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Undergraduate grade point average is a poor predictor of scientific productivity later in career

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Abstract

The aim of this study was to investigate the usefulness of the undergraduate grade point average in prediction of scientific production of research trainees during their fellowship and later in career. The study was performed in 1 320 research trainees whose fellowships from the Croatian Ministry of Science, Education and Sports were terminated between 1999 and 2005. Undergraduate grade point average exhibited negative association with scientific productivity both during and after the fellowship termination. Other indicators, such as undergraduate scientific productivity exhibited much stronger positive association with scientific productivity later in career and should be given more weight in candidate selection in research.

Key words: grade point average, scientific output, prediction, undergraduate, postgraduate, research trainee, junior researcher, Croatia

1. Introduction

Candidate selection process has one of the central roles in human resources management. It does not only provide the system with the appropriate candidates, but also serves as one of the most potent ways to increase its effectiveness through the acquisition of optimal staff. The main problem of selection process is prediction imprecision, given that it is often not possible to precisely predict candidate's job successfulness based on the selection criteria available during selection process. While this entire process has received a lot of attention in the industrial sector, it has received somewhat less attention in academia.

Candidates for junior positions in research are usually recent graduates, without a lot of experience in the scientific work. In such situation, one of the most widespread selection criteria used in the selection process is undergraduate academic successfulness, predominantly measured through the grade point average. This is a convenient, semi-qualitative indicator that combines candidate's entire undergraduate academic performance in a single number.

For a better understanding of the issue of career-success Tharenou (2001) divided career success theories into organizational, interpersonal and individual theories. Organizational theories highlight the role of objective factors like organizational commitment, career paths and centrality. Individual theories examine the role of personality traits, leadership traits, motivation, human capital, role-related issues and managerial skills and interpersonal theories include the role of mentors, informal social networks and similarities to the dominant group. Notably, the common conclusion is that career-success determinants are very difficult to predict by examination of only few factors, putting more weight towards their interaction.

Grade point average has been associated with professional success in a number of studies, suggesting that students with higher grade point average exhibited greater knowledge and skills and job satisfaction, often in conjunction with other characteristics. Abele-Brehm and Stiel (2004) find that attitudes, interests, self-concept and study performance predicted occupational success. In academia, GPA was also often associated with career success. It has even been shown that the nowadays professors of medicine had higher undergraduate grade point average than their peers (Kuzman et al. 2004).

In contrast to occupational and professional success, the effects of the grade point average on the scientific successfulness were less often investigated. A large longitudinal study suggested that undergraduate academic achievements including GPA were not correlated to scientific production later in career, and that only critical attitude, independence, inventiveness, and curiosity were correlated with research activity (O'Brecht and Friesen 1996).

Research trainees support scheme by the Croatian Ministry of Science, Education and Sports aims to employ the best graduates and provide employment and appropriate training to them, with a final goal of completing a PhD degree. Research trainees were also termed research fellows (Polasek et al. 2006) or junior researchers (Polasek et al. 2007, Petrovecki et al. 2008), but neither of those two terms provides accurate description of this group. While the research trainee support system has been implemented ever since 1991, it has just recently received substantial attention marked by the several studies attempting to perform systematic evaluation and suggest the ways to increase its effectiveness (Petrovecki 2006, Polasek et al. 2007, Petrovecki et al. 2008). Given that the main advancement criterion for research trainees is scientific productivity (which is also one of the requirements for the PhD completion), we aimed to investigate whether the principal selection criterion, undergraduate grade point average, is associated with their scientific productivity. Therefore, we designed a study in which we compared scientific productivity, a measure of the extrinsic successfulness of research trainees who were among the top 10% of the best students according to their undergraduate grade point average to those who were not.

2. Materials and methods

The study was based on the available data on research trainees supported by the Croatian Ministry of Science, Education and Sports. Trainees whose fellowships have terminated between 1999 and 2005 were included in this study, without any restrictions on the year in which they entered the fellowship or the reason why their fellowship was terminated.

2.1. Study setting

Croatian Ministry of Science, Education and Sports provides research fellowships to young graduates since 1991 (MSES 2006). Candidates for research fellowships are young graduates who are offered to work in an MSES supported research project. Their salaries are provided directly from the MSES, not from the individual project budgets. During fellowship, trainee's main goal is to be scientifically active, gather knowledge and skills needed for the scientific work and, most importantly, complete a PhD degree.

Fellowship duration is set to six years, with a possibility to extend it for additional four years if a trainee manages to obtain a PhD degree (Official gazette 2003). The system does not only provide employment for young graduates interested in science and research, but also plays an important role as it provides the basis for the selection of best candidates among research trainees for the full-time employment in research and higher education institutions.

