Electronic Journal of Applied Statistical Analysis: Decision Support Systems and Services Evaluation
EJASA:DSS (2012). Vol 3, Issue 1, 1 – 14
e-ISSN 2037-3627, DOI 10.1285/i2037-3627v3n1p1

COURSE ORGANISATIONAL STRUCTURE AS A DETERMINANT OF ACADEMIC SUCCESS. SOME EVIDENCE FROM THE UNIVERSITY OF PADOVA (ITALY)

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Received 27 October 2011; Accepted 06 July 2012
Available online 28 December 2012

Abstract: *This work is part of a research project funded by the University of Padova, focusing on the main learning difficulties encountered by university students, and on the most suitable strategies to overcome and/or prevent them. We present an analysis by students cohort and by degree courses using data from the administrative archives of the University of Padova. Our aim was to examine the influence of the contextual characteristics of the degree courses on educational failure/success. The analysis is in two steps. First we use Multiple-decrement life tables to describe, by means of survival rates and cumulative decrement rates, levels of withdrawal, change of course and delay, to segment the courses into homogenous groups. Then, by means of hierarchical regression models, we examine the effects of contextual variables which, together with personal characteristics, influence withdrawal.*

Keywords: *University drop-out, cohort analysis, multiple-decrement life tables, hierarchical regression models.*

1. Introduction

University drop-out is one of the major problems in Italian universities. According to MIUR/CNVSU data [22], in 2008/09 only 60% of students had regular careers in tertiary first-degree-level education, and 18% withdrew from university after the first year. The percentage of

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drop-outs was quite high before the university reform of 2001, after which a temporary small decrease occurred, but at present the proportion of students who enter tertiary education without obtaining a degree is still below the OECD and EU19 averages [24].
Italian Ministerial Decree (D.M.) no. 509/1999 rearranged teaching organisation, with passage to the so-called “3+2” system (three-year degree course, followed by a specialised degree). The period from academic years 2001/02 to 2006/07 coincided with the duration of the educational system according to D.M. 509/1999 (now replaced by D.M. 270/2004), which carried out EU implementations as set out in the Sorbonne and Bologna Declarations. In this delicate phase, Italian university institutions have become more aware of their task, which is that of supplying students with instruments to enable them to finish their courses within the allotted time-span.
The need to assess university performance is certainly not a novelty in the Italian academic world (e.g. [3], [10], [11], [17], [21], [23]), and several authors have also examined the extent and causes of delays and drop-outs in university studies (see [1], [4], [5], [6], [12], [14], [19], [26]). In addition, various authors (e.g. [2], [9]) have studied how to detect the factors of academic failure/success, as well as the support policies implemented by universities (see, among others, [13]).
This work is part of a research project funded by the University of Padova, focusing on the main learning difficulties encountered by university students, and on the most suitable strategies to overcome and/or prevent them. Its specific goal is to examine the extent of the phenomena of delays in study, substantial course changes and drop-outs in three-year degree courses (DCs) at the University of Padova. The representation by DCs of the phenomenon serves as basis for further analysis to ascertain the main causes (individual, socio-cultural/educational background and contextual factors characterising DCs) of one specific aspect, i.e. drop-out.

2. Drop-out measures

2.1 Definition of drop-out

As a result of preliminary reflection on the definition of drop-out, we conclude that student withdrawal depends on the appropriate prospective: that of a degree course (DC), a faculty, or a university. Giving up a DC does not necessarily mean giving up a faculty and even less of giving up university entirely, as a student may choose a different DC. Similarly, withdrawal from a faculty is not necessarily withdrawal from a university, as students can change faculties within the same university.
In this research, the focus is on DCs which, although within various faculties, may have differing types of students and teaching/training organisation (frequency, access, etc.) and thus, in our hypothesis, must be examined specifically. We used the following definitions:
Withdrawal: formal giving-up of study, or of not re-enrolling in the University of Padova.
DC internal change: transfer to another course in the same faculty of the University of Padova.
DC external change: transfer to another course in another faculty of the University of Padova.
Delay: a student still enrolled in the first or second year out-of-course (further delays are not considered, as the observation is censored at the fifth year).
Drop-out: a complex phenomenon which includes the various types of “withdrawal” and “change” defining university careers which are non-linear and which do not respect the usual times.

