Working Paper Series, N.9, November 2013

A multilevel competing risks model for analysis of university students' careers: evidence from Italy

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Abstract: This paper examines individual and institutional characteristics which may influence the outcomes of university students' careers. In particular, it examines the withdrawals, course changes, delays or graduations of students enrolled in first-cycle degree courses in a large public university in North-East Italy. Individual longitudinal data from administrative archives were used, taking into account both the temporal dimension in a discrete-time competing risks approach, and the organisational and structural characteristics of the degree courses in which students were enrolled. In order to examine the hierarchical nature of the data properly, analyses were carried out within a multilevel framework. At individual level, results indicate that the profile of a successful student is defined by both socio-demographic factors and pre-university educational experience. At course level, some characteristics such as restricted access to some courses, study fields, and course size were important for students' university careers, although the effects were not always in the expected direction.

Keywords: University outcomes, Survival analysis, Competing risks, Multilevel analysis

Final Version (2013-11-18)

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The determinants of academic outcomes in a competing risks approach: evidence from Italy[1]

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Abstract: This paper examines individual and institutional characteristics which may influence the outcomes of university students' careers. In particular, it examines the withdrawals, course changes, delays or graduations of students enrolled in first-cycle degree courses in a large public university in North-East Italy. Individual longitudinal data from administrative archives were used, taking into account both the temporal dimension in a discrete-time competing risks approach, and the organisational and structural characteristics of the degree courses in which students were enrolled. In order to examine the hierarchical nature of the data properly, analyses were carried out within a multilevel framework. At individual level, results indicate that the profile of a successful student is defined by both socio-demographic factors and pre-university educational experience. At course level, some characteristics such as restricted access to some courses, study fields, and course size were important for students' university careers, although the effects were not always in the expected direction.

[1] The study is carried out with the project at University of Padova "Learning difficulties and disabilities from primary school to university: diagnosis, intervention and services for the community" (Prot. STPD08HANE_005), in particular, within the Research Unit 5.

Keywords: University outcomes, Survival Analysis, Competing Risks, Multilevel analysis

1. Introduction

Although international studies have shown the importance for both individuals and society of obtaining a university qualification (Eurydice 2010; EACEA 2012), entering higher education does not necessarily conclude with a degree (Lassibille 2011; Chen 2012). Increasingly interest has been paid to the determinants of students' outcomes during their university careers. Academic careers can in fact give rise to highly complex data, and only recently have researches highlighted the need for refined methodological tools to take this complexity into due account.

First of all, the temporal dimension cannot be neglected, due to the complex paths followed by students during their time at university, and a survival approach must therefore be used to analyse their behaviour throughout their university path (Singer and Willett 1991; Arias Ortiz and Dehon 2013). In addition, since the assumption that the precise time of occurrence of an event is known to be fairly unrealistic in educational contexts (Singer and Willett 1993; Scott and Kennedy 2005), a discrete framework must be considered. Although the importance of these issues is clearly recognised in the literature, the same cannot be said for the fact that different university career paths require a competing risks approach: highly complex educational histories are indeed observed in the learning process, and single-risk models assuming event independence may be inappropriate. A competing risks approach can reveal the complex interdependencies between multiple and

competing events and highlight differences in the factors which influence them (see discussion in DesJardins et al. 2002, and Arias Ortiz and Dehon 2013). Lastly, most previous studies have focused on individual student perspectives (the "*student-centered research tradition*"; Smart et al. 2006), whereas very few have also addressed how university characteristics affect students' progress, although their potential importance is obvious (Berger and Milem 2000; Patrick 2001) and consequently interesting for educational managers and policy-makers. When university characteristics affecting students' results are examined, the hierarchical nature of the data must be taken into account: students are clustered in degree courses, and degree courses are clustered in universities. Since the seminal work of Goldstein (1987), the hierarchical nature of educational phenomena has been viewed as essential if those phenomena are to be correctly understood and interpreted (Tate 1988; Darrel 1989; O'Connell and McCoach 2008). Nevertheless, the international literature contains few studies in which the temporal approach is integrated in a multilevel framework in analysing the individual and contextual dimensions of university path outcomes (Patrick 2001; Arulampalam et al 2004; Chen 2012).

In Italy, research on these topics is still in its infancy (Di Pietro 2004; Boero et al. 2005; Cingano and Cipollone 2007; Di Pietro and Cutillo 2008; Belloc et al. 2010, 2011; Aina et al. 2011; Aina 2013). This is due to the lack of appropriate data (national datasets with complete individual students' records are not available) and only recently have students' complex, multiple university paths been considered in a temporal dimension by means of a competitive risks approach (Clerici et al. 2013).

The aim of this paper was to study, in a single Italian university, how the characteristics of both degree courses and students as individuals affect those students' university outcomes. With respect to the existing literature, we integrate the discrete temporal dimension and competitive risks approach in multilevel modelling of hierarchical data on students and degree courses, applying methodological tools taking all these aspects into account. Since this is one of the first studies examining the hierarchical nature of educational data within an appropriate survival approach in Italy, particular attention is paid to the effects of course-level characteristics.

Our data refer to four cohorts of students entering three-year undergraduate degree courses (tertiary education – ISCED 2011 level 6, first degree programs) at the University of Padova, a large public institution in North-East Italy. We therefore identify those categories of students who are most greatly exposed to the risk of unsuccessful departure from university, and the course characteristics which may encourage successful learning or turn students away from it. The results are indicative not only for individual students but also for universities, in designing informed policies and interventions to discourage students from leaving higher education before graduating and to create support systems. By examining a set of three possible students' behaviours, we can define different types of at-risk students and suggest how universities can focus their resources more efficiently.

This paper is organised as follows. Section 2 presents the theoretical framework, section 3 describes the main features of the Italian university system, and section 4 explains our methodological approach, with data and methods. Section 5 presents a multilevel competing risks model, and section 6 discusses the results and concludes.

2. Theoretical framework

The literature on success and failure in higher education is huge and well-established (e.g., Thomas 2002; Lassibille and Gómez 2008; Lassibille 2011; Chen 2012). From both empirical and theoretical points of view, scholars explore the individual, social and organisational factors which determine students' outcomes at university. However, only a few aspects have been explored in depth. The main focus is on drop-outs, a problem which is faced from the perspective of both students and institutions. Starting from Tinto's Student Integration Model (Tinto 1975, 1993), the most famous theory on student attrition, student performance and departure from university are the

consequences of interactions between students' personal and social characteristics and universities' institutional practices. This view opens up the attractive possibility of effective intervention by academic institutions to reduce withdrawals. Nevertheless, there is not much empirical evidence indicating "support for the main elements in Tinto's model" (Braxton et al. 1997), since empirical works on institutional characteristics affecting student retention rates are quite rare (see, among others, Pascarella and Terenzini 1991; Ethington 1997; Patrick 2001; Titus 2004; Chen 2012), and there are even fewer analyses examining how these characteristics can also affect successful students compared with non-continuing ones (see, e.g., Titus 2004, and Cristie et al. 2004).