2.2. Measurements

The data for this study were obtained from the MSES database on research trainees. This database presents up-to-dated source of information from which the demographic data, employment data and fellowship outcome data were obtained. Fellows from all research areas were included in this study; natural, technical, biomedical, biotechnological, social sciences, and humanities, defined according to the national guidelines (National Science Council 2005). Additionally, bibliographic database *Web of Science* (WOS; *http://wos.irb.hr*) was searched, in order to collect data on scientific articles published by the research trainees included in the study, similar to our previous study (Polasek et al. 2008). The number of articles published by a research trainee was determined for the period before, during, and after the fellowship termination (up to the year 2005).

Based on these data, we calculated average annual scientific production for each research trainee. This indicator was calculated for the fellowship duration (P_F) and for the period after the fellowship termination, concluding with the year 2005 (P_A). Both variables were defined as the ratio of the total number of articles published in a given period and the duration of each period in years, in order to obtain a standardized indicator of scientific productivity that was insensitive to the variation in fellowship duration.

Due to differences in the mean value of the grade point average across various undergraduate schools from which trainees have originated, we only used a binary indicator of the trainees undergraduate academic successfulness - the information whether the research trainee was among the top 10% of students according to the undergraduate grade point average or not.

2.3. Statistical analysis

Numerical data were presented as medians with interquartile ranges, calculated as a difference between the 75^{th} and 25^{th} percentile and used as an indicator of data variability. Categorical data were presented as absolute and relative frequencies (n, %). Chi-square was used for the analysis of categorical variables and Mann-Whitney test was used for numerical variables. Binary logistic regression was used as a multivariate method, in which scientific productivity was used as the dependent variable, while a number of other variables were used as the independent ones. Data analysis was performed with Statistical Package for Social Sciences v. 13.0 (SPSS Inc., Chicago, IL, USA), with $P<0.05$ considered statistically significant. Additionally, we used back-propagation neural network with hyperbolic tangens transfer function to estimate the usefulness of the predictor set in predicting the outcomes. The neural network model was trained using the data on research trainees whose fellowships terminated during 1999-2004, while those whose fellowships terminated in 2005 were used as the testing group.

3. Results

A total of 1 320 research fellows were included in this study. Among them, a total of 671 (50.8) were among the top 10% of undergraduate students according to their grade point average. Best undergraduates were more commonly men (54.8% vs. 47.0%; P=0.005, χ^2=7.94).

Both investigated groups were equally scientifically productive during undergraduate studies (Table 1). A total of 7.2% of research fellows managed to publish at least a single scientific article before fellowship start. However, fellows who were among the best undergraduate students exhibited poorer performance in all other indicators - they published scientific articles less often, and had lower average scientific productivity both during and after the fellowship termination (Table 1). They were also significantly less likely to be employed in academia on a permanent basis, after the fellowship termination (Table 1).

Multivariate analysis indicated that grade point average was negatively associated with scientific productivity both during and after the fellowship termination (Table 2). Additionally, trainee's age was inversely associated with scientific productivity (Table 2). Men trainees had higher odds for being scientifically productive (Table 2). Trainees whose mentors were women had higher odds of being scientifically productive during fellowship, while this effect was diminished later in career (Table 2). Significant differences were also recorded according to the research area and institution type (Table 2). Finally, the single strongest association with scientific productivity was recorded if the trainee was scientifically productive during undergraduate studies, with approximately 9 times higher odds for scientific productivity both during and after the fellowship termination (Table 2). The percent of explained variance for the logistic regression model was 31.5%. Additionally, neural network model was created, with the same predictors that were use in logistic regression analysis. The best neural network model consisted of one hidden layer with 28 neurons and an output layer with 2 neurons. The network was trained for 500 epochs with 1082 pairs of input-output vectors and was tested on a test set of 238 input vectors. The testing was performed with the segmentation of the obtained output values with a threshold of 0.75. The percent of correctly classified outcomes was 66.8%, while the percent of misclassified trainees was 12.2%.

4. Discussion

The results of this study suggest that undergraduate grade point average is a poor predictor of the scientific productivity among research trainees and later in career. Research trainees who were among top 10% of all candidates according to their undergraduate grade point average were employed for a shorter period of time, less scientifically productive both during and after fellowship and less often remained in academia.

The use of the GPA is based on the presumption that it may serve as the discriminative criterion, and that is reflects candidate's research potential. This assumption hypothetically fits well into the scientific productivity studies, which suggested that persistence, initiative, intelligence, creativity, learning capability, concern for advancement, and professional commitment were the main productivity predictors in a cohort of agricultural scientists (Ramesh Babu and Singh 1998).

The main underlying assumption of the GPA as the principal selection criterion in research is that is associated with the scientific productivity. However, the fundamental restriction of GPA is that it mainly reflects “reproducibility”, which is student’s ability to learn and reproduce the knowledge. In its essence, the GPA does not reflect qualities and skills needed for the productive scientific career, primarily inventiveness. GPA is also restricted by the several methodological issues. It is a semi-qualitative indicator, which consists of an average value of all undergraduate grades. Grades are ordinal measure, sometimes given on the basis of written exam (considered to be an objective measure), and in other times by an oral exam (considered to be less objective measure). Calculation of average on the ordinal scale variable is methodologically not the best possible solution. Secondly, GPA is usually calculated based on the equal weighting in all subjects that incorporate it, suggesting that all curricular subjects are equally important in its calculation. Finally, while the grades should theoretically exhibit normal distribution in the student population, GPA often tends to be highly skewed towards both left and right in various schools. All these premises suggest that pooling an average value on a number of various subject grades is methodologically sub-optimal.

