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Networks of PhD Students and Academic Performance: A Comparison across Countries

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Abstract

In this article we compare regression models obtained to predict PhD students' academic performance in the universities of Girona (Spain) and Slovenia. Explanatory variables are characteristics of PhD student's research group understood as an egocentered social network, background and attitudinal characteristics of the PhD students and some characteristics of the supervisors. Academic performance was measured by the weighted number of publications.

Two web questionnaires were designed, one for PhD students and one for their supervisors and other research group members. Most of the variables were easily comparable across universities due to the careful translation procedure and pre-tests. When direct comparison was not possible we created comparable indicators.

We used a regression model in which the country was introduced as a dummy coded variable including all possible interaction effects. The optimal transformations of the main and interaction variables are discussed.

Some differences between Slovenian and Girona universities emerge. Some variables like supervisor's performance and motivation for autonomy prior to starting the PhD have the same positive effect on the PhD student's performance in both countries. On the other hand, variables like too close supervision by the supervisor and having children have a negative influence in both countries. However, we find differences between countries when we observe the motivation for research prior to starting the PhD which increases performance in Slovenia but not in Girona. As regards network variables, frequency of supervisor advice increases performance in Slovenia and decreases it in Girona. The negative effect in Girona could be explained by the fact that additional contacts of the PhD student with his/her supervisor might indicate a higher workload in addition to or instead of a better advice about the dissertation. The number of external student's

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advice relationships and social support mean contact intensity are not significant in Girona, but they have a negative effect in Slovenia. We might explain the negative effect of external advice relationships in Slovenia by saying that a lot of external advice may actually result from a lack of the more relevant internal advice.

1 Introduction

This study belongs to a wider project designed to predict PhD students' academic performance carried out by the INSOC research group (International Network on Social Capital and Performance, http://srcvserv.rug.ac.be/insoc/insoc.htm). The INSOC research group is composed by researchers of the universities of Girona (Spain), Ljubljana (Slovenia), Giessen (Germany) and Gent (Belgium).

The aim of the INSOC research group is to develop comparative analyses about the PhD students' academic performance across the INSOC member universities. In this article we compare the regression models obtained to predict PhD students' academic performance in the universities of Spain (Girona) and Slovenia. These models include characteristics of the PhD students' research group understood as a social network, background and attitudinal characteristics of the students and some characteristics of the supervisors.

The study of performance in jobs that are knowledge intensive (such as a PhD student's job) from these three types of variables (social network, background and attitudinal variables) has already been done in the literature, but in most cases studying only one type of variable at a time.

These three types of variables have rarely been used together. Authors who did it (Collins et al., 2001; Harvey et al., 2002; and Smith et al., 2005) suggest that these three types of variables are all important to obtain higher performance or new knowledge creation capability.

In Coromina (2006) the analysis of performance of PhD students using the INSOC data of Girona was already done from these three types of variables simultaneously on the PhD student and supervisor dyads. According to Coromina (2006), attitudinal and background variables were good predictors of performance. Ferligoj et al., (2005) and Ziherl et al., (2006) analyzed the INSOC Slovenian network data and they found all three types of variables to be good predictors of performance (the first paper used dyads, the second complete networks). Matelič (2005) analyzed the dyads student-supervisor to fit a model using mostly attitudinal and background variables which were both found to be good predictors of performance. Our research will mainly draw from the results of the four studies mentioned in this paragraph.

In greater detail, the variables included in the INSOC study of academic performance of PhD students are:

1. Social network variables measuring social capital: Social capital consists basically of relations among people that facilitate action. Social networks can be defined as the pattern of ties linking a defined set of people. Each person can be described in terms of his/her links with other people in the network, and the relations defined by the ties between units are important network components. The importance of some of these networks is strongly supported by the literature like De Lange (2005); Krackhardt and Hanson (1993); Sparrowe et al. (2001); Buskens (1998); or Glaeser et al.(2000).

The *networks* analyzed in each university collaborating in the INSOC project were scientific advice, collaboration, getting crucial information, trust, getting along well, emotional support and socializing, which draw from the literature about different types of networks in the organizational context (De Lange, 2005; Sparrowe et al., 2001 and Hansen, 1999). In fact, a factor analysis done by De Lange et al., (2004) obtained three predictive factors for performance where these networks can be included. The first factor was *work-related,* where the scientific advice, collaboration and getting crucial information networks can be included. The second factor was *friendship,* where the trust and getting along well networks can be included. The third factor was *social support,* where the emotional support network can be included. We also included the *socializing* network in order to study the influence of the activities with colleagues outside the work context. These networks refer to the PhD students' research group, as defined by their supervisor, although for scientific advice and collaboration PhD students could add new members to the group.