With reference to a single institution (Patrick 2001; Cristie et al. 2004), the hypothesis is that students who enrol in the same degree course face the same organisational context, teaching methods and levels of academic support. In addition, activities such as tutoring, contacts with faculty members and other services (e.g., support for working students) can be offered in different ways for each degree course. Lastly, the social environment surrounding degree courses (percentage of working students, class sizes, compulsory attendance, etc.) can greatly influence peer relationships and thus, indirectly, students' performance.

Most previous researchers have focused on more than a single university. They found that important factors of students' successful careers were mainly financial (Ryan 2004, Kim 2007, Chen 2012). In the case of a single institution, as in the present study, these factors are clearly not influential, since all students can benefit by the same financial resources for students' services, and any grants assigned to students depend on their personal characteristics (see Clerici et al. 2013, for a discussion on Italian university grants). Other important institutional factors having significant associations with student persistence versus drop-out are the structural characteristics of institutions, such as size and selectivity. In particular, both university size (Ryan 2004; Titus 2004) and selectivity (Kim 2007; Titus 2004, 2006; Gansemer-Topf and Schuh 2006) are negatively related to student drop-out. As regards size, Ryan (2004) suggests that, in large universities, due to scale economies, several academic services and types of support can be offered to students, thus enhancing persistence and leading to degree attainment. Conversely, highly selective universities have higher retention and graduation rates (Gansemer-Topf and Schuh 2006).

Apart from these theoretical considerations, from the statistical viewpoint, the hierarchical structure of data should also be considered. Statistical problems caused by the clustering of students in homogeneous groups - in the current study, those following degree courses - can be overcame by means of a multilevel framework (Patrick 2001). Multilevel modelling examines the links between individuals' characteristics and their contextual settings by partitioning variations in response variables to factors associated with levels (in the current study, students and degree courses).

3. An overview of higher education in Italy

Italy has one of the largest higher educational systems in the European Union (Eurostat 2012) and was one of the first countries which created what is now called the "European Area of Higher Education".

The Italian university system (based on the "3+2" reform, which came into force from academic year 2001/2002[1]) is organised in three cycles, offering three consecutive programme levels: the first-cycle academic degree (*laurea triennale*) grants access to the second cycle (*laurea magistrale*) which, in turn, gives access to third-cycle courses for research doctorate degrees.

First-cycle degrees, which are the focus of this study, give students basic theoretical preparation and an adequate command of general scientific methods and contents, in addition to specific professional skills. They normally last three years, but there are no regulations limiting the length of time in which students must complete their studies: provided they pay the fees, they can

[1] Ministerial Decree 270/2004 subsequently introduced some changes to the system, but they do not affect the students involved in this study.

continue to be enrolled at the university as long as they wish. The average fees vary from one university to another and also depend on the chosen course of study. Private universities are clearly more expensive than public ones. Students are entitled to scholarships and financial aid on the basis of financial means and/or merit.

Admission to first-cycle degrees may involve a restricted number of places (with compulsory assessment tests) or admission requirements (but without limited places). Foreign students can also apply, but must have foreign school-leaving qualifications satisfying requirements for access to university education in Italy and must be competent in the Italian language[2].

For this study, we used data from the University of Padova, which is one of the ten largest public institutions in the country, and also one of the oldest and most prestigious in Europe. It is highly multidisciplinary[3]. Students were enrolled in 81 different courses, covering all the main study fields. It is therefore very unlikely that our results reflect differences in the nature of programmes offered at this one institution, and this point is essential to the external validity of our estimates (see also Clerici et al. 2013).

4. Data and methods

4.1. Data

Data were obtained from the administrative archives of the University of Padova. The academic careers of 32,201 newly enrolled students in academic years 2002/03 to 2005/06 in 81 first-cycle degree courses were examined[4]. Information on each student's career is available for a maximum period of five years, but not after December 2009 (due to changes in computerised recording) (for a detailed description of data, see Clerici et al. 2013). In particular, this work focuses on three events which students may experience: course change (transfer to another University of Padova course), withdrawal (formal withdrawal from a degree programme, without re-enrolment at the University of Padova[5]), and graduation. Clearly, if students are still enrolled in the first or second year out-of-course (since observations are censored at the fifth year at most, further delays cannot be considered), they have not yet experienced any of these events. In the following, this situation is called "delay" and is one of the most important problems afflicting Italian universities (MIUR 2011; OECD 2013).

The University of Padova's administrative database also collects data on students' secondary education (type of secondary school attended, results of secondary school final examination, school career regularity) and some personal characteristics (gender, age, year of university enrolment, place of residence, nationality). Students are required to furnish all this information at the time of their application. Thus, our database does not contain missing data and is not affected by problems of bias, which may affect survey data.

The 32,201 students of our study comprise approximately 8,000 students enrolled in each academic year from 2002/03 to 2005/06; 45% are men. About 97% are Italian and 51% reside in their home town (Padova); 85% obtained their secondary school diploma and enrolled at the university in the same year. As regards secondary education, 60% of students come from high schools, 33% from polytechnics, and the rest from vocational schools; nearly 82% did not repeat any year in secondary school, and the average secondary school grade was 80/100.

[2] For details on requirements for foreign students, see http://www.study-in-italy.it/php5/study-italy.php?lang=EN&idorizz=3&idvert=15

[3] For details see http://www.unipd.it/en/.

[4] In order to obtain reliable estimates in multilevel models, students enrolled in three other low-dimensional courses (fewer than 50 students in the four cohorts) were excluded from analysis.

[5] Students who transferred to another university before graduating at the University of Padova were thus considered as withdrawals. This definition is due to the local dimension of our study: if it had been conducted at national level, some of these withdrawals would have been classified as "change of university".

Some information on the organisational (admission with or without restricted number of places, with or without compulsory attendance) and structural characteristics (study fields, number of enrolled students, percentages of working students) of degree courses are also available. As mentioned above, this paper focuses on students enrolled in 81 first-cycle degree courses. Most courses (72.8%) place no restrictions on number of places, but 22 courses (27.2%) do have restricted numbers, and best-ranking candidates are selected for admission according to an assessment test[6]. Just over half the courses (50.6%) have compulsory attendance. Various study fields are covered and four main subject areas are identified: professional health studies (11 courses; 13.6% of all courses), humanities (12 courses; 14.8%), and social sciences (16 courses; 19.7%). Most courses - 42, corresponding to 51.9% of all courses - regard scientific studies[7]. The average number of students enrolled in degree courses, calculated for all four cohorts, is about 397, varying from 51 students enrolled in "Logopedia" (Speech therapy) to 1,729 in "Scienze psicologiche della personalità e delle relazioni interpersonali" (Psychology of personality and interpersonal relationships). Working students are under 20% in all courses, varying each year from 3.7% of "Informazione Scientifica sul Farmaco" (Scientific information on pharmaceutics) to 19.7% of "Scienze dell'Educazione" (Educational Sciences).

