

College cost and time to obtain a degree: Evidence from tuition discontinuities.*

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Abstract

For many students throughout the world time to obtain an academic degree extends beyond the normal completion time, while college tuition is essentially constant during the years of enrollment and in particular does not increase when a student remains in a program after its regular end. Using a Regression Discontinuity Design on data from Bocconi University in Italy, this paper shows that if tuition is raised by 1000 Euros in the last year of the program, the probability of late graduation decreases by 6.1 percentage points with respect to a benchmark average probability of 80%. We conclude showing that an upward sloping tuition profile may be efficient when effort is sub-optimally supplied in the presence of peer effects.

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1 Introduction

For many students enrolled in academic programs throughout the world time to obtain a degree extends beyond the normal completion time. Interestingly, this happens while college tuition is typically kept constant during the years of enrollment and in particular does not increase (actually often decreases) when a student remains in a program after its regular end. This paper shows that these two findings, concerning the structure of tuition and the speed of graduation, are related and suggests that an increase in continuation tuition, rather than regular tuition, may increase efficiency in the presence of peer effects.

We discuss the link between continuation tuition and time to graduation in a simple model of human capital accumulation in which obtaining a degree is an uncertain outcome and requires time. Whereas early tuition is sunk vis-a-vis the optimal effort choice, students anticipate an increase in the continuation cost of education and react accordingly. Thus, an increase in the continuation cost of education raises students' effort and speed of completion. The core of the paper takes this simple prediction to the data, and estimates the causal effect of an increase in continuation tuition on the probability to obtain a degree beyond the normal completion time.

We base this empirical analysis on detailed administrative data from Bocconi University in Milan, a private institution that, during the period for which we have information (1992-2000), offered a 4 years college degree in economics. This dataset is informative on the question under study not only because more than 80% of Bocconi graduates typically obtain a degree in more than 4 years, but also because it offers a unique quasi-experimental setting to analyze the effect of tuition on the probability of delaying degree completion. Upon enrollment in each academic year, Bocconi students in our sample are assigned to one of 12 tuition levels on the basis of their income assessed by the university administration through the income tax declaration of the student's household and through further inquiries. A Regression Discontinuity Design (RDD) can then be used to compare students who, in

terms of family income, are immediately above or below each discontinuity threshold. These two groups of students pay different tuitions to enroll, but should otherwise be identical in terms of observable and unobservable characteristics determining the outcome of interest, which in our case is the decision to complete the program in time. Using this source of identification of the causal effect of a tuition increase, we show that if the fourth year tuition effectively paid by a student is raised by 1000 Euros, the probability of late graduation decreases by 6.1 percentage points. We also show that this decline in the probability of late graduation is not associated with a fall in the quality of students' performance as measured by the final graduation mark.

In light of these results, we proceed to ask whether there might be efficiency reasons suggesting that continuation tuition should be increased in real life academic institutions. While we are not in a position to estimate the marginal cost of providing education at Bocconi university or in other educational settings, our theoretical results can easily be given a normative implication. In our simple model an increase in continuation tuition, rather than in regular tuition, is desirable if there are peer effects in students effort. In such setting, tuition should be raised relative to the marginal cost of providing education, since effort would otherwise be sub-optimally supplied.

The paper proceeds as follows. Section 2 describes the related literature. Section 3 presents the available international evidence on time to degree completion and on tuition structures. Section 4 proposes a simple model of human capital accumulation that delivers our main empirical prediction, namely, the existence of a negative causal effect of the size of continuation tuition on the probability of obtaining a degree beyond the normal completion time. Section 5 describes the data, while Section 6 shows how a Regression Discontinuity Design can be used to identify the causal effect of interest and discusses the robustness of our results with respect to some important complications generated by the institutional setting in which our evaluation takes place. Finally, Section 7 goes back to the model and shows that if

peer effects are important, efficiency considerations suggest that continuation tuition should be raised relative to the marginal cost of providing education. Section 8 concludes.

2 Related Literature

There is a small literature looking at the effect of financial incentives on graduation times, but its findings are ambiguous and typically not based on experimental evidence capable to control adequately for confounding factors and in particular for students' ability. Among the less recent non experimental studies, Bowen and Rudenstine (1992) and Ehrenberg and Mavros (1992) find evidence of an effect of financial incentives, in particular on completion rates and time to degree, while Booth and Satchell (1995) find no such evidence.

A more recent study of Hakkinen and Uusitalo (2005) evaluates a reform of the financial aid system in Finland aimed at reducing incentives to delay graduation finding that the reform had some small effect in the desired direction. Similar in spirit, but with ambiguous findings, is the paper by Heineck et al (2006) that evaluates the German reform of 1998 which introduced a fee for students enrolled in a university program beyond the regular completion time. Both these studies, although based on the exogenous variation generated by a policy change, have nevertheless to rely on a comparison between similar students before and after the reform in order to identify the effect of a tuition increase on delayed enrollment.

Similarly plagued by the likely presence of confounding factors is the study of Groen et al. (2006) which evaluates the effect of the Graduate Education Initiative financed by the A.W. Mellon Foundation. This program distributed a total of 80 million dollars to 51 departments in 10 universities with the explicit goal of financing incentives aimed at reducing students' attrition and time to degree. By comparing these departments with a sample of similar control institutions, the study concludes that the GEI had a modest impact on the outcomes under study, mostly reducing student attrition rather than

increasing degree completion.¹

Related to our paper is also the vast literature on the effect of tuition on university enrollment, summarized for example in Kane (2003) and Heller (2001)². According to these authors the consensus estimate is that a 1000\$ increase in college costs decreases enrollment rates by 4%, a order of magnitude which is reassuringly similar to the one we find in our context. Also, the literature that focuses more generally on the effect of financial incentives on other indicators of student's performance finds results that are important for our study. This literature is typically based on randomized experiments. For example, Angrist and Lavy (2002) run different trials offering financial incentives to Israeli highschool students aimed at increasing matriculation rates and conclude that worthwhile gains in these rates can be obtained by offering cash awards in low-achieving schools. Leuven et al. (2006) perform instead a field experiment in which first year university students can earn financial rewards for passing all first year requirements. They find small and non-significant average effects of financial incentives on the passing rate and the numbers of collected credit points, which are the sum of a positive effect for high ability students and a (partly) off-setting negative effect for low ability students.