In the following we give a measure of the incidence of these phenomena in the University of Padova in the period 2001-2008. We chose "stable" DCs as our unit of analysis. Hence, we only considered 3-year DCs at the University of Padova, according to D.M. 509/1999, which were not closed when the system changed. We included all courses offered according to that decree, which were stable in time, i.e., active during the study period and not closed as a result of the new decree, in order not to count "fictitious" changes in name or order. To identify cases of interest, we reconstructed in detail the three-year degree courses offered in the period 2001-2008: for each faculty and each academic year [7]. We analysed data from the administrative archives of the University of Padova made available by the University's Statistics Centre. This archive contains information on all enrolled students and on theirs careers.
For the initial analyses we used an archive aggregated by student cohort and DC. We considered as valid cases only 84 out of 110 active DCs, selected according to their stability during the period of analysis and across system changes. The analysis covered a total of 39,833 students enrolled in the first year of the three-year DC, from academic years 2001/2 to 2005/6, corresponding on average to slightly less than 8,000 enrolments for each of the five academic years in question.

2.2 Multiple decrement life tables

One of the most frequently used indicators to assess the capacity of a university to achieve its politico-social mandate is the drop-out rate, a mean ratio in which the events of interest are related to a reference aggregate (course, faculty and university, from a organisational perspective; region, country and supranational aggregate from a territorial perspective) and specified according to the approach used in the study (cross-sectional or longitudinal).
They are also linked to the time-span in which they took place (during first year of course; between first and second years; between second and third years). The drop-out rate clearly takes on values, evaluative functions and meanings according to the choices made in its specification.
In our research perspective, drop-out indicators are constructed according to a longitudinal approach, in which the cohort is identified by the first year of enrolment, and are interpreted with reference to the initial degree course chosen.
Aggregations at hierarchical level higher than that of the degree course, i.e., faculty or university, are thus marked by this fundamental choice, and may produce indicators which do not correspond to those obtained, although on the same data, when different selection criteria were used. Since we had chosen to analyse the three-year degree course, students who do not obtain their degree within three years of enrolment are considered as delayed.
Thus, students enrolled in the first and successive years beyond the usual three-year limit (from the fourth year of enrolment onwards) are called "delayed".
The statistical methodology used here applies Multiple-decrement life tables[1] to cohorts of students enrolling in academic years 2001-2005 in three-year degree courses at the University of Padova.
Starting from an initial contingent l_0 (placed in our case at 100 enrolments in a three-year course at the University of Padova), the life tables serve to describe exits, year by year for one or more

[1]The Multiple-decrement (or competing) life table is a method for analyzing event history data in case of more than one absorbing states: total exits are subdivided into the different causes; this subdivision is made on the basis of the actual distribution of the exits by cause at each year of course. For further methodological information, see [8], [15], [25], [27], [28], [29].

reasons (the events of interest) by the initial group: therefore, they describe the results of action of one or more competing risks without involving regression models with explanatory variables. This enabled us to obtain a series of performance indicators (in terms of intensity and timing), and to identify preliminarily the success of learning (observing the number of degrees granted per 100 students enrolled in the first year) or its failure (analysing drop-out or delay rates with respect to the standard three-year period). Withdrawals and changes in faculties are true exits from the cohort, whereas delays can be calculated as numbers of "survivors" at the first year out-of-course.

A cohort is an open collectivity, in the sense that the students who have left can come back, and subject to the various reasons for exit (withdrawal, internal change of course, external change of course, degree) and entry (re-enrolment after a period of absence and transfer to another degree course). Unfortunately, due to the structure of the available data, which privileged analysis of "pure" cohorts, it was not possible to quantify the entries of newly enrolled students, coming from a different degree course, whereas possible re-entry of students originally belonging to the cohort could be counted.

The starting data for calculating the life tables were the cohorts enrolled in the 84 degree courses examined P_{wj} (where w = 2001, ..., 2005 academic years; j = 1, …, 84 DCs) and $U^p{}_{wjx}$ are the events which caused the exit from the *w-th* cohort of students enrolled in course j, during course year x (where x = I, II, III, I out-of-course, II out-of-course), by reason (where p = Withdrawal [A], Internal faculty change [IF], External faculty change [EF], Degree [L]). Re-entries by students who had not paid their university taxes and who returned to be regularly enrolled in year x were subtracted from the number of withdrawals in the year in question.

The tables for the DCs were constructed by aggregating the five annual cohorts of students enrolled in each year of course of the five-year period 2001-2005 ($P_{jx} = \sum_{w=2001}^{2005} P_{wjx}$) in DCs, that held their enrolment in the same DC in the whole considered period, and the events which involved them (U_{jx}^{p}) over academic years.

We define the probability (q_{jx}^{p}) that someone, enrolled in the *j-th* DC, exactly at the beginning of the *x-th* year of course, will exit before reaching the (x+1)-*th* year, for each of the p reasons considered as follows:

$$q_{jx}^{p} = \frac{U_{jx}^{p}}{P_{jx}} \tag{1}$$

The definition q_{jx}^{p} yields other survival functions which illustrate the various aspects of the process analysed, in particular: exits during the year for various reasons ($d_{jx}^{p} = l_{jx} \cdot q_{jx}^{p}$), students still enrolled ("surviving" or "living") at the beginning of each new degree course year ($l_{jx+1} = l_{jx} - \sum_{p} d_{jx}^{p}$) and the cumulate number of exits ($D_{jx}^{p} = d_{jI}^{p} + d_{jII}^{p} + \ldots + d_{jx}^{p}$) within a certain year, with reasons.

