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The Determinants of University Dropouts : A Sequential Decision Model with Selectivity Bias

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The Determinants of University Dropouts : A Sequential Decision Model with Selectivity Bias[*]

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Résumé / Abstract

Cette étude examine les déterminants des abandons scolaires à l'aide de données longitudinales de l'Université de Montréal. Un modèle probit bivarié avec biais de sélection montre que les variables expliquant la persévérance et l'abandon sont reliées à l'information acquise par l'étudiant concernant ses intérêts et ses habiletés. Le nombre moyen d'étudiants dans les cours obligatoires en première année est également un facteur déterminant. Les résultats obtenus supportent une version simple du modèle d'expérimentation scolaire de Manski et des modèles de décisions séquentielles d'Altonji, d'Oosterbeek et d'Hartog et al., sans pour autant rejeter l'approche de l'adéquation entre l'environnement et la personne proposée par Tinto.

In this paper, we study the determinants of university dropouts with a longitudinal data set on students' enrollments at the University of Montreal. With a bivariate probit model with selectivity bias, the variables explaining persistence and dropouts are related to the information gathered on the student about his or her interests and abilities. The average number of students in first-year compulsory courses is also a determining factor. These results support a simple version of Manski's model of schooling as an experimentation process and the models of sequential decisions of Altonji, Oosterbeek and Hartog et al. Also supported is the idea of person-environment fit, pioneered by Tinto.

Mots clés :   abandon scolaire, persévérance, intervention, modèle probit bivarié, biais de sélection

Key words :   university dropout, persistence, intervention, bivariate probit model, sample selection.

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1. INTRODUCTION

Postsecondary dropouts have become a major concern in many countries over the past years, because the dropout rates have reached notable levels [see Tinto (1987), Grubb (1989), Oosterbeek (1989), Hartog, Pfann and Ridder (1989) and references herein]. In North America and Western Europe, notably in many European community member countries, a surge in enrollment in the last decade has widened the gap between the number of students who enter the university system and the number of graduates. This has produced tensions between selective "elite" schools and largely accessible public universities. It has also resulted in low completion rates considered socially undesirable [Pritchard (1990), Neave and van Vught (1991)].

The problem, for many, is an important social issue, with American authors suggesting that society would be better off if dropout levels were lower [see, for example, Fisher (1987) and James (1988)]. In many Canadian political and educational sectors [see Montmarquette (1990)], people are concerned that higher graduation requirements will increase the dropout rates. With national economies challenged by international competition where education matters, not schooling, this kind of concern is troublesome.

In a recent article, Manski (1989) took a different stand by suggesting that being a postsecondary dropout is not necessarily a social problem. When schooling is regarded as an experiment, Manski argues "that the conventional wisdom regarding postsecondary dropout has no normative basis. Lowering dropout levels would not necessarily make society better off. The decision to enroll is a decision to initiate an experiment, a possible outcome of which is dropout" (p. 305). He suggests that completion has both exogenous and endogenous determinants. A simpler version of his model assumes that, conditional on enrollment, completion is exogenous : a student must be able to pass the prescribed courses. A more general version makes completion partly endogenous : the student must decide whether persisting to graduation is worthwhile. Hartog et al. (1989) make a similar point, arguing that "there is no fundamental distinction between decisions on completed educations and on partial educations" (p. l374). It is in accord with Oosterbeek's (1989) and Altonji's (1993) models of sequential decisions, since the educational process is uncertain and yields information to students to revise prior beliefs. This general line of approach complements the psychosociological model of attrition pioneered by Tinto (1975) based on the idea of person-environment fit. Vincens and Krupa (1994) have shown that the explanation of successes and failures in the French academic system combines individual variables and the organizational characteristics of the system with respect to entrance selection and the continuing evaluation of students. Specific programs and institutional policies designed to enhance student retention must be evaluated in this

global context. Finally, we note that in the economics of education litterature, concerns were raised in the design of better admissions rule (Anderson, Benjamin and Fuss, 1994) and the need to identify predictors of persistence (Horvath, Beaudin and Wright, 1992)

In this paper, we study the determinants of university dropouts with a longitudinal data on students' enrollments at the University of Montreal. Section II presents the statistical model and the data. Given the longitudinal nature of our dataset, we will refer to a bivariate probit model with selectivity bias to estimate the model. Section III discusses the empirical results. Section IV concludes.