4.2. Methods

Although students may change course, withdraw or graduate at any time during the academic year, the exact date when such an event occurs is not known, so that time was measured as the number of years from the first year of enrolment to the year of the first of these events. Discrete-time hazard models were consequently used: the data were examined in the person-period format, which includes a record for each time period - one academic year - in which the student is at risk of the event (Allison 1984; Singer and Willett 1991; Yamaguchi 1991; Scott and Kennedy 2005). As noted above, information on students' careers is available for a maximum period of five years, so that the maximum number of periods (years) during which a student may be at risk is five. In this way, the final dataset contains 99,438 person-period records for 32,201 students. In addition, since multiple outcomes at university (course changes, withdrawals, graduation) are of interest, a competing risks approach was used. In this framework, students "in delay" - those still enrolled at the university without having graduated by the time of our last observation - are considered as censored.

In general, assuming that there are K outcomes of interest (in our case, $K = 3$) and the non-outcome 0 (in our case, delay) for each discrete point in time t, we can compute hazard $h_i(k,t)$ which, here, is the conditional probability that student i transfers ($k = 1$), withdraws ($k = 2$) or graduates ($k = 3$) in time t, if that student has not yet left the educational system[8] (thus, non-outcome 0 happens in every period before t). In the competing risks framework, students can experience only one of the three outcomes of interest and, if one of them occurs, they are no longer at risk of experiencing any other outcome. To combine the discrete-time base and the competing risks context, hazard $h_i(k,t)$ is modelled through the discrete-time analogue of the continuous-time proportional hazards model with multinomial logistic regression (following the methodology presented by Scott and Kennedy 2005):

[6] For some courses, admission is based on assessment tests combined with grades in secondary school final examinations.

[7] For details on courses, see Clerici et al. (2013).

[8] Clearly, students can transfer or withdraw at any time (year); as first-cycle degree studies usually last three years, students are not expected to graduate in their first or second years, so that the hazard probability of outcome $k = 3$ should be zero for the first two years of enrolment. In fact, this is not necessarily the case, since our dataset includes students for whom some of the university credits required to obtain their degrees had been accepted from previous degree courses or professional activities considered particularly relevant to their current degree courses, which were consequently shortened.

$$log\left(\frac{h_i(k,t)}{h_i(0,t)}\right) = \alpha_{k1}D_{1i} + \alpha_{k2}D_{2i} + \alpha_{k3}D_{3i} + \alpha_{k4}D_{4i} + \alpha_{k5}D_{5i} + \beta_k x_i \quad k = 1, 2, 3 \qquad (1)$$

where $h_i(0,t)$ is the hazard of the non-event (delay), x_i is a vector of individual characteristics of student i, and β_k is the corresponding vector of regression coefficients for outcome k ($k = 1, 2, 3$), which captures the effect of the predictors on the baseline profile[9]. D_{li} ($l= 1,...,5$) are dummy variables corresponding to each time-point (in our case, years). The α_{kl} capture the baseline level of hazard in each time period[10] for outcome k. In this specification, the outcome-specific hazard ratio $log\left(\frac{h_i(k,t)}{h_i(0,t)}\right)$ measures the relative risk of experiencing event k with respect to the risk of experiencing the non-event. In other words, in the multinomial setting, the outcome-specific hazard ratio compares one outcome to a non-event, rather than to its complement (as in the single-outcome setting). In fact, an alternative specification of time is considered in this paper. In particular, a constant term (representing the intercept) and four dummy variables are used, corresponding to years 1 to 4 of enrolment: in this way, year 5 of enrolment is the reference category and the other year coefficients must be interpreted as differences from year 1:

$$log\left(\frac{h_i(k,t)}{h_i(0,t)}\right) = \alpha_{k0} + \alpha_{k1}D_{1i} + \alpha_{k2}D_{2i} + \alpha_{k3}D_{3i} + \alpha_{k4}D_{4i} + \beta_k x_i \qquad k = 1, 2, 3 \qquad (2)$$

One further point which must be made, in view of the hierarchical nature of our dataset, is the problem of possible clustering within degree courses. Several theories have emphasised the importance of the dynamic and reciprocal interaction between the environment and individual students (Chen 2012): in particular, institutions' characteristics may influence students' involvement in the academic and social systems at university and their academic outcomes. In addition, students in the same context (courses) may behave more similarly than ones from other contexts, which means that statistical procedures which incorporate hierarchical structure are necessary and important. In this analysis, students (level-1 unit of analysis) are clustered within courses (level-2 unit of analysis). Ignoring this nested nature of the data is equivalent to assuming that the timing of different outcomes at university is independent of the courses in which students have enrolled: this assumption may lead to incorrect estimates (Raudenbush and Bryk 2002). The hierarchical structure of our data is confirmed in Clerici et al. (2012).

In a multilevel framework, we consider a random intercepts model[11] (Steele et al. 1996; Kreft and de Leeuw 1998; Snijders and Bosker 1999; Steele et al. 2004), starting from an average

[9] In this specification, the effect of each predictor is to shift the outcome-specific hazard ratio vertically at every point in time, which requires an assumption of proportionality. In fact, although it is important to calculate year-specific estimates for covariates (since the effects of regressors may change over time), here we estimate models according to the proportionality assumption. This choice was made not only for reasons of parsimony and convenience, but also because we were interested in an overall effect and, in particular, in the effect of course (level 2) covariates (a multilevel model could not be estimated, due to convergence problems when time interactions were added). Clearly, this does not give us temporal information, since we assume that the relationships between a regressor and the dependent variable are constant over time. Another assumption of the discrete-time hazard model is that of linearity, but it was not relevant in our case because, as following sections will show, explanatory variables were all categorical.

[10] For details on the meaning and interpretation of the effect of time on hazard probabilities, see discussion in Arias Ortiz and Dehon 2013.