2.3 Aggregate analysis

The 84 life tables constructed according to each DC analysed can be aggregated in a University Table (Table 1), in which the levels of the survival functions are substantially a weighted mean of those for DCs. An hypothetical cohort of first-year students ($l_{x=I}$, assumed at 100) is subject to four kinds (p = L, A, IF, EF) of year-specific removal rates, which have different patterns and levels: the probability of exit for degree (q^{L}_{jx}) is near zero during the first two years, while it assumes importance starting from the end of the third year, and reaches his maximum at the beginning of the first year out-of-course (0.422); the probability of exit for withdrawal (q^{A}_{jx}) has his greatest intensity at the beginning of the first year (0.133), decreases during the second and the third year, and increase again at the beginning of the first year out-of-course; the probabilities of exit for internal or external faculty change (q^{IF}_{jx} and q^{EF}_{jx}) have similar patters, but their intensities are the smallest and decrease progressively from the first year of course.

These four risks produce a summative effect that reduce the cohort size. So, the number of "living" students at the beginning of the second year of course are 80 out of 100 (initial cohort); at the beginning of the second year they are 74%, at the beginning of the first year out-of-course (i.e. at the end of the regular duration of the course study) they are 43%.

Since the duration of program is three years, the meaning of the figures of survival function changes moving from the third year to the first year out-of-course. Who is absent at the roll-call at the beginning of the second (20 out of 100) and third year (another 6 out of 100) shows more or less serious failure state. Who is still enrolled at the beginning of the second year out-of-course (22 out of 100) shows a delay in his university career.

Table 1. Multiple-decrement life tables: survival functions. Total 84 DCs (3-year degree course; 2001-05).

x	**Survivors l_x**	**Probability of exit for degree $q^L{}_x$**	**Exits for degree $d^L{}_x$**	**Probability of exit for withdrawal $q^A{}_x$**	**Exits for withdrawal $d^A{}_x$**	**Probability of exit for internal change $q^{IF}{}_x$**	**Exits for internal change $d^{IF}{}_x$**	**Probability of exit for external change $q^{EF}{}_x$**	**Exits for external change $d^{EF}{}_x$**
I	100[(a)]	0.001	0.1	0.133	13.3	0.029	2.9	0.033	3.3
II	80	0.002	0.1	0.057	4.6	0.014	1.1	0.008	0.6
III	74	0.384	28.4	0.028	2.1	0.006	0.4	0.003	0.2
I FC	43	0.422	18.1	0.046	2.0	0.006	0.3	0.002	0.1
II FC	22	...	...	....	...	...	...	...	...

([a]) Enrolled at beginning of academic year in same degree course.

Table 2 shows the data of Table 1 reprocessed and presented as indicators referring to:

Time until degree: 29 out of 100 students regularly enrolled took their degree within the third course year. However, we note that, if we exclude those who left university for various reasons (other than having obtained degrees), the probability of obtaining a degree in the three-year period is far greater, 40%, i.e., 29 degree students out of 72 "survivors" at the end of the third year (100 minus 20 withdrawals and minus 8 changes of course). By the end of the first year out-of-course, 47 of the 100 original students had obtained their degrees, i.e., 65% of the 72 who continued with the same degree course (that is, not considering exits for various reasons).

Delay with respect to normal times for taking a degree: 43 out of 100 students in the initial cohort were “delayed” (a degree by the end of the third year). However, the probability of being delayed with respect to the standard time for those who did not leave is higher, 60% (43/72); 22 out of 100 originally enrolled students turn out to be “delayed” by one year, but the probability of a year's delay for those who remain enrolled is higher, at 31% (22/72).
Withdrawals (at least from the University of Padova): in the three-year period, 20 out of the original 100 students had withdrawn; 65% of those who withdrew so during the first year.
Change of degree course within the same faculty: this involved a total of 4 out of every 100 original ones; the numbers for changes for another faculty were the same. Overall, 8 out of every 100 original students made one course transfer during the three-year period.

Table 2. Living and cumulative[(b)] decrement rates of degree, withdrawal and course change. Total 84 DCs (3-year degree course; 2001-05).

x	Survivors l_x	Cumulative degree rate $D^L{}_x$	Cumulative withdrawal rate $D^A{}_x$	Cumulative internal change rate $D^{IF}{}_x$	Cumulative external change rate $D^{EF}{}_x$
I	100[(a)]	0	13	3	3
II	80	0	18	4	4
III	74	29	20	4	4
I FC	43	47	22	5	4
II FC	22	….	….	….	…..