2. Background variables used for the prediction of PhD students' performance were related to the student's personal characteristics, education, experience and knowledge diversity. These groups of characteristics represent the amount of knowledge or background in a specific point of time (Dierickx and Cool, 1989 and Smith et al. 2005). All background variables used were placed in one of the mentioned groups. Personal characteristics include the variables age, gender and having children. Education includes the licentiate degree grade average and the year in which students obtained their most recent licentiate degree. Experience includes the seniority at the department and the year in which students started their doctorate at the university. Finally, knowledge diversity includes the supervisor's academic performance.

3. Attitudinal variables can be classified into six different groups: The first group is related to the recalled reasons to start a PhD, such as motivation for autonomy (Gulbrandsen, 2004) or motivation and identification with the researcher's job (Pierce and Delbecq, 1977). The second group is related to PhD students' perceptions of their relationships with supervisors, for example, informal contacts with the supervisor or advice from the supervisor concerning the development of PhD students' project. The third group is related to the evaluation of the integration of the PhD thesis within the research group. The fourth group is related to the social atmosphere in the research group (Cook et al., 1981:242-245).

The fifth group is related to the attitudes towards publishing (Deschrijver et al., 2001). Some examples are the extent to which publishing is stimulating and motivating, or useless. Finally, the sixth group concerned the feelings of PhD students at work. Some examples are exchanging views with their colleagues about research, and research giving students a chance to demonstrate their creativity.

The dependent variable academic performance of PhD students was measured by the number of publications weighted by their relevance (see Coromina, 2006: 42-43 for detailed information about this Index of Performance):

$$\text{Index of performance} = 2(\text{international articles}) + 2(\text{reviewed publications}) + \text{other publications} + \text{conference papers}$$

2 Study design

This comparative analysis uses a part of the INSOC data and compares the models predicting academic performance of the PhD students of Girona and Slovenia. The population studied in this comparative analysis is composed by the PhD students who began their doctoral studies at the University of Girona and at different universities and research institutes of Slovenia in the academic years 1999/2000 and 2000/2001. These students were in their third and fourth academic year when the data were collected. Only PhD students with a link with their university were considered. In Girona these included students with grants, assistants and researchers hired for particular research projects; in Slovenia students belonging to the project of young researchers. This choice has been made because these students have frequent contact with other researchers (they more or less formally belong to a research group), and they can spend a lot of time doing research as their main job.

Once the population was defined, the students' research groups that would constitute their networks also had to be defined. Three focus groups (Morgan, 1997; Krueger, 1998) were carried out in Girona and one in Slovenia with supervisors and leading researchers of different fields in order to discuss the definition of research group. The aim in those focus groups was not only to create a common concept of research group but also to define which questions were to be asked (name generators) to supervisors of PhD students so that their answers could be used to obtain the names of people in their research group connected to the research topic of their PhD students.

Once each student's supervisor had been interviewed to get the composition of the research group, data for the variables described in Section 1 were obtained by means of a web survey (De Lange, 2005; Coromina and Coenders, 2006). The web questionnaire design was a complex and long process. It involved two years of discussions, many international meetings, and several focus groups and pre-tests

(De Lange, 2005) within the INSOC research group. The fact that we had to produce comparable versions in several languages and university systems lengthened the process even further, and involved two independent translations and a pre-test of the translated questionnaires with further discussions and modifications.

An e-mail was sent to PhD students and their supervisors with a link which took them to the external web questionnaire, which already contained the research group member names in the case of the network questions. Our population had universal internet access, so that using a web survey did not lead to any coverage problem. As regards non-response, a mixed-mode follow-up design (De Lange, 2005) was followed.

A thorough data cleaning process was carried out. Inaccurate respondents who gave constant answers to complete batteries of items were removed from the sample. Where possible, responses were thoroughly checked for consistency and inconsistent ones were made missing; for instance in some filter questions respondents said they had published a certain type of articles but in the next question they said they had zero publications of the type. Under these types of inconsistencies we made both responses missing.

We selected the cases for which both the PhD student and the supervisor had responded the questionnaire. The final results about response rate in both countries and the number of cases available after data cleaning are shown in Table 1.