[11] A random effects model was preferred to a fixed effect one, since our sample does not cover the full population of degree courses in Italy. Although estimates obtained with fixed effects models are very similar, this is not surprising, in view of the relatively large number of students in each degree course (see previous section). More complex models with random slopes were not estimated, due to convergence problems of estimates and also partly to the difficulty of interpreting them.

baseline level of hazard for course *j* (with *j = 1,..., 81*, corresponding to the 81 first-cycle degree courses of our data) indicated by α_{k0j}:

$$\alpha_{k0j} = \gamma_{k00} + u_{k0j} + \delta_k z_j \tag{3}$$

$$log\left(\frac{h_{ij}(k,t)}{h_{ij}(0,t)}\right) = \gamma_{k00} + \alpha_{k1}D_{1i} + \alpha_{k2}D_{2i} + \alpha_{k3}D_{3i} + \alpha_{k4}D_{4i} + \beta_k x_{ij} + \delta_k z_j + u_{k0j} \qquad k = 1, 2, 3 \tag{4}$$

In this model, z_j is a vector of the characteristics of course *j*, with its corresponding vector of regression coefficients δ_k for outcome *k*. γ_{k00}, α_{kl} ($l = 1, 2, 3, 4$), β_k and δ_k are fixed effects. For random intercepts u_{k0j}, varying among courses, we assume multivariate normal distribution with zero expectation and covariance matrix Σ. For simplicity[12], we restrict covariances to zero, so that Σ is a diagonal matrix. This is thus a two-level discrete-time competing risks model, with students as level 1 and courses as level 2, and variances in the intercept across courses are taken into account.

4.3. Individual level and course level covariates

As noted above, both individual-level and course-level characteristics may influence the different outcomes of university careers.

Two sets of aspects of students, which the literature has found to be important for university outcomes (Smith and Naylor 2001; Lassibille and Gómez 2008, 2009; Belloc et al. 2011; Lassibille 2011; Clerici et al. 2013) are considered in the analyses. The first includes all students' main personal characteristics: gender, age, year of enrolment, place of residence, and nationality. The second refers to their secondary education: type of secondary school, grades for secondary school final examinations, and school career regularity.

Age at enrolment is expressed as a dichotomous covariate, and indicates whether students enrolled immediately after secondary school or not. The year of enrolment, considered to control for the potentially different behaviours of students enrolled in the years close to the "3+2" reform (see Section 3), in comparison with those of students enrolled in more recent years, is taken into account through three dummies for academic years from 2002/03 to 2004/05 (i.e., 2005/06 is taken as reference). Students' nationality is measured through a dichotomous covariate distinguishing foreign students from Italians. Place of residence is described by a three-category variable, distinguishing students who reside in their home town (i.e., that of the University of Padova), those who live in Padova for study reasons ("live-in" students), and commuting students.

As regards students' educational background, the type of secondary school was taken into account through a three-category covariate: high school (*liceo*), polytechnic (*istituto tecnico*) and vocational school (*istituto professionale*). Grades from secondary school final examinations are expressed, for simplicity, as a dichotomous covariate describing whether the students obtained a grade equal to or greater than 70 (range: 60-100). Lastly, the regularity of secondary school careers was measured by a dichotomous variable.

The literature has also shown the importance of course characteristics for students' outcomes (Patrick 2001; Titus 2004; Kim 2007; Chen 2012). Here, course-level characteristics concern on one hand organisational aspects, such as criteria for admission and attendance and, on the other, structural factors such as study fields, number of enrolled students, and the proportion of working students.

Although there are very few studies of the effect of type of admission to courses, we expect that, since courses with limited access may be more selective in defining student peer groups than

[12] Models were estimated by PROC NLMIXED in SAS; estimation is very time-consuming, due to the complexity of the model. Maximum likelihood estimation of the parameters is in fact difficult, as the likelihood function consists of a product of 81 integrals (one for each course defining level-2 units), in which each cannot be solved in closed form. Here, an estimation based on adaptive quadrature was used.

those without restricted access, this may affect individual student behaviour at university (Astin and Oseguera 2005). In the literature, when studying retention behaviour by comparing various institutions, a negative relationship between selectivity and withdrawal has been found, in which selectivity is measured by admitted students' test scores (Titus 2004; Kim 2007). However, a similar pattern may be plausible within a single university. In particular, peer groups in courses with limited access tend to be better prepared academically and more highly motivated and, for students who may be at risk of an interrupted career, the presence of such peers may cause these students to reconsider their situation and try to invest more in their careers (Kim 2007). A dichotomous variable was used to control for restricted access to courses.

A similar peer group effect may hold, if the course requires compulsory attendance at lectures. Many studies have shown the positive relationship between students' lecture attendance and their performance (Lockwood et al. 2006; Newman-Ford et al. 2008; Delaney et al. 2011). Unfortunately, in this work, we could not control for individual students' attendance at lectures (student-level characteristic), due to lack of appropriate data. However, peer groups in courses with compulsory attendance are expected to have more successful careers at university and to motivate students at risk of interrupting their careers to improve their performance. This characteristic is measured by a dichotomous variable indicating whether attendance is compulsory or not.

A similar observation holds for the presence of working students: having a job while enrolled at university is associated with a lower probability of retention and graduation (Thomas 2002; Dolton et al. 2003; Kim 2007; Lassibille and Gómez 2011). Again, we cannot control for the individual-level variable, but information on course-level counterparts is available. It is also possible that courses with high percentages of working students have particular services and support schemes for such students, so that (in this hypothesis), a higher proportion of working students should be associated with more successful university careers. A three-category variable distinguished courses with fewer than 10% of students with jobs, those with percentages between 10-15%, and those with more than 15%.

Significant differences also exist across study fields (Patrick 2001). For example, some authors have shown that students following professional health studies have lower risks of withdrawal and higher probabilities of graduation than students in other courses (see, e.g., reviews by Lassibille 2011, and Ortiz and Dehon 2011, or the results of Clerici et al. 2013). This result may be due either to differences in the effectiveness of educational inputs in various fields, or to the specific subject matter, which may be more or less difficult according to the field of study. In this paper, four main groups of study fields were examined: professional health studies, humanities, social sciences, and scientific studies[13].

The literature also indicates that course size is important for students' outcomes at university, and the fact that it is also one of the simplest variables for policy-makers to manipulate makes programme size potentially a key variable in the learning process. It is expected to have a negative impact on students' successful careers, for several reasons. For example, the number of students in a programme may affect how students interact with each other and, in particular, with their teachers: in larger courses, fewer personal interactions occur between students and teachers. Course size may also affect how much teachers can invest in individual students and their specific needs, rather than on the group as a whole: the smaller the course size, the more likely individual attention can be given. In fact, larger courses may also offer better academic and support services (Ryan 2004), offsetting the potential negative effect of student isolation and the lack of integration typical of larger courses (Kim 2007). Some studies have found no influence of size, probably due to these opposite effects (Montmarquette et al. 2001; Arulampalam et al. 2004; Titus 2006). In the

[13] Professional health studies include professions in Medicine, such as Nursing and Physiotherapy, Pharmacy and Veterinary Medicine; humanities comprise Arts and Philosophy, Education, and Psychology; social sciences include Economics and Management, Law, and Political Sciences; scientific studies include Agriculture, Astronomy, Biology, Biotechnology, Chemistry, Engineering, Mathematics, Physics, and Statistics. For details on the complete course list at the University of Padova, see http://www.unipd.it/sites/en.unipd.it/files/L_270_prospectus%202013.pdf.

present paper, course size is defined by a four-category covariate, considering the number of students attending each year (courses with fewer than 50 students, with 50-99, 100-179, and more than 179 students[14]).