II. THE MODEL AND THE DATA

Academic success and sustained interest with the student's initial choice of discipline are important "a priori" determinants of his or her persistence. The student might question his or her initial choice or drop out if he or she encounters academic difficulties or disillusion in light of actual information and current experimentation. Many outcomes are to be considered when experimenting with schooling : retention or persistence, transfer to a new program, and dropout or expulsion, which discrete sequential choice models can analyze.

Consider that an individual i in a two-period model must choose between two alternatives : persistence and dropout. For a given individual i, i = 1, ..., N, the total utility of each alternative j, j = 1, 2 at time t can be expressed as a sum of two components :

$$U_{ijt} = \beta'_{jt} X_{ijt} + \varepsilon_{ijt} , \qquad (1)$$

where X_{ijt} denotes the observed component that is a known function of the characteristics and socioeconomic background of the individual and of some environmental variables, and ϵ_{ijt} is an unobserved, random component.

The total utility variable is unobservable. The corresponding observed variable at period one is for an individual i to choose persistence over dropout defined in this binary outcome as :

$$y_{i1} = \begin{cases} 1, & \text{if } U_{i1} > 0 \\ 0, & \text{otherwise} \end{cases} \qquad (2)$$

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In period 2, conditional on having persisted in the first period, the individual i has again to choose to persist or dropout under the same rules. Formally :

$$
y_{i2} = \begin{cases} 1, & \text{if } U_{i2} > 0 \\ \\ 0, & \text{otherwise} \end{cases} \qquad (3)
$$

Assume that the unobserved components ϵ_{i1} and ϵ_{i2} are from a bivariate normal distribution with a correlation coefficient ρ : $\epsilon_{i1}, \epsilon_{i2} \sim N(0, 0, 1, 1, \rho)$. However, we observe data for the second round of choices only when the student has persevered after the first semester. This is a bivariate probit model for the two outcomes with sample selection. The observed persistence data are nonrandomly selected from the set of persistent students after the first semester. Formally, (y_{i2}, x_{i2}) is observed only when $y_{i1} = 1$.

The log-likelihood for the bivariate probit model with selection is[1]

$$
\begin{aligned}
& \sum\nolimits_{y_{i1}=1, y_{i2}=1} \ln P(y_{i1} > 0, \; y_{i2} > 0) \\
+ & \sum\nolimits_{y_{i1}=1, y_{i2}=0} \ln P(y_{i1} > 0, \; y_{i2} < 0) \\
+ & \sum\nolimits_{y_{i1}=0} \ln P(y_{i1} < 0) \\
= & \sum\nolimits_{y_{i1}=1, y_{i2}=1} \ln \Phi_2 [\beta_1' \; X_{i1}, \; \beta_2' \; X_{i2}, \; \rho \;] \\
+ & \sum\nolimits_{y_{i1}=1, y_{i2}=0} \ln \Phi_2 [\beta_1' \; X_{i1}, \; -\beta_2' \; X_{i2}, \; -\rho \;] \\
+ & \sum\nolimits_{y_{i1}=0} \ln \Phi [-\beta_1' \; X_{i1}] \; ,
\end{aligned} \qquad (4)
$$

where Φ_2 is a bivariate normal cumulative distribution function and Φ is univariate normal CDF.