([a]) Enrolled at beginning of academic year in same degree course.
([b]) Obtained by cumulating exits for various reasons until year x (Table 1). Totals are rounded to nearest unit figure/one.

2.4 Comparative analysis

The life tables constructed for each of the 84 three-year DCs allow detailed study. In order to simplify comparison of the results, as a measure of non-continuation of study we use the cumulate values for the third regular course year of the cumulate withdrawal rates (D^{A}_{III}), internal course changes (D^{IF}_{III}), and external course changes (D^{EF}_{III}). As a delay measure, we use the “survivors” enrolled in the same degree course at the first year out-of-course (l_{IF}).
The results are presented in Table 3.

Table 3. Performance indicators. 84 DCs (3-year degree course; 2001-05).

Indicator	min	1st quartile	2nd quartile	3rd quartile	max
cumulative withdrawal rate, third year (D^{A}_{III})	0	14	20	25	41
cumulative internal change rate, third year (D^{IF}_{III})	0	2	3	4	36[(*)]
cumulative external change rate, third year (D^{EF}_{III})	0	2	4	7	23[(*)]
delay rate (year I out-of-course) (l_{IF})	0[(*)]	30	39	49	72

([*]) Outliers

The distribution of cumulate withdrawal rates ranges from 0 to 41 (exits every 100 students) within the third year, and shows good symmetry with respect to the mean value (20/100).
The distribution of the cumulate rates of changes within and outside the same faculty have a range which is only apparently ample (from 0 to 36 changes every 100 students), because of the substantial number of outliers in the higher values. When these anomalous cases are excluded,

the distribution is quite symmetric, highly concentrated around central values, and with a range of values between 0 and 7.
More variable and asymmetric is the distribution of cumulate rates of course changes to other faculties. When we exclude a single anomalous value, the range is from 0 to 13 changes within the third year, with 50% of courses at lower or equal levels for 4 out of 100 students.
Lastly, delay rates, i.e., the number of students still enrolled in the first year out-of-course with respect to the 100 at the start, show the greatest variability (from 3 to 72), but there is substantial symmetry around the median value of 39 students still enrolled for every 100 who started out.

3. Drop-out determinants

In the previous section we characterised the 84 “stable” DCs by means of students’ performance in those courses. Performance was measured in terms of drop-out (withdrawal, DC internal change and DC external change), delay and time until degree, where the definition of these terms are given in the preceding sections. In the following, we explore the reasons which influence one of the aspects of students’ performance, i.e. drop-out. As seen above, drop-out rates are quite heterogeneous in the 84 DCs, ranging from 0 to 41 students out of 100 who drop out by the end of the third year. One explanation for these differences is that DCs, although in the same faculty, may be quite different in terms of structure, organisation and services to students, and that these peculiar features, together with students’ characteristics, can explain the different values for drop-out rates. More specifically, we consider both students' individual characteristics and organisational and structural characteristics peculiar to the DCs which can explain drop-out. Our goal is to detect whether:

1. individual characteristics of students determine drop-out levels (i.e., students enrolled to DC with high levels of drop-out are mainly poorly motivated or have jobs, i.e., students with a high propensity to drop out);
2. DC characteristics affect the probability of dropping-out (i.e., DCs with organisational problems, lack of or poor support to students, and lack of other “good” features which may generate higher drop-out rates with respect of better organised DCs);
3. there is an interaction between students’ and DCs characteristics (i.e., “good” students mainly enrol in good DCs and “poor” students in “poor” ones).

We first present some exploratory analyses of students' characteristics in the 84 DCs, in order to give some descriptive evidence that distinguish DCs with high and low levels of drop-out rates. Then, by means of multilevel discrete models, we model the probability of a student dropping out conditioned to individual characteristics and to the contextual and organisational characteristics of the DCs in which students are enrolled, to ascertain which variables mainly affect the probability of dropping out.

3.1. Exploratory analysis

As in previous analyses, data comes from the administrative archives of the University of Padova. In the following, we analyse individual data, that is, the academic careers of students enrolled in the 84 DCs in the cohorts 2002/03, 2003/04 and 2004/5. The choice of these three cohorts instead of the five available is due to two facts. First, we decided not to consider the first year of application of DM 509/1999 system (2001/02), because for some DCs there was a certain amount of delay in implementing the new rules, and the beginning of the new regime was postponed until the following academic year. Secondly, we needed to observe students belonging to different cohorts for the same period of time: since the administrative archives available to us gather data of students' careers until 2009[2], in order to have equal observation time for all students, we decided to consider only students enrolled from 2002/03 to 2004/05 for which we have five years of observations.