4.4. Descriptive analyses

In the five-year period considered here, less than half our sample students had graduated, and withdrawals and delays both exceeded 20%; i.e., almost one student out of ten was still enrolled in the first or second year out-of-course (without having achieved a degree) (see last row of Table 1).

Table 1 lists the proportion of students in each of the four outcomes in each subgroup defined by individual-level and course-level characteristics.

The first part of Table 1 describes the process of students' departure from university according to individual characteristics. The percentages of outcomes according to academic year of enrolment are only comparable for the first three cohorts of students (enrolled in academic years 2002/03, 2003/04 or 2004/05), since for them information on university careers is available for a maximum period of five years. Students enrolled in 2005/06 were censored in the fourth year after enrolment, due to the lack of available data. In the first three cohorts, the percentage of withdrawals decreased, although course changes increased; the proportions of students graduating do not show monotonic distribution. Women and students with Italian nationality have more successful careers than men and foreign students, respectively, with higher percentages of graduation and fewer withdrawals and delays. Other important individual characteristics in discriminating more or less successful careers are age at enrolment and secondary school experience: students who enrolled in the university immediately after leaving high school, with better grades and after a regular school career, have the highest proportion of degrees and, conversely, the fewest withdrawals. There are no great differences in the percentages of outcomes according to place of residence. In general, students who transferred to other courses do not show highly differentiated distributions according to individual characteristics.

The second part of Table 1 refers to course-level characteristics for which, as already noted, the hierarchical nature of the data is defined by the 81 first-cycle degree courses. Students' progress through university is shown to vary according to course characteristics. As regards type of admission, students enrolled in courses with restricted access have more successful careers, with fewer withdrawals (15.5% vs. 25.9% of students enrolled in courses without restricted access) and delays (12.6% vs. 25.3% among other students) and higher percentages of graduation. Compulsory attendance also defines courses with students with better performance: students following such courses do show higher percentages of graduation in comparison with others, and fewer delays and withdrawals. Confirming findings from the literature (see review by Lassibille 2011), students in professional health studies perform better than students in other courses, as nearly 70% of them graduate, and the percentages for unsuccessful departures from university are under 10%. At the opposite end of the scale, less than half the students enrolled in humanities graduate, and their percentages of withdrawal and delay are nearly 30%. Students following social and scientific courses show similar performance and are intermediate with respect to the two other types of courses.

As regards course size, Table 1 does not show great differences in the process of students' departure from university: students in less frequented courses are more advantaged, with more graduations and fewer withdrawals, but the differences are not very great. Similarly, the presence of working students does not lead to great differences in students' careers, and the trend is not monotonic.

[14] These thresholds are defined according to the requirements for study courses defined in Ministerial Decree 17/2010, available at http://attiministeriali.miur.it/anno-2010/settembre/dm-22092010.aspx.

Table 1: Students' academic career outcomes by individual and course level characteristics (percentage values).

	Course change	Withdrawal	Graduation	Delay	Total =100	%
STUDENT-LEVEL CHARACTERISTICS						
Academic year of enrolment						
2002/03	7.0	25.3	55.0	12.7	8,005	24.9
2003/04	8.1	23.5	56.3	12.1	8,269	25.6
2004/05	9.6	21.7	48.6	20.1	8,006	24.9
2005/06*	10.5	20.5	27.6	41.4	7,921	24.6
Gender						
Female	9.1	19.9	51.1	19.9	17,623	54.7
Male	8.5	26.2	42.1	23.2	14,578	45.3
Nationality						
Italian	8.6	22.3	47.8	21.3	31,113	96.6
Other	14.6	35.0	24.8	25.6	1,088	3.4
Residence						
Resident students	8.9	22.4	46.0	22.7	16,395	50.9
"Live-in" students	9.0	24.5	48.9	17.6	6,745	21.0
Commuting students	8.5	22.2	47.3	22.0	9,061	28.1
Enrolment after graduation						
Immediately after	8.9	20.1	49.5	21.5	27,256	84.6
Not immediately after	8.2	37.4	33.4	21.0	4,945	15.4
Type of secondary school						
High school	9.8	18.1	52.2	19.9	19,359	60.1
Polytechnic	7.1	28.6	40.5	23.8	10,660	33.1
Vocational school	8.1	35.5	33.3	23.1	2,182	6.8
Secondary school final score						
Mean score (/100)	79.2	75.8	84.3	77.4	80.4	
Median score (/100)	78.0	74.0	85.0	76.0	80.0	
Regularity of school career						
Irregular	8.9	37.2	28.8	25.1	5,914	18.4
COURSE-LEVEL CHARACTERISTICS						
Restricted admission						
No	7.5	25.9	41.3	25.3	22,492	69.8
Yes	11.7	15.5	60.2	12.6	9,709	30.2
Attendance						
Compulsory attendance	9.3	19.9	53.4	17.4	12,575	39.1
Not compulsory attendance	8.5	24.6	42.9	24.0	19,626	60.9
Study fields						
Professional health studies	8.9	15.6	68.2	7.3	2,662	8.3
Humanities	7.5	27.7	38.5	26.3	6,370	19.8
Social sciences	9.2	20.9	48.2	21.7	10,766	33.4
Scientific studies	9.1	23.4	45.7	21.8	12,403	38.5
Course size						
< 50 students	9.3	20.8	51.8	18.1	3,279	10.2
50-99 students	6.3	22.4	48.1	23.2	6,360	19.8
100-179 students	9.2	22.8	43.9	24.1	7,803	24.2
> 179 students	9.5	23.4	47.1	20.0	14,759	45.8
% working students						
Under 10%	9.3	21.1	48.9	20.7	14,114	43.8
10%-15%	6.2	25.4	44.6	23.8	8,756	27.2
Over15%	10.5	22.8	46.3	20.4	9,331	29.0
N	2,832	7,334	15,132	6,903	32,201	
%	8.8	22.8	47.0	21.4	100	

* censored.

Clearly, all the percentages of Table 1 are marginal, and the net effect of each individual and course characteristic should be obtained by multivariate analysis, which can control simultaneously for multiple factors. In particular, the effects of course-level characteristics must be identified net of

those of individual variables: for example, the different paths of students enrolled in different study fields may be due to the selection of students for these courses.