Table 1: Web survey response rates for PhD students and supervisors.

	Response rate PhD Students	Response rate Supervisors	% complete Student-Supervisor dyads	Number of complete Student Supervisor dyads
Girona	78%	75%	63%	54
Slovenia	62%	54%	34%	59

The final number of cases was 111 after removing two outliers with Cook's distance larger than 1 which substantially modified the estimates in a non-interpretable way. The low average percentage of missing data (1.6%) made pairwise deletion appropriate.

3 Constructing comparable indicators

The carefully coordinated design of the study made it possible to create a common comparable database for Girona and Slovenia. Nearly all the questions were asked both in Slovenia and in Girona. However, there were a small number of questions asked in only one questionnaire and in consequence; these ones cannot be used in our comparative study. For instance, the questionnaires for PhD students in Girona

contained a question about their type of contract with the university. This question was not possible to ask in Slovenia because there all PhD students belonged to the project of young researchers. In cross-cultural questionnaires these limitations are normal because some questions are necessarily country specific, since some profound differences exist between countries.

Most of the questions asked in both countries are easily comparable due to the careful translation procedures and pre-tests. When direct comparison is not possible we created comparable indicators. For instance, both countries have a different scale for grading students and we had to work out a common one.

Also each country had used factor analyses to detect sets of one-dimensional items from which summated rating scales (SRS) were computed for the attitudinal variables. The comparable SRS contained only those items with high loadings in both countries: we eliminated all items that had any inter-item correlation below 0.3 in either country.

Table 2: Predictive variables for academic performance used in previous studies in Girona and Slovenia.

Variable type	Girona (Coromina, 2006) [1]	Slovenia (Matelič, 2005)[2]
• Attitudinal	• Motivation to start a PhD: Autonomy • Motivation to start a PhD: Academic advantages	• Motivation to start a PhD: Autonomy • Motivation to start a PhD: Academic advantages • Motivation to start a PhD: Academic career • Guidance of the supervisor during the PhD • Too close supervision by supervisor • Motivation to start the PhD: Research interest
• Background	• Supervisor's academic performance • Seniority at the department • Having children (dummy, 1:yes) • Age	• Supervisor's academic performance • Supervisor's age.
• Network		• Frequency of supervisor advice

[1] The Girona study also used the field of study variable, but it was discarded here due to its high collinearity with other more relevant variables.

[2] The Slovene study also included supervisor's gender which was discarded here due to its political connotations.

4 Variable selection and preliminary analyses

Our aim is to explain the academic performance of PhD students from all three types of variables defined in Section 1, by specifying a regression model to determine the best predictors of performance for both countries and the predictors that have different effects across countries.

As it would not prove practical to use all the variables described in Section 1, we select only those variables which proved to have predictive power for academic performance in the individual studies done in Girona (Coromina, 2006) and Slovenia (Matelič, 2005), which are shown in Table 2.

In order to extend the small set of network variables, we defined additional variables from the egocentered network of the PhD student: size of the student's research group, number of different institutions to which the members of the research group belong, count of researchers external to the research group that have advice or collaboration relationships with the PhD student, and average contact intensities between the PhD student and the remaining group members for the four groups of networks defined in Section 1: work-related, friendship, social support and socializing.

5 Specificities of regression models for comparative studies

The standard practice to compare two regression equations in two populations is to specify a model on the pooled data including all variables, a population dummy and its product by all variables. If we only have one variable x and D is the population dummy (in our case country, Girona is the reference group and Slovenia is coded as 1), the equation looks as:

$$E(y) = \beta_0 + \beta_1 x \ + \beta_2 D + \beta_3 Dx$$

$$\text{If } D = 0 \qquad E(y) = \beta_0 + \beta_1 x$$

$$\text{If } D = 1 \qquad E(y) = (\beta_0 + \beta_2) + (\beta_1 + \beta_3) x$$

The β_0 intercept and the β_1 main effect coefficient of the x variable refer to the population coded as 0. The β_3 interaction coefficient gives the increase or decrease in slope when we move to the population coded as 1.

The β_2 coefficient of the dummy variable country measures the difference in expected performance for the value 0 of all other variables (Irwin and McClelland, 2001). Thus, it is advisable to mean-centre all numeric variables, so that this interpretation refers to a meaningful situation (and not to a PhD student aged 0 years, for instance). Besides, using mean-centred variables reduces collinearity

(Irwin and McClelland, 2001). In any case, mean-centring must be done always before computing the product variables for the interaction effects, never after. This is so because if we later transform the variables in any way, then the interaction variable fails to be equal to the product of both main effect variables.