Every year, approximately 8,000 students enrolled in undergraduate programs at the University of Padova, and in the time-span examined the population totals about 24,000 students. The administrative database collects information on students' previous education (type of high school diploma and grades), academic results (number and timing of examinations, credits and grades) and some personal characteristics (gender, age at enrolment, place of residence, citizenship). Table 4 lists some descriptive statistics of these 3 cohorts of students.

Table 4. Descriptive statistics of students enrolled in undergraduate courses at University of Padova, Academic years 2002/03 – 2004/05.

Students' characteristics	2002/03	2003/04	2004/05
mean high school grade	80.26	80.64	80.31
percentage of students enrolled immediately after leaving school	82.10	85.73	85.49
percentage of students with high school diplomas	56.50	56.98	56.61
percentage of students with regular school careers	80.46	81.34	81.18
percentage of female students	53.64	54.84	54.15
percentage of foreign students	3.21	3.35	4.04
percentage of commuting students	27.92	29.10	27.40
percentage of resident students	19.60	21.13	20.76

Students' characteristics varied greatly between DCs, as clearly shown in Table 5, which lists some summary indicators of the distribution of the variables in the 84 DCs. If we divide the DCs according to the values of the drop-out rate[3] calculated in section 2.4 (high, medium-high, medium-low, low) and calculate the same summary indicators in these four groups, we see that DCs with low drop-out levels are better in terms of "good" students characteristics (see Table 6): higher secondary school grades and more regular school career. A higher percentage of female students and students with high school diplomas were observed in DCs characterized by low drop-out level.

[2] In 2009, the University of Padova passed to a new "platform" for managing students' careers. Details of all careers are stored in a new administrative archives and the old one is no longer used. For this reason, our most recent data reaches spring 2010.

[3] To obtain the four groups described above, we divided the distribution of the drop-out rate of the 84 DCs according to its quartiles: the first group contains DCs with drop-out rates below the first quartile, called "low drop-out rate", the second group contains DCs with drop-out rate values between the first and the second quartile, "medium-low drop-out rate", and so on for the "medium-high drop-out rate" and "high drop-out rate" groups.

Table 5. Descriptive statistics of students enrolled in three academic years in undergraduate courses at University of Padova, by DC.

Students' characteristics in DCs	Descriptive statistics			
	Mean value	Variance	Minimum value	Maximum value
mean high school grade	80.40	168.45	65.75	94.61
	Mean Percentage		Minimum value	Maximum value
percentage of students enrolled immediately after leaving school	84.45		38.10	99.17
percentage of students with high school diplomas	56.70		8.06	89.36
percentage of students with regular school careers	81.00		42.08	97.52
percentage of female students	54.22		1.08	100.00
percentage of foreign students	3.53		0.00	19.82
percentage of commuting students	28.15		7.92	46.3
percentage of resident students	20.50		3.15	71.43

Table 6. Descriptive statistics of students enrolled in three academic years undergraduate courses at University of Padova, by DC drop-out rate.

Students' characteristics in DCs, descriptive statistics	Drop-out rates			
	Low level	Medium-low level	Medium-high level	High level
mean high school grades	82.14	80.99	80.13	78.33
percentage of students enrolled immediately after leaving school	82.59	86.56	85.55	82.90
percentage of students with high school diplomas	62.82	62.04	52.81	47.15
percentage of students with regular school careers	83.70	83.24	80.40	76.54
percentage of female students	65.66	60.96	41.87	46.08
percentage of foreign students	3.31	2.65	3.92	3.81
percentage of commuting students	25.02	29.11	30.86	27.69
percentage of resident students	16.01	27.55	19.84	15.31

3.2 Individual and contextual explanation of drop-out: a multilevel approach

To examine in more depth the relation between drop-out rates, students' characteristics and course organisation, we modelled the probability that a student drops-out given individual and course characteristics. The data we consider have a hierarchical structure: students are clustered in courses and courses are clustered in faculties. Considering this multilevel structure in modelling our data instead of a multiple regression model with dummies for course characteristics improves the efficiency of the regression estimates, since the results of students in the same courses tend to be correlated, and provide correct standard errors [16]. This approach also allows us to explore the extent to which differences in career results among courses are explained by factors such as internal organisation, other student characteristics or interactions between such factors. In our analysis, we considered a two-level model: first-level units are students; students are clustered in the 84 "stable" DCs which are the second-level units. Data on students' careers are supplemented with data for second-level units. Several features of DCs were collected from administrative sources[4]: information on compulsory attendance to classes, whether DCs have a limited number of enrolments per year, number of students who declare at enrolment that they have jobs, ect.. From a survey on first-year students conducted in 2004, we obtained some information on students' intentions with regard to jobs, e.g., the percentages of students already working and of students willing to work during their university career. Examination of previous sections allowed us to characterise DCs by their students' performance: drop-out rates at the third year, rates of internal and external change, mean time until degree, and mean number of students enrolled.