Multivariate models were estimated in the discrete-time competing risks multilevel approach (with random intercepts) described above. Covariates are listed in Table 1. They refer to the two levels of analysis: student-level characteristics (year of enrolment, gender, nationality, residence, age at enrolment, and educational background by type of secondary school, grades, and regularity), and course-level variables (limited access, compulsory attendance, study fields, course size, and presence of working students).

5. Results

Table 2 lists the coefficient estimates of individual and contextual covariates in a multilevel competing risks model: column 1 compares course changes and no event (i.e., censored information/delay), column 2 compares withdrawals and no event, and column 3 graduation and no event.

As regards the individual-level covariate, net of other factors, and confirming descriptive analyses, men more frequently interrupt their university careers than women, are more likely to withdraw, and less likely to graduate[15]. Other at-risk students are not Italian: they show significantly higher probabilities of course change and withdrawal, and are less likely to graduate than Italian students. Live-in students have higher risks of withdrawal than students resident in Padova, but are also more likely to graduate. Being a commuting student does not appear to decrease graduation rates directly, but it does so indirectly by increasing the probability of withdrawal. As expected, enrolling at university immediately after leaving secondary school significantly increases the probability of graduation and decreases the risk of withdrawal; such students are also less likely to change course.

The characteristics of secondary school experience (type of school, final examination grades, regularity) have significant effects on students' outcomes. Students entering university with qualifications other than high school diplomas (in particular, those from vocational schools), and those with low secondary school grades or with irregular school careers are more prone to withdrawal and less likely to graduate than other students. However, those from high schools, with good secondary school grades and regular careers, are at greater risk of course changes. Belloc et al. (2010, 2011) believe that this mixed evidence is due to the fact that students with a better educational background are more sensitive to course contents and, when they realise they do not enjoy them and/or are not satisfied, they change.

As regards course-level variables, results generally show evidence of variations in intercepts across courses (intercepts' variances are significantly different from zero) and course characteristics are important in students' outcomes.

Although there is evidence that the probability of withdrawal and course changes is lower in courses open to all students, students following courses with restricted access are more likely to graduate (as expected). Instead, students in courses with compulsory attendance have a lower risk of withdrawal than others, but do not have different profiles in terms of graduation.

Study fields are particularly important as regards withdrawals and graduation: students following professional health programmes have a higher probability of graduating than students in other courses, although they are at higher risk of course changes and withdrawal. Conversely, students in social studies have a (weak) lower probability of graduating than those following scientific programmes, and also lower risks of withdrawal and course change: thus, they are more likely to make consecutive enrolments without actually obtaining their degrees. Students enrolled in humanities are more similar to those in scientific studies, but have a weak lower probability of withdrawal.

[15] In particular, the estimated odds of withdrawing in any given year are 1.08 (= *exp(0.08)*) times greater for men than for women; the odds of graduating are 13% (= *100*[exp(-0.14)-1]*) lower for men than for women.

Table 2: Coefficient estimates of covariates in a multilevel competing risks model with three destinations.

	Course change (1)	Withdrawal (2)	Graduation (3)
STUDENT-LEVEL FIXED EFFECTS			
Intercept	-1.57***	-3.54***	-0.39
Year (*ref: 5)*			
1	1.51***	2.78***	1.81***
2	1.17***	1.88***	1.81***
3	0.95***	1.19***	1.78***
4	0.70***	0.68***	1.18***
Academic year of enrolment (*ref:2005/06)*			
2002/03	1.18***	1.46***	2.20***
2003/04	1.45***	1.50***	2.25***
2004/05	0.87***	0.84***	1.49***
Gender (*ref: female*)			
Male	-0.05	0.08**	-0.14***
Nationality (*ref: Italian*)			
Other	0.08	0.31***	-0.94***
Place of residence (*ref: resident students*)			
Live-in students	-0.00	0.37***	0.19***
Commuting students	-0.05	0.09***	0.03
Enrolment after graduation (*ref: immediately*)			
Not immediately after	-0.13**	0.54***	-0.34***
Secondary school (*ref: high school*)			
Polytechnic	-0.38***	0.26***	-0.33***
Vocational school	-0.29***	0.29***	-0.70***
Secondary school score (*ref: 70 or higher*)			
Under 70	-0.28***	0.13***	-0.91***
School career (*ref: regular*)			
Irregular	-0.15***	0.26***	-0.61***
COURSE-LEVEL FIXED EFFECTS			
Access (*ref: restricted access*)			
No restrictions	-0.90***	-0.22***	-0.99***
Attendance (*ref: not compulsory*)			
Compulsory	-0.20	-0.17***	-0.08
Study fields (*ref: scientific studies*)			
Professional health studies	1.06**	0.64***	1.28***
Humanities	-0.30	-0.07*	-0.26
Social sciences	-0.75**	-0.33***	-0.48*
Number of students (*ref: < 50*)			
50-100	-0.45**	-0.10**	-0.19
100-180	-0.03	-0.01*	-0.37**
> 180	-0.01	0.05	-0.41**
% working students (*ref: > 15%*)			
> 10%	-0.24	-0.24***	-0.45**
10-15	-1.04**	-0.19***	-0.43*
Random effects (course level)			
Variance (intercept)	0.43***	0.15***	0.22***

***= p<.001; **=p<0.05; *=p<0.10

Course size does not completely influence students' careers in the expected direction: courses with many students (more than 100) lower the probability of graduation, but those of intermediate size have higher risks of withdrawal. In some cases, these opposite potential effects of course size probably compensate each other.

Lastly, the significant effects of students with jobs are observed, not always in the expected direction. Although students enrolled in courses with low numbers of working students have lower risks of withdrawal, they also have a lower probability of graduating, particularly when numbers are under 10%.

6. Discussion

This paper analyses both individual and course factors influencing students' behaviour throughout their university careers. Course changes, withdrawals and graduations are considered in a multilevel discrete-time competing risks survival setting. Examining the multiple outcomes of university careers is clearly a very realistic way of treating student behaviour. In addition, as multilevel event history models are not common, the possibility of having individual longitudinal data on student outcomes and course characteristics creates a unique opportunity to study students' careers at university.

The analysis is worthy of note for its implications for individuals and institutions, in view of the rising human and financial costs of attendance and the increased importance of higher education in Western societies, thanks to its crucial role in human capital development.

At individual level, students' characteristics show expected effects in the opposite direction as regards the risk of withdrawal and that of graduation. The profiles of successful students are defined from a socio-demographic viewpoint as being women, of Italian nationality, and living in a university city - in this case, Padova - for study reasons. As regards pre-university education, graduating students had enrolled at university immediately after leaving high school, which they had regularly attended, and had good grades in their final school examinations.