The main shortcoming of this study is the use of binary indicator for the grade point average, which was necessary as the grade point averages varied across various schools from which candidates for research trainees have graduated. Additionally, the use of *Web of Science* as the source of indexed articles was quite restrictive, especially for the humanities as the majority of their articles are not usually indexed in this database (Prpic 2003). The results of this study suggest the possible continuation and broadening of the research question by the investigation of personality traits, motivation, human capital, similarities to the dominant group, organizational commitment or the role of mentors or some surreptitious career-success strategies (Harris and Ogbonna 2006). Finally, low percent of explained variance in logistic regression and in neural network model suggest that research trainee’s career development was under the substantial influence by variables other than the ones that were collected in this study This finding is in line with several articles suggesting that the career development has a strong stochastic component, often reaching even a third of the variance in the career development (Hart et al. 1971, Pryor et al. 2003, Bright et al. 2005).

The main result of this study is the poor predictive value of the scientific productivity among research trainees based on the undergraduate grade point average. Other measures, such as undergraduate scientific productivity were much strongly associated with scientific productivity and retention in academia, and should therefore be given more weight in selection process for junior positions in research.

Table 1. Comparison of research trainees who were among the best 10% of undergraduate students according to their grade point average to those who were not

Characteristic	Among top 10%	Not among 10%	P
Fellows published *WOS* indexed article as an undergraduate student; n (%)	56 (8.3)	39 (6.0)	0.101[a]
Fellows who published at least a single article during fellowship; n (%)	216 (32.2)	268 (41.3)	0.001[a]
Average annual scientific production during fellowship (P_F); median (ir)	0.0 (0.3)	0.0 (0.4)	0.008[b]
P_F; $\bar{x}$ ± stdev[c]	0.35±0.85	0.40±0.94	-
Fellows who published at least a single article after fellowship termination; n (%)	206 (30.7)	245 (37.8)	0.007[a]
Average annual scientific production after fellowship termination (P_A); median (ir)	0.0 (0.2)	0.0 (0.5)	0.006[b]
P_A; $\bar{x}$ ± stdev[c]	0.39±0.97	0.47±1.00	-
Fellows who got employed in academia after fellowship termination; n (%)	211 (31.4)	266 (41.0)	0.001[a]
Total fellows; n (%)	671 (50.8)	649 (49.2)	1 320

[a]Chi-square test;
[b]Mann-Whitney test;
[c]Average and standard deviation were shown as there were no detectable differences when median was used.

Table 2. Predictors associated with publishing at least one scientific article indexed in the *Web of Science* bibliographic database during and after fellowship termination – logistic regression

	During fellowship			After fellowship termination		
	OR	95% CI	P	OR	95% CI	P
Trainee's age group						
22-25	1.00		0.011	1.00		0.002
26-30	0.72	[0.54-0.96]	0.026	0.67	[0.50-0.90]	0.008
Over 30	0.43	[0.23-0.81]	0.009	0.36	[0.18-0.69]	0.002
Trainee's gender						
Men	1.00			1.00		
Women	0.77	[0.58-1.02]	0.070	0.68	[0.51-0.90]	0.008
Mentor's gender						
Men	1.00			1.00		
Women	1.66	[1.22-2.27]	0.001	1.19	[0.86-1.64]	0.287
Trainee was among the top 10% of undergraduate students according to the grade point average						
No	1.00			1.00		
Yes	0.64	[0.49-0.84]	0.001	0.69	[0.52-0.91]	0.009
Trainee published a scientific article as an undergraduate student						
No	1.00			1.00		
Yes	8.88	[4.82-16.36]	<0.001	9.21	[5.01-16.93]	<0.001
Research area						
Natural sci.	1.00		<0.001	1.00		<0.001
Technical sci.	0.24	[0.16-0.36]	<0.001	0.22	[0.15-0.33]	<0.001
Biomedicine	1.10	[0.74-1.62]	0.638	1.16	[0.79-1.71]	0.458
Biotechnology	0.54	[0.32-0.94]	0.028	0.58	[0.34-1.00]	0.050
Social sci.	0.15	[0.09-0.26]	<0.001	0.06	[0.03-0.13]	<0.001
Humanities	0.08	[0.04-0.16]	<0.001	0.08	[0.03-0.16]	<0.001
Institution type						
Research institutes	1.00		0.001	1.00		0.034
University schools	0.63	[0.45-0.88]	0.008	0.72	[0.50-1.02]	0.061
Other institutions[a]	0.40	[0.24-0.65]	<0.001	0.52	[0.31-0.86]	0.011

[a]Trainees in this group were predominantly employed in medicine, in various clinics and clinical hospitals.

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