We modelled the total drop-out[5], i.e., the probability of dropping out at the end of fourth year, and the first year drop-out. Because the two phenomena are motivated by different reasons, we decided to model them separately. Whereas first-year drop-outs may be due to wrong decisions (students do not really want to study, bad choice of DC, etc.), the total drop-out may be due to difficulties arising during academic careers, such as learning difficulties, personal problems, and so on.

The two response variable for the *ij-th* first-level unit are thus the binary variables (0,1), which indicate whether the *i-th* student in *j-th* DCs drops-out at the end of the fourth year or after the first year. For these variables, considering the hierarchical structure of the data, we specify a multilevel discrete model ([16], [18]). Statistical models for such data belong to the class of generalised linear models [20]. A generalised linear model has three distinct components: a linear regression equation, a specific error distribution and a link function. In the case of binary responses, the logit function can be used as link function and the corresponding error distribution is the binomial. A second-level model of the binary response y_{ij} with a single explanatory variable may be written in the form:

$$\begin{aligned} \text{logit}(\pi_{ij}) &= \beta_{0j} + \beta_{1j} x_{ij} \\ y_{ij} &\approx Bi(1, \pi_{ij}) \end{aligned} \qquad (2)$$

where π_{ij} is the expected value of the response for the *ij-th* first-level unit and the individual variance components is var(y_{ij}) = $\pi_{ij} \cdot (1 - \pi_{ij})$. We allow random coefficients at the second-level specifying the regression coefficient as random variables. Introducing contextual variables – variables which characterised the second-level units – the random coefficients are modelled by:

$$\begin{aligned} \beta_{0j} &= \gamma_{00} + \gamma_{01} Z_j + u_{0j} \\ \beta_{1j} &= \gamma_{10} + \gamma_{11} Z_j + u_{1j} \end{aligned} \qquad (3)$$

which leads by substitution to:

$$\text{logit}(\pi_{ij}) = \gamma_{00} + \gamma_{10} X_{ij} + \gamma_{01} Z_j + \gamma_{11} Z_j X_{ij} + u_{ij} X_{ij} + u_{oj}. \qquad (4)$$

[4] Dean's offices, student Office, enrolment Office.

[5] Because we adopted a DC perspective in our analysis, we were obliged to consider as drop-outs any changes in both DCs and faculties (the so-called DC internal and external changes). For that reason, the drop-out rate is slightly higher than those of the previous descriptive analyses.

The first components is the fixed part of the model and the second is the random part. We can generalise considering more than one explanatory variable. As regards parameter estimation, since the log likelihood has no closed form, it is approximated by adaptive Gaussian quadrature. The model is estimated with the STATA procedure XTMELOGIT.
Explicative variables and students' individual and DC contextual characteristics, for both models are listed in Table 7.

Table 7. Explicative variables for the two models.

Name of variable	Value(*)
First-level unit	
gender	female / male
place of residence	Padova / outside Padova commuting / resident student
citizenship	Italian / Foreign
type of secondary school	high school / technical institute / professional institute
secondary school grade	quantitative (centred on DCs mean value)
regular school career	regular / not regular
enrolled immediately after leaving school	enrolled / not enrolled
cohort	2002 / 2003 / 2004
Second-level unit	
limited number of enrolment in a DC in a year	not limited / limited
percentage of students who work	quantitative
mean number of students in DC	quantitative
compulsory attendance to classes	not compulsory / compulsory

(*) *The first values are taken as basis for the dummy variables. Thus the basic student is Italian, female, lives in Padova, has secondary school grade equal to the mean of DC chosen, had a regular school career and enrolled in university immediately after leaving school.*

Also, for both models, we estimate the null model (the multilevel discrete model without individual or contextual explicative variables). From these models we can estimate an intra-DCs-correlation which is a measure of the proportion of the total variance between DCs. The existence of a nonzero intra-unit correlation results from the presence of more than one residual term that is typical of a hierarchical structure and thus explains the use of a multilevel model [27]. For the first model (probability of dropping out at the end of the fourth year) the intra-DCs-correlation is 0.074 and 0.062 for the second model. These values, albeit quite low, are significantly different from zero and justify the use of a multilevel model. The results of models with explicative variables and random effects, reported in terms of odds-ratio, are listed in Table 8 e 9.
As regards the probability of dropping out at the end of the fourth year, the variables whose coefficients are significant are: being a resident or foreign student, having a technical or professional diploma, the grade of diploma (an higher grade protects, albeit slightly, from drop-out), not having a regular school career and not enrolling university immediately after leaving school. In the random component the contextual variable, which has a protective effect on the probability of dropping out, is the limited number of enrolments in a DC in a year.

