network aspects which hindered students from publishing were related to the lack of time to publish, in general terms and, specifically, due to teaching or to administrative work. As expected, these issues were mostly mentioned by students without a grant. The lack of resources within the research group hindered them as well. Research groups obtained their resources depending on their performance and the fund raising ability of certain members or, as often mentioned, through sheer size *"it's a small group and (...) I'm happy with my group but I am not*

with the support we're given". Overall, students without a grant mentioned much more often non-network hindrances.

DISCUSSION AND POLICY IMPLICATIONS

The relevant variables in the quantitative study are supervisors' academic performance, seniority, having or not a grant, having or not children and motivation for autonomy at work.. As mentioned, our findings included a combination of types of variables, which partly supports our initial research hypothesis (H1 and H2). The most relevant finding is, as we pointed at the beginning, that PhD students are influenced by their supervisors, which was also suggested by Cryer (2006), Delamont *et al.* (2000) and Austin (2002). PhD students whose supervisors publish and attend conferences more often will follow the same rule. Following the Nobel Prize laureate Samuelson (1972) "*I can tell you how to get a Nobel Prize ... by having great teachers*".

The influence of supervisors is supported by the organizational literature as well (Chao, Walz and Gardner, 1992; Noe, 1988), as mentoring in business organizations somewhat resembles PhD student supervision. These results could also be related to social resource theory (Lin, 1990), which stresses the importance of the contacts through which resources can be accessible, in our case, the contacts with the supervisor as a source of publication know-how.

Seniority at the department also has predictive power for performance. A person who is a member of the department since longer will better know how the department is organized, and therefore can focus more on publishing. That person will already know the most adequate people to work with. Seniority is also helpful because of the sheer fact that publishing involves a long process from the first idea to the final publication. This is in agreement with Cohen and Levinthal (1990), who also proposed that higher levels of experience enable individuals to more readily understand and absorb new information. One might suspect that the seniority effect is confounded with age, but age was not significant when controlling for seniority, whereas seniority was when controlling for age.

Two background predictors seem to hint at the importance of time use. Having a grant improved performance. This was to be expected given the far better working conditions and available time for research of students with a grant. Having children obviously reduces the available time for research, at least if we assume that much research gets done at home beyond compulsory working hours. However, no gender effect was found.

The last variable with predictive power for performance is attitudinal. The more PhD students were motivated by autonomy, the higher their performance

(Gulbrandsen, 2004). The number of publications is higher for doctoral students who prefer to have more intellectual freedom or to be more self-organized.

As regards the qualitative study, the supervisor again emerged as a key actor. In addition to the supervisor's performance, we found other more intangible elements, such as high quality advice and interest in the topic. Seniority was not mentioned at all. Time use was, especially on the negative side by students not having a grant. Motivational variables again emerged as relevant.

What is really new to the qualitative results is the emergence of variables related to the network as a whole, thus supporting hypothesis H3, which had failed to obtain support from the quantitative data. The quantitative network measures, mostly having to do with presence or absence of contact and its frequency, failed to collect information that is relevant according to the qualitative study, such as support by other young researchers, quality of group performance, expertise of network members, group culture pushing to publish, or even the quality of physical meeting places. These characteristics are linked to our literature review, which suggests the influence of the research group as a whole (Gulbrandsen, 2004), socialization (Austin, 2002) or the negative effect of isolation (Rudd, 1984). In other words, quantitative social network measures might not be able to grasp the whole impact of network variables on performance. The vast majority of social network analysis literature makes use of quantitative measures (Breiger, 2008; Wasserman and Faust, 1994) but the case analysed in this article shows that, in occasions, this can be misleading. The particular type, characteristics and variety of the resources available through the network and the behavioural aspects of the relations have been shown to be of relevance to predict the behaviour of PhD students. These results support the claim made by some literature on social network analysis that the content of ties can matter as much as the structure of the networks (Ahuja, 2000; Hite, 2005). More research is then needed in social network analysis in which the quantitative and qualitative aspects are balanced.

Finally, the results of this article suggest a number of useful policies for improving PhD students' success. The quantitative study has shown that supervisors' performance is crucial for PhD students' performance. In the sample there was a high diversity in the publication performance of supervisors, as revealed by a very high SD-average ratio. For many students, having a mediocre supervisor is, thus, a considerable hindrance. Fortunately this situation has recently changed; according to current legal regulations, students can only be supervised by doctors with proven research experience, though individual universities enjoy some freedom in deciding how research experience is to be proven. The results of this article should encourage universities to be strict in this respect.

In current standards, the average degree grade is one of the most used indicators to decide whether a person is able to obtain a grant, or to enrol in a PhD programme. This variable did not emerge as relevant in either the qualitative or the quantitative analysis. On the contrary, motivational variables showed their relevance both in the quantitative and qualitative studies. The selection process should, therefore, take motivations into account and involve long interviews with candidates.

Having a grant also emerged as a helpful factor in both the quantitative and the qualitative studies. The obvious implication is the need to offer more grants for PhD students and ensure that PhD students with a grant really have the PhD thesis as the main task, as mandated by law.

The qualitative study mentioned lack of resources as an important factor, often linked to small group size. An obvious policy implication is to improve the resources of high quality groups independently of their size. These resources need not be only financial but can include the allocation of a large number of PhD students with grants, and travel money, as travel and a critical mass of PhD students were commonly reported as important in one way or another.

The qualitative study also revealed that the research group is a key factor for student success. An obvious policy implication is to allocate grants to high performing research groups. At the moment of finishing the study, this was the case of the University of Girona grants, which were giving more weight to the group CV (60%) than to the candidate's CV when allocating grants to groups. The Spanish ministry, at the time of finishing the study, still allocated a very low percentage to the group CV (10%, although it allocated a further 20% to the supervisor's CV). Another obvious implication would be to mandate or at least encourage all PhD students' integration in a research group, having a grant or not.

The Bologna Reform in Spain will lead to PhD programmes focused only on research and leading to PhD theses and, supposedly, publications. The first year mandatory courses have been suppressed. This change will make the results in this article even more relevant than beforehand, since it defines PhD student's success as research success and PhD student's network as his or her research network.

As regards the limitations of the study, we are aware that the final regression model may be, mostly, the result of singularities of the University of Girona, given the relatively small population size and the fact that the same data set was used to specify and test the model. The results should, thus, be validated with data from other Spanish universities. However, the convergence in many respects of the qualitative and quantitative findings is rather encouraging.

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