The University of Montreal has developed a longitudinal data bank, starting with the cohort of first-year students registered in the fall semester of 1987. For each successive term, we know if the student is still enrolled in the initial program, if he or she dropped out, or if he or she transferred to another program within the university. The data used in the present study cover three semesters (fall 1987, winter 1988 and

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[1] Technical details are presented in Greene (1993, p. 660-664). See also for earlier applications and discussions of the bivariate probit model with sample selection, van de Ven and van Praag (1981) and Venti and Wise (1982).

fall 1988) beginning with the entrance semester where the student is required to select a specific (specialized) program at the University of Montreal.[2] The sample concerns 3,418 students, of which 91.2 percent return to their initial choice program for the second semester, while 1.9 percent transfer to a new program. After the first academic year, the dropouts represent 24.7 percent with 6.9 percent quitting as early as after the first semester. "Dropping out" is a concept that is defined relative to time. Students can quit school temporarily or permanently. We observed that some students who leave a specialized program come back a few sessions or even years later in the same program or in another program at the same university. The proportion of students coming back is low, however, and the attrition happens mostly during the first or second semester of study in a program.[3] Looking at the dropout rate in those terms, even with the knowledge that some students might come back, remains valid. In informational terms, the problem may be viewed as an interaction between an experiment in school and an experiment in the labor market. This data set offers a privileged test ground for the "schooling-as-experimentation" model : for almost twenty years, the tuition fees at the University of Montreal (and across Québec) have remained at $ 500 (Can.) for the whole academic year. Furthermore, the province of Québec keeps undergraduates eligible for financial benefits even if they change five times to a different academic program. These are clear invitations to experiment with schooling. A similar situation can be found in European countries where low tuition fees and many student support programs are also prevailing.

The tree structure of Figure 1 illustrates our simple sequential decision model and reports the number of observations at each decision node for two sample specifications. A **full sample** specification includes, as persistent, the students that have transferred to another program within the university. In the **restricted sample** specification, the students who have transferred are excluded. This sample is restricted to students enrolled in a program with an entrance quota and for students whose academic college performance variable, ZSCORE, is available. The ZSCORE variable is a key element to gain access to a university program with an entrance quota (see below for a full description of this variable).

[Insert Figure 1 about here.]

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[2]   At the undergraduate level, the summer term is not treated as a regular term.

[3]   In our sample, we observed that 15 students returned to their initial program after dropping out and 15 more have reintegrated the university through another program. These categories have too few observations to be modeled.

Table 1 presents the independent variables of the model and the descriptive statistics for each variable.

[Insert Table 1 about here.]

We have information on the characteristics and socioeconomic background of the student. Some of these explanatory variables reflect an ex-ante student demand to experiment with schooling. The individual characteristics variables include gender (GENDER), age (AGE), performance at college (ZSCORE), attendance to public or private college (PUBLIC), university grade point average after the first semester (UGPA1), admission status at the university (FLTIME), characteristics of the program chosen at the university, for example, programs with an entrance quota (PROGQ). In Québec, high school students graduate after eleven years of education and "colleges" are institutions between the high schools and the universities. The college level institutions offer two types of training : a preuniversity education, a prerequisite for university, and a vocational education leading directly to the job market. The ZSCORE is a standardized measure of the performance of students at the "collegial" level.[4] The ZSCORE is used in the admission of students to programs with quotas. These programs concern more than 77.0 percent of the students (see PROGQ in Table 1). The ZSCORE variable provides information about the relative position of a student in his college group. If the quality of education varies from one institution to the other, the ZSCORE does not consider this diversity.[5] The variable ZSCORE was missing for 7.9 percent of students in the sample, mainly for students that came from outside the Québec collegial system. For the full sample, we have obtained estimates for the missing collegial academic performance variable, ZSCORE, with a set of instrumental variables diversity.[6] If the means and the standard deviations of the ZSCORE variables are comparable for the two samples, however, for the restricted sample, the mean of UGPA1 is greater and has a lower standard deviation than for the full sample.