Table 8. Results for first model (probability of dropping out at end of fourth year), odds ratio and standard errors.

Students' characteristics	Odds ratio	Standard errors	95% confidence intervals	
resident	1.2345	0.0477	1.1445	1.3317
foreign	1.8350	0.1441	1.5732	2.1404
technical diploma	1.4634	0.0504	1.3679	1.5655
professional diploma	1.9972	0.1161	1.7822	2.2382
secondary school grade	0.9711	0.0012	0.9687	0.9736
no regular school career	1.4913	0.5628	1.3849	1.6057
not enrolled immediately	1.5530	0.0645	1.4315	1.6848
DC characteristics				
limited number of enrolment	0.5471	0.0792	0.4111	0.7266
Variance components				
variance (limited number of enrolment)	0.1884	0.1207	0.0537	0.6616
residual variance	0.1616	0.0350	0.1056	0.2472

Table 9. Results for the second model (probability of dropping out at first year), odds ratio and standard errors.

Students' characteristics	Odds ratio	Standard errors	95% confidence intervals	
resident	1.7774	0.0919	1.6060	1.9670
commuting	1.0920	0.0516	0.9954	1.1980
technical diploma	1.7129	0.0756	1.5710	1.8676
professional diploma	2.4014	0.1678	2.0940	2.7538
secondary school grade	0.9765	0.0017	0.9732	0.9797
no regular school career	1.3452	0.0640	1.2254	1.4766
not enrolled immediately	1.3759	0.0707	1.2441	1.5216
cohort 2003	0.8989	0.0417	0.8207	0.9845
cohort 2004	0.7838	0.0377	0.7133	0.8614
DC characteristics				
percentage of students who declare to work	0.9759	0.0111	0.9544	0.9979
Variance components				
variance (% of students who declare to work)	3.1e-15	1.5e-09	-	-
residual variance	0.2001	0.0407	0.1343	0.2981

As regards the probability of dropping out in the first year, the variables whose coefficients are significant are again being a resident student, having a technical or professional diploma, the grade of that diploma, not having a regular school career and not enrolling university immediately leaving school. In this case, significant features are also being a commuting student and the cohort of enrolment. According to the model, the probability of withdrawing is lower for students enrolled in 2003 or 2004, probably due to better course organisation in the years after the establishment of the DCs. In the random component a very low protective effect is given by contextual variable: the number of students already working.

4. Discussion and conclusions

In this paper, we analyse the characteristics and give a possible explanation of the drop-out phenomenon at the University of Padova in the first years of application of the D.M. 509/99 educational regime. We characterise DCs by means of their students' performance and we model the probability of dropping out at the first year and at the end of the fourth year, conditioned to students' individual characteristics and contextual variables of DCs. We use multilevel discrete models to exploit the hierarchical structure of the data. The results show that the variables which most greatly influence the probability of dropping out are students' individual characteristics, which differ between the two models. The effect of contextual variables is quite low and in any case lower than expectations. This result needs further study and suggests the use of factor variables which can capture the weak effects of contextual variables in a more organised way.

Acknowledgement

Research carried out within the University of Padova Strategic Project "Learning difficulties and disabilities from primary school to university: diagnosis, intervention and services for the community" (2008-10), Prot. STPD08HANE_005.
The authors are grateful to the Servizio Studi Statistici and in particular to C. Stocco for collaboration on use of archival material.

References

[1]. Broccolini, C. (2005). Una prima valutazione degli effetti della Riforma Universitaria: il caso dell'Università Politecnica delle Marche. *Quaderni di Ricerca del Dipartimento di Economia*, 244, Università Politecnica delle Marche. http://onlinelibrary.wiley.com/doi/10.1002/0471667196.ess1705.pub2/abstract

[2]. Cammelli, A. (2007). *I laureati dell'Università riformata*. http://www.almalaurea.it/universita/profilo/profilo2006/premessa/pdf-file/totale.pdf

[3]. Carli Sardi, L., Delvecchio, F. (2002). *Indicatori e metodi per l'analisi dei percorsi universitari e post-universitari*. Padova: Cleup.

[4]. Chiandotto, B., Giusti, C. (2005). L'abbandono degli studi universitari, in *Modelli statistici per l'analisi della transizione università-lavoro*, ed. C. Crocetta, Padova: Cleup, 1-22.

[5]. Chiandotto, B., Varriale, R. (2005). Un modello multilivello per l'analisi della durata degli studi universitari, in *Modelli statistici per l'analisi della transizione università-lavoro*, ed. C. Crocetta, Padova: Cleup, 63-86.