This is why standardized effects are not interpretable in a model with interaction effects. If one wants to get estimates in comparable units, one must manually standardize numeric main effect variables prior to computing the product interaction variables, which will not generally have neither a zero mean nor a unit standard deviation. As standardized main effect variables have a zero mean, the collinearity problem described above is also solved. We thus standardized all numeric main effect regressors, but left binary dummy coded regressors and the dependent performance variable in their original units (one performance unit equals one conference paper, one non-reviewed publication, the half of a reviewed publication or the half of an international article).

Thus the main effect β_1 is interpreted as the expected increase in performance units resulting from a standard deviation increase in *x* in Girona. The sum $\beta_1 + \beta_3$ is interpreted in an identical manner in Slovenia. β_0 and $\beta_0 + \beta_2$ are the intercepts in Girona and in Slovenia respectively, that is the expectation of the dependent variable corresponding to the mean value of *x*.

As all variables have to be multiplied by the country variable, an exceedingly complex model may result. The procedure we used to drop the irrelevant variables and thus simplify the regression model also has some specificity. Variables with a t-value lower than 2 in absolute value can in principle be removed from the regression model one by one starting with those with a non-interpretable effect sign. However, the main effect variables can only be removed if interaction effects have been removed before. This is so because an interaction effect without its own main effect is not interpretable (Irwin & McClelland, 2001). On the contrary, a main effect without its own interaction effect is nicely interpreted as an effect that is constant across countries. The main country effect also has to be in the model if at least one interaction term is.

6 Results

The first model's estimates are shown in Table 3. In this table we show all the variables that we used and the effects in each country computed as shown in Section 5 (the effect in Girona as the main effect and the effect in Slovenia as sum of main and interaction effects). The t-values for Girona show the significance of the main effects and the t-values for the interaction effects show the significance of the differences between the effects in both countries.

After removing the non-significant variables in the manner shown in Section 5, the final model is shown in Table 4. All interaction effects have a t-value, in

absolute value, higher than 2. Some main effects have a t-value lower than 2 but they have to be in the model because their interaction effects are.

The intercepts in Girona and Slovenia are not significantly different, which means that for the value zero of all variables (i.e. for childless students with the mean value of the numeric variables) Slovene and Girona students publish about the same. The remaining interaction t-values show the significant differences between the two countries. Thus the effects are different between countries for the variables seniority at the department, motivation to start PhD: research, frequency of supervisor advice, count of researchers external to the research group that have advice relationships with the PhD student and social support mean contact intensity from the research group members to the PhD student.

Table 3: Estimates by country for the initial model.

Adjusted R^2=0.47	$\hat{\beta}$ Girona	$\hat{\beta}$ Slovenia	t-value Girona	Interaction t-value
Intercept	21.6	16.9	6.3	-1.1
Supervisor performance	10.2	12.5	3.4	0.6
Seniority at the department	6.0	-3.2	2.8	-2.0
Motivation to start PhD: Research	-2.1	3.1	-0.8	1.2
Motivation to start PhD: Autonomy	4.6	4.7	1.7	0.0
Motivation to start PhD: Academic career	2.0	-1.1	-0.8	-1.0
Motivation to start PhD: Academic advantages	-0.9	0.8	-0.4	0.5
Too close supervision by supervisor	-1.9	-1.7	-0.9	-0.5
Age	-1.4	4.6	-0.7	1.0
Supervisor Age	0.6	-1.2	0.2	-0.5
Student has children	-10.2	-6.5	-0.9	0.3
Frequency of supervisor advice	-3.7	4.8	-1.2	2.3
Research group size	0.0	-0.4	0.0	-0.1
Number of different institutions	1.0	0.8	0.3	-0.1
Number of external student's advice relationships	1.7	-3.7	0.6	-1.7
Number of external student's collaboration relationships	-1.1	1.5	-0.6	0.8
Work related mean contact intensity	-1.0	1.3	-0.3	0.5
Socializing mean contact intensity	-2.0	-1.7	-0.7	0.8
Social support contact intensity	3.3	-3.0	0.9	-1.4
Friendship mean contact intensity	-0.4	0.1	-0.2	0.4

According to Table 4, the supervisor's performance has a high positive influence in both countries on the PhD student performance. A high motivation for autonomy has the same positive effect in both countries. Too close supervision has the same negative influence in both countries and having children also reduces performance in both countries. Seniority at the department increases performance only in the Girona case. A high motivation for research prior to starting the PhD increases performance in Slovenia but not in Girona. Regarding the network variables, they show very high differences between countries. On the one hand, the frequency of supervisor advice is significant in both countries, but this variable

affects negatively in Girona and positively in Slovenia. On the other hand, the number of external student's advice relationships and the social support mean contact intensity are not significant in Girona, while in Slovenia they affect performance negatively.