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[4]   Z-score = (X - M) / S, where X is the student's grade; M is the grade average of students having taken the same course, at the same term, and in the same group, in the same college; S is the standard deviation. Once the Z-score for each course has been computed, the average of all Z-scores for one student is determined. It varies between -3.00 and 3.00. So as not to deal with negative values, the constant 50.00 is added. Therefore, ZSCORE has a maximum of 53.00 and a minimum of 47.00.

[5]   Z-scores have only been officially corrected by the "perceived" quality of the college since 1989.

[6]   Missing elements of the ZSCORE variable were estimated by OLS with the independent variables GENDER, AGE, MTONG, REGION and PUBLIC.

The socioeconomic variables are the student's mother tongue (MTONG), citizenship status (CITIZEN) and regional home base (REGION). There are obvious limitations concerning these variables, since parental income and education are not available.

We expect that differences in the personal characteristic and socioeconomic variables observed among students of the sample will reflect their differences in quality and information and that the less-qualified and the less-informed students will drop out.

Finally, we include an intervention or environmental variable with the average number of students attending the first-year compulsory courses taken by the students (GMEAN). The square of this variable (GMEAN2) accounts for potential nonlinearity influence of this environmental variable on the retention status of the student.

III. THE EMPIRICAL RESULTS

Table 2 presents the bivariate probit with sample selection estimations of the "determinants of university dropouts" model for the two sample specifications.[7] In the restricted sample specification, the students who have transferred are excluded and the sample is restricted to students enrolled in a program with an entrance quota and students for which a ZSCORE is directly observed. The ZSCORE is a key element to gain access to a program with an entrance quota, and we expect this variable to be particularly important for that group of students.[8]

[Insert Table 2 about here.]

For both samples, ZSCORE measures the quality of the students in the determinants of perseverance (or dropout) in the first-semester decision. In the second semester, the university grade point average after the first semester (UGPA1) is used for the student quality variable. This way, the reference to a performance-grading

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[7]   The estimations were done with LIMDEP.

[8]   By avoiding a two-step estimation procedure as in the full sample specification (the first step is to estimate the missing Z-scores), we escape a potential heteroskedasticity problem which in a discrete choice model might produce nonconvergent estimators.

variable to measure the student quality is exogenous to the decision of dropping out or not of school.[9]

Consider, first, the results of the first-period decision for the **full sample** model specification. The statistically significant coefficient of AGE supports Manski's model of experimentation : for an older student, the cost of experimenting is higher and the student will therefore drop out after the first semester rather than wait much longer. A part-time university student experimenting (voluntary or forced to) with both the labor market and schooling is more likely to drop out than a full-time student (see the coefficient of FLTIME). The PROGQ variable shows that if a student is enrolled in a program with an entrance quota, the probability of perseverance is significantly higher. This is in accordance with the experimentation model, as the academic requirements are greater for programs with quotas than with the other programs.[10] These programs and their corresponding labor market are generally better known among students.

The individual's relative academic performance in college, the ZSCORE variable, offers an interesting result on educational market signalling. With an insignificantly positive coefficient in the econometric specification, this variable suggests that a better relative academic performance in college does not reduce the probability to drop out after the first semester.[11] In order to explain this unexpected result, we realized that to improve his or her ZSCORE, a student might have voluntarily chosen a lower-quality college and the easiest curriculum as possible to increase his chance of being accepted in a selected program at the University of Montreal.

The size of the class, in the first-year mandatory courses that usually benefit from an experienced teacher, affects the probability of persistence in a nonlinear way

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[9] The possibility of the endogeneity of the performance variable is an econometrically difficult and important issue not addressed in the attrition literature. One notable exception is Dagenais and Dagenais (1988) who considered the decision not to drop out a function of anticipated performance. An argument can be made, however, that the causality runs in the other direction : a student performance is affected by his or her decision to drop out. The authors used data from the University of Montreal Business School after the first academic year and at the end of the undergraduate program, but not in the specific context of a sequential decision model.