The profiles of students who withdraw is the complete opposite. The weakness of their secondary school careers is thus a clear indication of a higher risk of educational failure. In this case, institutional planners should pay more attention to these students: on one hand, by discouraging students whose chances of not graduating are high and, on the other, by organising support activities and services in the various forms of tutoring, counselling and coaching. It is interesting to note that, in comparison with students in delay, those who change courses have pre-university educational experience similar to that of successful students (although their socio-demographic profiles do not significantly differ from those of students in delay). This similarity leads us to consider course changes as only partial failure, rather as re-orientation directed to educational success. This hypothesis should be verified by studying events after course changes, but the approach would clearly be different with respect to the one used here. However, our results suggest that university management should apply some kind of pre-enrolment orientation, focusing particularly on students from high schools. These students may not have complete information on educational offers or, more simply, they may be re-oriented by an interest in some study fields they only discovered during their university experience, since the subjects in question were not taught during their pre-university education.

Considering the results at course level, besides the effect of each covariate, it is interesting to note a macro-uniformity in the results: course characteristics tend to operate in the same direction for the three outcomes of interest. This suggests that some contexts may favour events, whatever they might be, in comparison with extending a delay condition. For example, courses with restricted admission lead to a higher probability of graduation, but they also have higher risks of withdrawal and course change, in comparison with delay. As regards study fields, there is evidence that students enrolled in certain disciplines have significantly different outcomes with respect to others. This may be connected with the fact that the "match" between students and the subjects they study

is easier in these fields than in others, or simply because in some fields academic requirements are lower or have a more supportive learning environment. In particular, similarity in outcomes is observed for students enrolled in scientific studies and humanities. Instead, the university careers of those enrolled in professional health studies and social sciences are quite opposite: the former being more likely to lead to graduation, course changes and withdrawal, and the latter to a static delay condition. More in general, our results highlight several contextual factors which should be considered by those responsible for educational practices and policies: actions and support services should be appropriately differentiated according to context, as well as to students' individual characteristics. In courses characterised by higher risks of delay, both support and counselling services for individual study and development of educational methods (for example, blended learning) should be provided. In courses with higher risks of change, more detailed orienting sessions at enrolment and psycho-pedagogical counselling during student careers could be organised.

This study emphasises the importance of contextual determinants, as well as individual factors, in the educational success or failure of university students. This implies that institutional planners should provide differentiated, personalised actions and services for particular groups of students defined according to their individual (e.g., pre-university career) and/or contextual (restricted admission, study field, course size) characteristics. Political decision-makers should clearly be more conscious of the need to invest greater economic resources in tutoring and orienting activities.

Unfortunately, the administrative data at our disposal did not provide information on students' family social and economic background, which has been found to be important in students' progress (Arias Ortiz and Dehon 2013; Lassibille 2011; Chen 2012). Similarly, another aspect which could not be taken into account was a subjective perspective, because of the nature of the administrative data source. Future research should consider family backgrounds, and attitudes, motivations and feelings about university study, in order to be able to propose comprehensive ways of improving the effectiveness of the educational process in higher education.

References

Aina, C. (2013). Parental background and university dropout in Italy. *Higher Education* doi: 10.1007/s10734-012-9554-z

Aina, C., E. Baici, and G. Casalone G. (2011). Time to degree: students' abilities, university characteristics or something else? Evidence from Italy. *Education Economics* 19(3): 311-325.

Allison, P. D. (1984). *Event history analysis: regression for longitudinal event data*. Sage University Papers: Quantitative Applications in the Social Sciences. Newbury Park, CA: Sage.

Arias Ortiz, E. A., and C. Dehon (2013). Roads to Success in the Belgian French Community's Higher Education System: Predictors of Dropout and Degree Completion at the Universite´ Libre de Bruxelles. *Research in Higher Education* 54: 693–723.

Arulampalam, W., R. A. Naylor, and J. P. Smith (2004). A hazard model of the probability of medical school drop-out in the UK. *Journal of the Royal Statistical Society. Series A* 167(1): 157-178.

Astin, A. W., and L. Oseguera (2005). Pre-college and institutional influence on degree attainment. In A. Seidman (Ed.), *College student retention: Formula for student success* (pp. 245–276). Westport, CT: Praeger Publishers.

Belloc, F., A. Maruotti, and L. Petrella (2010). University drop-out: an Italian experience. *Higher Education* 60: 127–138.

Belloc, F., A. Maruotti, and L. Petrella (2011). How individual characteristics affect university students drop-out: a semiparametric mixed-effects model for an Italian case study. *Journal of Applied Statistics*, 38(10): 2225-2239.

Berger, J. B., and J. F. Milem (2000). Organizational behavior in higher education and student outcomes. In J.C. Smart (Ed.), *Higher Education: Handbook of theory and research*, Vol. XV, pp.209-240, New York: Springer.

Boero, G., T. Laureti, and R. A. Naylor (2005). *An econometric analysis of student withdrawal and progression in the post-reform Italian universities*. CRENOS Working paper, no. 1048.

Braxton, J. M., A. V. Shaw Sullivan, and R. M. Johnson (1997). Appraising Tinto's theory of college student departure. In J. C. Smart (Ed.), *Higher Education: Handbook of Theory and Research*, Vol. XII, pp. 107–164. New York: Agathon Press.

Chen, R. (2012). Institutional characteristics and college student dropout risks: a multilevel event history analysis. *Research in Higher education* 53: 487-505.

Christie, H., M. Munro, and T. Fisher (2004). Leaving university early: exploring the differences between continuing and non-continuing students. *Studies in Higher Education* 29(5): 617-636.

Cingano, F., and P. Cipollone (2007). *University drop-out: The case of Italy*. Temi di discussione, Banca D'Italia no. 626.

Clerici, R., A. Giraldo, and S. Meggiolaro (2013). *The determinants of academic outcomes in a competing risks approach: evidence from Italy*, Working Paper n.1/2013, Department of Statistical Sciences, Padova.

Clerici, R., A. Giraldo, and E. Visentin (2012). Course organisational structure as a determinant of academic success. Some evidence from university of Padova (Italy). *Electronic Journal of Applied Statistical Analysis: Decision Support Systems and Services Evaluation*, 3(1): 1-14.

Darrell, B. R. (Ed.) (1989). *Multilevel Analysis of Educational Data*. San Diego, CA, US: Academic Press.

Delaney, L., C. Harmon, and M. Ryan(2011). *Does lecture attendance matter for grades? Evidence from a longitudinal tracking of Irish students*. Working Paper available at http://ciisn.files.wordpress.com/2011/01/martin-ryan-_-does-lecture-attendance-matter-forgrades_working-paper.pdf.

DesJardins, S. L., D. A. Ahlburg, and B. McCall (2002). A temporal investigation of factors related to timely degree completion. *The Journal of Higher Education* 73 (5): 555-581.

Di Pietro, G. (2004). The determinants of university dropout in Italy: A bivariate probability model with sample selection. *Applied Economics Letters* 11: 187–191.