Table 4: Estimates by country for the final model**.**

Variable type	Adjusted R^2=0.59	$\hat{\beta}$ Girona	$\hat{\beta}$ Slovenia	t-value Girona	Interaction t-value
	Intercept	20.3	18.0	11.6	-0.9[1]
Background	Supervisor performance	10.7	10.7	8.2	–– [2]
	Seniority at the department	6.0	-1.6	4.7	-2.5
	Student has children	-7.7	-7.7	-2.6	–– [2]
Attitudinal	Motivation to start PhD: Research	-2.2	2.7	-1.2	2.2
	Motivation to start PhD: Autonomy	4.1	4.1	2.9	–– [2]
	Too close supervision by supervisor	-2.2	-2.2	-2.2	–– [2]
Network	Frequency of supervisor advice	-3.8	4.3	-2.3	3.7
	Number of external student's advice relationships	1.9	-3.0	1.0	-2.1
	Social support mean contact intensity	2.0	-2.6	1.2	-2.0

[1] For the intercept, it shows the significance of the main effect of country.

[2]Absent because the interaction term has been removed from the model: the effect estimates are the same in both countries.

7 Conclusions

In order to predict the academic performance of PhD students, we use a regression model, for both countries, combining three types of variables: background, attitudinal and social network. Previously, comparable indicators had to be created. The country was introduced as a dummy coded variable including all possible interaction effects in order to test for country differences. Although it would be interesting to also test for differences across fields of study (like for instance would be the case if some fields require more individual efforts while the others depend more on team work), our sample size was not large enough to include all needed interaction terms. We carefully considered and explained the choice of the most convenient transformation of the main effect and interaction variables, as these variables play an important role for comparative research.

The results show that not all variables have the same influence in order to predict the academic performance for PhD students in Girona and in Slovenia. The final predictive variables and their influence are the following:

Supervisor's performance has the same high positive effect on the PhD student's performance in both countries. The recent establishment of a minimum publishing performance in order to become a supervisor in Spain seems to be a sensible move in the light of these results.

Seniority at the department increases performance in the University of Girona. In Slovenia this variable has a negative effect; however, descriptive statistics revealed that seniority was nearly constant in Slovenia, so that the effect of this variable should be very small in practice in this country. In Girona, on the contrary, many PhD students have been employed as assistants for many years before starting their PhD, which results in a high diversity in seniority.

A high *motivation for research* prior to starting the PhD increases performance in Slovenia but not in Girona. On the contrary, *motivation for autonomy* prior to starting the PhD has the same positive effect in both countries.

Too close supervision by the supervisor and *having children* have a negative influence in both countries.

The effects of the background and attitudinal variables described above are intuitively meaningful and coincide with the previous INSOC results. Background variables such as experience and family obligations are important for predicting performance as reported by Braun & Mohler (2003). Attitudinal variables such as motivation are also important for prediction performance (Nonaka & Takeuchi, 1995). On the contrary, we find rather counter-intuitive estimates for the network variables as discussed below.

Frequency of supervisor advice is significant in both countries, but this variable affects negatively in Girona. An interpretation for the negative effect in Girona seems to argue for the fact that PhD students in Girona are overloaded with work that has nothing to do with their own PhD and publications, which are mainly used for assessing their academic performance. Additional contacts with the supervisor might indicate a higher workload in addition to or instead of a better advice. *The number of external student's advice relationships* and *social support* mean contact intensity are not significant in Girona, but they have a negative effect in Slovenia. We can explain the negative effect of external advice relationships in Slovenia arguing that if the research group gives enough advice, external advice is not so much needed. Thus a high level of external advice may well occur together with a lack of internal advice.

In conclusion, while the use of these three types of variables together seems to be the best way to predict the performance of the PhD students, there are large country differences in the way in which these variables operate, which we want to explore by means of a follow-up qualitative study. This qualitative study will also be aimed at revealing some reasons for the counter-intuitive effects of the network variables.

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