[6]. Cingano, F., Cipollone, P. (2007). *University drop-out: The case of Italy*, Temi di discussione del Servizio Studi, 626, Roma: Banca d'Italia.

[7]. Clerici, R., Giraldo, A., Visentin, E. (2011). Academic careers between educational success, withdraw, change of course and delay. Analysis by cohort using data from the administrative archives of Padova University. *Technical Report Series*, 1, June 2011.

[8]. Clerici, R., Rossi, F. (1997). Applicazioni di Tavole di Sopravvivenza, in *Popolazione e Mercato*, eds. G. Micheli and G. Rivellini, Milano: FrancoAngeli, 167-196.

[9]. Coggi, C. (2001), Successi e abbandoni (1996-2000), in *Valutare l'Università: la facoltà di Scienze della Formazione a Torino*, ed. R. Grimaldi, Torino: UTET Libreria, 173-211.

[10]. Crocetta, C. (2006). *Metodi e modelli per la valutazione del sistema universitario*, Collana “Determinazione e previsione di rischi sociali e sanitari“, n. 9, Padova: Cleup.
[11]. CRUI. (2003). *La valutazione: un indispensabile strumento di garanzia e governance*. http://www.crui.it/data/allegati/links/902/VAL%208ottobre.pdf.
[12]. Delvecchio, F., D’Ovidio, F. (2002). Alcuni fattori di rischio per l’abbandono degli studi universitari, in *Indicatori e metodi per l’analisi dei percorsi universitari e post-universitari*, eds. L. Carli Sardi and F. Delvecchio, Padova: Cleup, 101-124.
[13]. Di Nuovo, S. (2010). Il ruolo dell'orientamento e del tutorato per evitare la dispersione, in *Vincoli dei sistemi formativi e sociali che provocano abbandoni e ritardi all'Università e possibili interventi risolutivi*, MIUR and CNVSU. http://www.cnvsu.it
[14]. Feltrin, P. (2010). Le cause della dispersione universitaria in Italia: alcuni suggerimenti per la sua riduzione, in *Vincoli dei sistemi formativi e sociali che provocano abbandoni e ritardi all'Università e possibili interventi risolutivi*, MIUR and CNVSU. http:/www.cnvsu.it
[15]. Garcia, P. (1994). Predicting College Enrollement. Results from a variant of the Life Table, in *Demographics. A Casebook for Business and Governement*, Kintner H.J. et al., San Francisco-Oxford: Westview Press-Boulder, 307-326.
[16]. Goldstein, H. (2011). *Multilevel Statistical models*. Cichester: Wiley.
[17]. Grimaldi, R. (2001). *Valutare l’Università: la facoltà di Scienze della Formazione a Torino*. Torino: UTET Libreria.
[18]. Hox, J. J. (1994). *Applied Multilevel Analysis*. Amsterdam: TT-Publikaties.
[19]. Marasini, D., Bagnardi, V. (2008). Monitoraggio delle carriere degli studenti: l'esperienza dell'Ateneo di Milano-Bicocca. *Statistica e Società*, VI, 1, 26-32.
[20]. McCullagh, P., Nelder, J. (1989). *Generalized Linear Models. 2nd edition*. London: Chapman and Hall.
[21]. MIUR/CNVSU (2010). *Vincoli dei sistemi formativi e sociali che provocano abbandoni e ritardi all’Università e possibili interventi risolutivi*. http://www.cnvsu.it.
[22]. MIUR/CNVSU (2011). *Undicesimo rapporto sullo stato del sistema universitario*. http://www.cnvsu.it.
[23]. Montinaro, M., Scagni, A. (1995). *Scienze Politiche a Torino. Indagine statistica sulle carriere degli studenti e dei laureati*. Torino: UTET Libreria.
[24]. OECD (2010). *Education at a glance 2010*. http://www.oecd.org.
[25]. Pollard, A.H., Yusuf F., Pollard, G.N. (1974). *Demographic Techniques,* part 10 (Multi-decrement tables), Sydney: Pergamon Press, 136-143.
[26]. Schizzerotto, A., Denti, F. (2005). *Perduti e in ritardo. L'esperienza dell'abbandono e dell'irregolarità degli studi in cinque leve di immatricolati all'ateneo di Milano-Bicocca. Rapporto di ricerca*. Milano: Dipartimento di Sociologia-Università degli Studi di Milano-Bicocca.
[27]. Schoen, R. (2006). *Dynamic Population Models*. Dordrecht: Springer.
[28]. Seal, H. S. (2006). Multiple Decrement Tables, in *Encyclopedia of Statistical Science*, S. Kotz and N. L. Johnson, Wiley Online Library.
[29]. Shryock, H.S., Siegel, J.S. and Associates (1976). *The methods and materials of Demography*, part 15 (The Life Tables). Orlando-London: Academic Press, 249-271.