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Raquel Oliveira, A. Manuela Gonçalves, and Rosa M. Vasconcelos

A Negative Binomial Model for Student Allocation to Higher Education in Portugal during the Post-Bologna Process

Raquel Oliveira[1, a)], A. Manuela Gonçalves[2, b)] and Rosa M. Vasconcelos[3, c)]

[1]*CMAT- Centre of Mathematics, University of Minho, IPCA_EST, Barcelos, Portugal*
[2] *CMAT- Centre of Mathematics, DMA- Department of Mathematics and Applications, University of Minho, Portugal*
[3] *2C2T – Centre for Textile Science and Technology, DET-Department of Textile Engineering, University of Minho, Portugal*
[a)]rmro_17@hotmail.com
[b)]mneves@math.uminho.pt
[c)]rosa@det.uminho.pt

Abstract. The primary goal of this paper is to model the student allocation in the Portuguese public higher education system, namely in academic engineering programs for the Post-Bologna period. This work follows the results obtained for the Pre-Bologna period. The data used refer to the years 2007 to 2015 and most of them are available online, provided by the Portuguese Ministry of Education. By estimating student allocation through the negative binomial regression model, we have concluded that the results are similar to the results already obtained for the Pre-Bologna period. That is, the model had a satisfactory performance for the data in study.

INTRODUCTION

It is well known that the implementation of the Bologna process has brought major changes in the organization of higher education, particularly regarding the students access.

The common duration of a higher academic program degree in the Pre-Bologna period used to be five years; in the mid-90s could also be of four years. The Bologna process imposes programs with the duration of three years. However, Portugal considers the possibility of maintaining a longer duration. Thus, after the implementation of the Bologna process, the available degrees have become:

- First cycle (*licenciatura-L*) – 3 years;
- Second cycle (*mestrado*) – 1.5 to 2 years.

It is possible as well to offer a combined degree called integrated master *(mestrado integrado-MI*), with the duration of 5 or 6 years.

Note that, as described in [1], Portugal has a binary higher education system, consisting of university (U) and polytechnic institutes (PI). Only the universities may offer the integrated master degree. So, the national contest for access to higher education is done for the first cycles in universities and polytechnic institutes, and for integrated masters in universities. The access to the second cycle (*mestrado*) is of the responsibility of each institution of higher education (IHE). This study focused on the national competition results.

In this work we intend to analyze the behavior of the model applied in [1] for the Post-Bologna period (2007-2015), in order to confirm the results obtained for the Pre-Bologna period.

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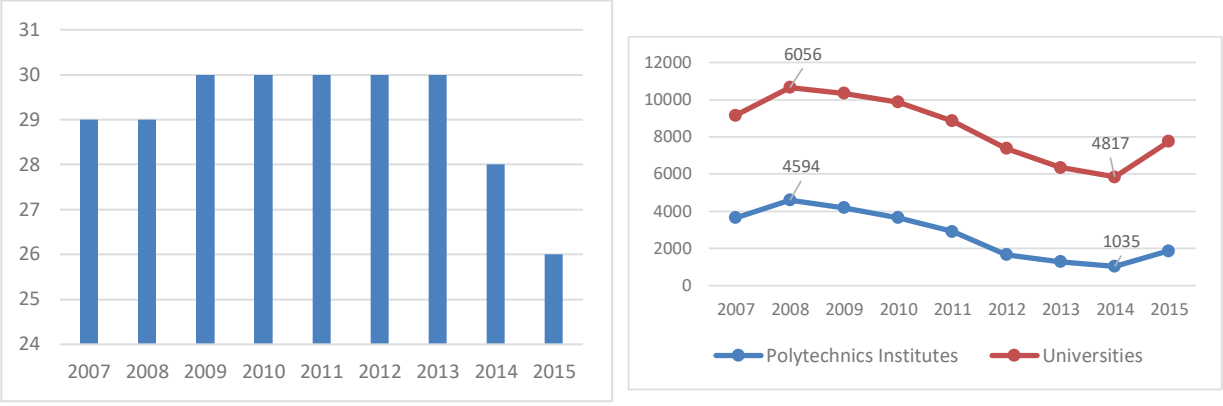
DATA ANALYSIS

The data set used covers the years from 2007 to 2015, the so called Post-Bologna period. Almost all of the data is available online, on a website of the Department of Higher Education (*Direção Geral do Ensino Superior-DGES*) [2], dedicated to announce the results of the national contest for access to higher education.

Figure 1 represents the number of IHE, each year, for the national contest by the type of IHE and illustrates the total of allocated applicants in the Post-Bologna period.



(a) (b)

FIGURE 1. (a) Number of IHE and (b) Total of allocated applicants

As we can see from Fig. 1(a) the number of IHE varies between 26 and 30. In the last two years it was observed a sharp decrease in the number of IHE, reaching the minimum in 2015. In respect of the number of the allocated applicants, Fig. 1(b) shows that the number of students allocated reached the minimum values in the period 2012-2015, in both type of IHE, with an increase in 2015.

Table 1 shows the number of academic programs available, each year, for the national contest by the type of HEI.

As in [1], the variables considered are: number of allocated applicants in each program (total number of allocated students in the pair institution/program, irrespective of their ranking); number of vacancies available in each program in the first stage of the application process; classification of the last allocated student, academic program size: first cycle (*licenciatura*) and integrated master (*mestrado integrado*).

We present in Table 2 a brief of some variables available.