[10] Hartog et al. (1989) recognized that dropouts and graduates have different access to information.

[11] This was also observed by Dagenais and Dagenais (1988).

(GMEAN and GMEAN2). A group of less than eighty-seven students will increase the probability of persistence relatively to an early dropout. Above this level, the size effect is negative.

With the data nonrandomly selected according to a first-semester persistence at the university, maximum likelihood estimate of the bivariate probit model with selectivity bias yields simultaneous estimates of the second-period decision including a correlation estimate between the error terms of the two periods. The AGE variable remains relatively significant and the coefficient of the regional home base variable, REGION, is significantly different from zero at the 10 percent level. A student from the Montreal region, already adjusted to living in a large metropolitan area and who might be still living with his family, stands a greater chance to stay at the university. This situation lowers the costs of experimenting and favours a better economics and emotional environment for the student. The PROGQ variable continues to be a strong determinant of persistence, but the most influential statistically significant variable is the university grade point average obtained by the student after the first semester (UGPA1). An academically successful first semester plays a major rule for a student in his or her decision to continue at the university. Finally, we note the negative but insignificant correlation coefficient estimate between the error terms.

The results for the **restricted sample** confirm, for the first-period decision, the importance of being a full-time student, FLTIME, and the positive influence of smaller groups (less than eighty students) in mandatory courses (GMEAN, GMEAN2). AGE remains a statistically significant variable at the 10 percent significance level. In those more competitive academic sectors submitted to entrance quotas, being a female (GENDER) increases the probability of persisting at the university. Students who have attended a public college, PUBLIC, drop out more than those graduating from a private college. The coefficient estimate of ZSCORE is positive and statistically significant, but at the 10 percent level. This result is coherent with a positive effect on persistence for those having attended a private college and the educational market signalling effect of the Z-score system discussed above : if private colleges attract better-quality students, an average-quality high school student attending a public college will obtain a better ZSCORE than if he or she had to compete with more talented students of a private college. The student's "good" ZSCORE, helps him to get into the program, where, however, he remains an average-quality student with lower academic credential to complete the program.

In the second-period choice, a student with a strong academic average after the first semester is the most important and almost the sole determinant of persistence at the university. Being originally from the Montreal region, closer to his or her

family, also improves the probability for a student of continuing in the same program after the first full academic year.

IV. CONCLUSION

With a logituditinal data set, the statistical analysis presented in this paper offers new results on the determinants of university dropouts. The variables that explain persistence and early dropout are related to the group size in the first-year mandatory courses followed by the student and to the information detained about the university programs. After a first semester, a strong academic performance is the key element to the decision to persist at the university. As we saw with the results for the ZSCORE variable, there were potentially mixed signals sent to future university students. These mixed signals have enhanced the need for more experimentation. With low tuition fees and various governmental financial support programs, this experimentation is an inexpensive private decision. Programs aimed at lowering the dropout level would not necessarily make the society better off in those circumstances. What perhaps is more in need of being reevaluated are the social and private prices of that experimentation.
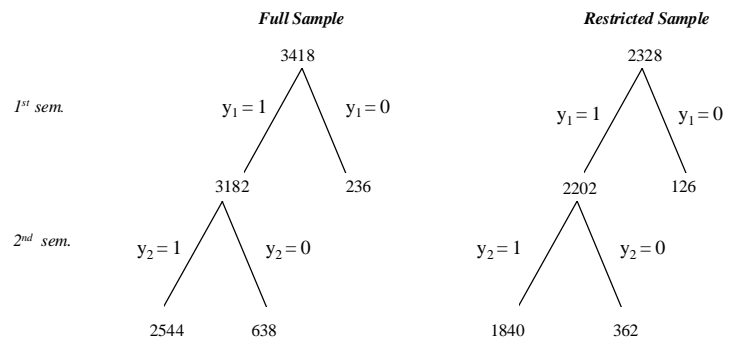
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Figure 1
"A Sequential Decision Model of University Dropouts"