Di Pietro, G., and A. Cutillo (2008). Degree flexibility and university drop out: The Italian experience. *Economics of Education Reviews* 27: 546–555.

Dolton, P., O. D. Marcenaro, and L. Navarro (2003). The effective use of student time: a stochastic frontier production function case study. *Economics of Education Review* 22: 547–60.

EACEA (2012). *The European Higher Education Area in 2012: Bologna Process Implementation Report*. Bruxelles: Eurydice. doi:10.2797/36567. Available online at: http://eacea.ec.europa.eu/education/eurydice

Ethington, C. A. (1997). A hierarchical linear modeling approach to studying college effects. In J. C. Smart (Ed.), *Higher Education: Handbook of Theory and Research*, Vol. XII, pp. 165–194. New York: Agathon Press.

Euridice (2010). *Focus on Higher Education in Europe 2010: the impact of the Bologna Process*, Brussels. doi 10.2797/38158.

Gansemer-Topf, A. M., and J. H. Schuh (2006). Institutional selectivity and institutional expenditures: examining Organizational factors that contribute to retention and graduation. *Research in Higher education* 47(6): 613-642.

Goldstein, H. (1987). *Multilevel Models in Education and Social Research*, London, Griffin, New York: Oxford University Press.

Kim, D. B. (2007). The effect of loans on students' degree attainment: Differences by student and institutional characteristics. *Harvard Educational Review* 77(1): 64–100.

Kreft, I., and J. de Leeuw (1998). *Introducing Multilevel Modeling*. London, Thousand Oaks, New Delhi: Sage.

Lassibille, G., and M. L. N. Gómez (2008). Why do higher education students drop out? Evidence from Spain. *Education Economics* 16(1): 89-105.

Lassibille, G., and M. L. N. Gómez (2009). Tracking students' progress through the Spanish university school sector. *Higher Education* 58(6): 821-839.

Lassibille, G., and M. L. N. Gómez (2011). How long does it take to earn a higher education degree in Spain? *Research in Higher Education* 52: 63-80.

Lassibille, G. (2011). Student progress in higher education: what we have learned from large-scale studies. *The Open Education Journal* 4: 1-8.

Lockwood, P., C. Guppy, and C. Smyth (2006). *Should lectures be compulsory?* Proceedings of the UniServe Science Assessment Symposium, Sydney, Australia, 2006. Available at http://science.uniserve.edu.au/pubs/procs/2006/lockwood.pdf.

MIUR (2011). *Undicesimo Rapporto sullo Stato del Sistema Universitario*. Ministero dell'Istruzione, dell'Università e della Ricerca, Comitato nazionale per la valutazione del sistema universitario. Roma.

Montmarquette, C., S. Mahseredjian, and R. Houle (2001). The determinants of university dropouts: A bivariate probability model with sample selection. *Economics of Education Review* 20: 475-484.

Newman-Ford, L., K. Fitzgibbon, S. Lloyd, and S. Thomas (2008). A large-scale investigation into the relationship between attendance and attainment: a study using an innovative, electronic attendance monitoring system. *Studies in Higher Education* 33(6): 699-717.

O'Connell, A. A., and D.B. McCoach (2008). *Multilevel analysis of educational data*. Greenwich, CT: Information Age Publishing.

OECD (2013). *Education at a Glance 2013: OECD Indicators*, OECD Publishing. http://www.oecd.org/edu/eag2013%20%28eng%29--FINAL%2020%20June%202013.pdf

Pascarella, E. T., and P. T. Terenzini (1991). *How College Affects Students: Findings and Insights from Twenty years of Research*. Jossey-Bass: San Francisco, CA.

Patrick, W. J. (2001). Estimating first-year student attrition rates: an application of multilevel modelling using categorical variables. *Research in Higher Education* 42(2): 151-170.

Raudenbush, S. W., and A. S. Bryk (2002). *Hierarchical Linear Models: applications and data analysis methods*. (2nd edition). Thousand Oaks: Sage.

Ryan, J. F. (2004). The relationship between institutional expenditures and degree attainment at baccalaureate colleges. *Research in Higher Education* 45(2): 97–114.

Scott, M., and B. Kennedy (2005). Pitfalls in pathways: some perspectives on competing risks event history analysis in education research. *Journal of Educational and Behavioral Statistics* 30(4): 413-442.

Singer, J. D., and J. B. Willett (1991). Modelling the days of our lives: using survival analysis when designing and analysing longitudinal studies of duration and the timing of events. *Psychological Bulletin* 110(2): 268–290.

Singer, J. D., and J. B. Willett (1993). It's about time: using discrete-time survival analysis to study duration and the timing of events. *Journal of Educational Statistics* 18: 155–195.

Smart, J. C., K. A. Feldman, and C. A. Ethington (2006). Holland's theory and patterns of college students success. In *Commissioned report for the national symposium on postsecondary success: Spearheading a dialogue on student success*. Washington DC: The National Postsecondary Education Cooperative.

Smith, J. P., and R. A. Naylor (2001). Dropping out of university: A statistical analysis of the probability of withdrawal for UK university students. *Journal of the Royal Statistical Society-Series A* 164: 389–405.

Snijders, T. A. B., and R. J. Bosker (1999). *Multilevel Analysis: An Introduction to Basic and Advanced Multilevel Modeling*. London, Thousand Oaks, New Delhi: Sage.

Steele, F., I. Diamond, and D. Wang (1996). The determinants of the duration of contraceptive use in China: a multilevel multinomial discrete hazards modelling approach. *Demography* 33: 12–33.

Steele, F., H. Goldstein, and W. Browne (2004). A general multilevel multistate competing risks model for event history data, with an application to a study of contraceptive use dynamics. *Statistical Modelling* 4: 145–159.

Tate, R. L. (1988). Multilevel Models in Educational and Social Research by Harvey Goldstein. *Journal of Educational Statistics* 13(2): 187-191.

Thomas, L. (2002). Student retention in higher education: the role of institutional habitus. *Journal of Education Policy* 17(4): 423- 442.

Tinto, V. (1975). Drop out from higher education: a theoretical synthesis of recent research. *Review of Education Research* 45: 89-125.

Tinto, V. (1993). *Leaving College: Rethinking the Causes and Cures of Student Attrition*. 2nd ed. Chicago: University of Chicago Press.

Titus, M. A. (2004). An examination of the influence of institutional context on student persistence at 4-year colleges and universities: A multilevel approach. *Research in Higher Education* 45(7): 673–699.

Titus, M. A. (2006). Understanding college degree completion of students with low socioeconomic status: The influence of the institutional financial context. *Research in Higher Education* 47(4): 371–398.

Yamaguchi, K. (1991). *Event history analysis. Applied social research methods series* (Vol. 28). Sage, Newbury Park, CA.

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