Figure 2 presents the minimum and maximum values of the classification of the last allocated student by type of IHE. Observing Fig. 2. we can conclude that the classification of the last allocated student is higher in the universities, both in its minimum or maximum values.

RESULTS

Similarly to [1], we want to explain the number of allocated applicants in each pair institution/program. Thus, we apply the model presented in [3], based on similar conditions to those applied in [4] and [5], considering the following explanatory variables: number of vacancies available in each program during the first phase, classification of the last placed applicant, type of institution and program size. As in [3], we applied a negative binomial defined in [6],

$$\Pr(Y = y|\mu,\alpha) = \frac{\Gamma(y+\alpha^{-1})}{\Gamma(y+1)\Gamma(\alpha^{-1})}\left(\frac{\alpha^{-1}}{\alpha^{-1}+\mu}\right)^{\alpha^{-1}}\left(\frac{\mu}{\alpha^{-1}+\mu}\right) \quad (1)$$

where $\boldsymbol{y}$ is the count for our dependent variable, $\mu = exp(\boldsymbol{x}\,\beta)$, $\alpha \geq 0$ is the overdispersion parameter, $\Gamma(.)$ is the gamma function, and $\boldsymbol{x}$ is a vector of regressors. This specification assumes constant dispersion within groups, equal to $1 + \alpha\mu$. The mean and variance of $\boldsymbol{y}$ are defined as μ and $\mu + \alpha\mu^2$, respectively.

The log-likelihood function for exponential mean $\mu_i = exp\,(\boldsymbol{x}_i'\,\beta)$ is therefore

$$\ln L(\alpha,\beta) = \sum_{i=1}^{n}\left(\left(\sum_{j=0}^{y-1}\ln(j+\alpha^{-1})\right) - lny_i! - (y_i+\alpha^{-1})ln\left(1+\alpha exp\,(\boldsymbol{x}_i'\,\beta)\right) + y_i ln\alpha + y_i\boldsymbol{x}_i'\,\beta\right) \quad (2)$$

The vector of regressors constituted by the number of vacancies available in each program in the first phase of the national competition (Vacancies), classification of the last allocated student (Classification), program size (Degree), and IHE type (IHE), as a dummy variable.

The results of the negative binomial regression on the total of allocated student in each program for the regressors considered are presented in Table 3.

As for the pre-Bologna period, the variable Degree is not statistically significant then we repeated the process without it. Table 4 presents the results for this model.

TABLE 1. Academic degree by type of IHE

Year		First cycle *licenciatura)*	Integrated master *mestrado integrado)*
2007	PI	129	0
	U	57	47
2008	PI	144	0
	U	61	47
2009	PI	148	0
	U	57	55
2010	PI	156	0
	U	58	57
2011	PI	154	0
	U	540	60
2012	PI	147	0
	U	53	63
2013	PI	113	0
	U	49	64
2014	PI	104	0
	U	47	65
2015	PI	100	0
	U	45	64

TABLE 2. Description of the variables used in the model

Year	Number of Academic Programs	Number of Vacancies	Number of Allocated Students
2007	233	11603	9161
2008	252	12203	10650
2009	260	12580	10336
2010	271	13026	9869
2011	26	12846	8859
2012	263	12611	7371
2013	226	11701	6356
2014	216	11340	5852
2015	209	10962	7755

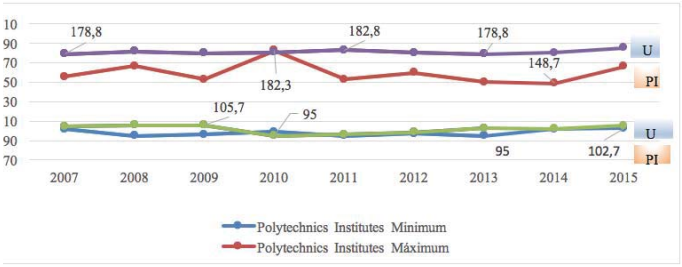


FIGURE 2. Variation of the classification of the last allocated student by type of IHE

TABLE 3. Parameters Estimates for Students Allocation, Negative Binomial Model.

			95% Wald Confidence Interval		Hypothesis Test	
Parameter	**β**	**Std. Error**	**Lower**	**Upper**	**Wald Chi-Square**	**p-value**
Intercept	.996	.1365	.728	1.263	53.216	<.0001
Vacancies	.018	.0002	.017	.018	7785.271	<.0001
Classification	.010	.0018	.007	.014	33.789	<.0001
IHE	.363	.0662	.234	.493	30.149	<.0001
Degree	-.019	.0249	-.068	.030	.601	.438

TABLE 4. Parameters Estimates for Students Allocation, Negative Binomial Model, without the variable Degree

			95% Wald Confidence Interval		Hypothesis Test	
Parameter	**β**	**Std. Error**	**Lower**	**Upper**	**Wald Chi-Square**	**p-value**
Intercept	1.014	.1274	.765	1.264	63.365	<.0001
Vacancies	.018	.0002	.017	.018	5513.543	<.0001
Classification	.010	.0015	.007	.013	43.548	<.0001
IHE	.348	.0806	.190	.505	18.609	<.0001

FINAL REMARKS

The results obtained confirm that the model applied to the Pre-Bologna period data also explains the number of allocated students during the Post-Bologna period. It seems that the conditions are fulfilled for analyze the behavior of this model for all data (1997-2015) and conduct the comparison between the two periods in order to assess the impact of bologna on the student allocation in academic engineering programs in Portugal.

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