Full Sample   *Restricted Sample*

3418   2328

1st sem. $y_1 = 1$ $y_1 = 0$ $y_1 = 1$ $y_1 = 0$

3182   236   2202   126

2nd sem. $y_2 = 1$ $y_2 = 0$ $y_2 = 1$ $y_2 = 0$

2544   638   1840   362

1 = persistent ; 0 = dropout

Table 1
"The Determinants of University Dropouts" :
Descriptive Statistics of Independent Variables

Symbol	Definition	Mean (Standard Deviation)	
Personal characteristics		**Full sample**	**Restricted sample**
GENDER	Gender of student (1 = female)	0.608	0.656
AGE	Age of student	20.671 (2.434)	20.612 (2.410)
ZSCORE	The student's relative academic performance in college (including estimates ZSCORE)	50.362 (0.651)	50.481 (0.633)
UGPA1	University grade point average after the first semester	2.660 (1.281)	2.894 (1.124)
PUBLIC	Attendance of public or private college (1 = public)	0.865	0.867
FLTIME	Admission status at the university (1 = full-time)	0.965	0.977
PROGQ	Characteristic of the program enrolled in at the university (1 = quota of admissions)	0.771	-
Socioeconomic factors			
MTONG	Mother tongue of the student (1 = French)	0.922	0.931
REGION	Region of origin of the student (1 = Montreal)	0.752	0.754
Environmental variables			
GMEAN	Average number of students in first-year compulsory courses	66.077 (29.987)	64.462 (28.637)
GMEAN2	Square of GMEAN	5265.140 (4315.686)	4974.978 (3992.302)
Sample size		3,418	2,328

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Table 2
A Statistical Analysis of "The Determinants of University Dropouts"

Variable	Full Sample		Restricted Sample	
	1st Period	2nd Period	1st Period	2nd Period
Personal characteristics				
GENDER	-0.04275 (0.0707)	-0.07516 (0.0610)	0.1962* (0.0957)	-0.05996 (0.101)
AGE	-0.03541* (0.0142)	-0.03166** (0.0170)	-0.03034** (0.0183)	-0.02553 (0.0221)
ZSCORE	0.06300 (0.0564)	–	0.1222** (0.0726)	–
UGPA1	–	0.6148* (0.0262)	–	0.9560* (0.0425)
PUBLIC	-0.04437 (0.109)	-0.07278 (0.0878)	-0.3192* (0.161)	-0.1112 (0.126)
FLTIME	1.1313* (0.124)	0.5668 (0.456)	1.1669* (0.188)	0.7502 (0.491)
PROGQ	0.3869* (0.0768)	0.3078* (0.109)	–	–
Socioeconomic factors				
MTONG	-0.08926 (0.140)	0.01790 (0.112)	-0.3280 (0.237)	0.1926 (0.167)
REGION	0.008362 (0.0818)	0.1342** (0.0693)	0.02774 (0.108)	0.2371* (0.0937)
Environmental variables				
GMEAN	0.01262* (0.00435)	–	0.01232* (0.00587)	–
GMEAN2	-0.0000739* (0.0000303)	–	0.00007728** (0.0000420)	–

Table 2 - Suite

A Statistical Analysis of "The Determinants of University Dropouts"

	Full Sample		Restricted Sample	
Variable	1st Period	2nd Period	1st Period	2nd Period
Other statistics				
Constant	-2.6208	-0.8353	-4.9701	-2.0718*
	(2.910)	(0.538)	(3.729)	(0.610)
$\rho(1,2)$	-0.08895		-0.04037	
	(0.935)		(1.067)	
Log of the likelihood function	-1,950.6		-1,093.6	

( )   Standard errors.

*   Significantly different from zero at the 5% level.

**   Significantly different from zero at the 10% level.

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