Positive effects of financial incentives on study effort are instead found by Kremer et al. (2005) in the context of a randomized experiment conducted in Kenia that offered school fees exemption and large cash awards to girls who scored well on academic exams. Interestingly from the viewpoint of our paper (see Section 7) Kremer et al. results suggest also that financial incentives to student performance have positive externalities, since boys, who were ineligible for the award, also experienced exam gains. The same happened for girls with low pretest scores who were very unlikely to win. These

¹Other papers study determinants of graduation times different than financial incentives: for example, demographic characteristics in Siegfied and Stock (2000); supervisor quality in Van Ours and Ridder (2003) and labor market conditions in Brunello and Winter-Ebmer (2003). Dearden et al. (2002) study instead the effects of financial incentives on educational choices of highschool graduates.

²See also Leslie et al.(1988)

authors conclude that these large externalities address some of the equity concerns raised by critics of merit awards, and provide further rationale for public education subsidies.

At the end of the day, the mixed results offered by this literature may be a consequence of the more general ambiguity of the effects of monetary incentives highlighted by Gneezy and Rustichini (2000) and certainly requires more research based on quasi-experimental evidence, which is our goal in this paper.

3 Time to degree and tuition structure around the world

A simple Google search of the words “Time to degree completion” produces an endless series of documents suggesting that throughout the world there is a generalized concern for the fact that a large fraction of students remains in educational programs beyond their normal completion times. Moreover, in many cases these tendency appear to have increased in recent years.

At the Ph.D. level in the US these are well known facts that have generated widespread concern. In the representative sample collected by Hoffer and Welch (2006), the average median time to obtain a Ph.D was 9 years in 1978 and increased to 10.1 years in 2003 with a similar pattern across fields. Such a number of years is almost twice what most universities consider as the regular completion time to obtain a Ph.D. (i.e. 4-5 years). These findings are confirmed also by OSEP (1990), Ehrenberg and Mavros (1992), Groen et al. (2005) and Siegfried and Stock (2000).

Perhaps less well known is the fact that a problem exist also at the undergraduate level where, according to the US Department of Education (2003), first-time recipients of bachelor’s degrees in 1999-2000 took on average “about 55 months from first enrollment to degree completion”. This is about one year more than the normal completion time of 45 months.

A long series of studies, available on the internet, conducted separately

by colleges and universities around the US confirm this general finding. Just to give some examples, the University of Southern California reports for its graduates of the academic years 96/97 - 00/01 that in all fields more than 12 quarters (the standard duration) are needed on average to obtain a degree. While in the social sciences the delay is more limited (12.2 quarters on average) in engineering and natural sciences completion time reaches 13.5 quarters. A report of the State of Illinois Board of Higher Education (1999) finds that only “25% of the entering freshmen of the classes of 1987 through 1992 at the Illinois public universities graduated within 4 years”, while 45% had not yet graduated at the 5 years mark. Similarly at UC Davis (2004), out of 5153 bachelor’s degrees conferred in 2002-03, 46% obtained a degree in more than 4 years. Even at the level of 2 years community colleges there is evidence that delayed completion is an issue, as indicated by Gao (2002), which finds that only 82.9% of the first-time full-time freshmen at the Collin County Community College in Texas completed their studies within the legal duration and 35.2 of these students needed more than 4 years to obtain a degree.

The situation is similar in Canada where a 2003 report of the Association of Graduate Studies indicates that “... in many universities times to completion were longer than desired.” Data are less easy to find for other countries, but the problem of the excessive time to degree completion is certainly not restricted to North America. A survey conducted by Brunello and Winter-Ebmer (2003) on 3000 Economics and Business college students in 10 European countries, finds that the percentage of students “expecting to complete their degree at least one year later than the required time ranges from 31.2% in Sweden and 30.8% in Italy to close to zero in the UK and Ireland. While Swiss and Portuguese students are close to the Anglo-Saxon pattern (3.5% and 4.6% respectively), French and German students lie in between these extremes (17.1% and 10% respectively).” The web site of the Spanish Ministerio de Educacion y Ciencia reports that out of 91238 graduates of the three year undergraduate program, only 38581 completed their studies

in time, and 33791 needed from 4 to 5 years. For the Netherlands, Van Ours and Ridder (2003) analyse the administrative data of three universities and find that “No Ph.D. student defends his or her thesis within three years, while a few students graduate in three to four years. Most students finish in five to seven years after the start, and after seven years the fraction remains almost constant, i.e. there are few graduations after seven years”. According to Hakkinen and Uusitalo (2002) the problem of reducing time to graduation has been on the Finnish government agenda since at least 1969, given that Finland is second only to Italy, among OECD countries, in terms of average age of tertiary graduation.

Indeed, the country where the problem is perhaps more evident is Italy, which offers the data used in the econometric analysis of this study. As shown in Table 1 Italy is the Oecd country with the smallest employment rate in the 25-29 age bracket, the highest enrollment rate in education in the 25-29 age bracket and the (second) lowest university graduation rate in the 35-44 age bracket. In other words, since it is unlikely that cohort effects may explain alone these figures, it seems that while most Italian youths remain in educational institutions for a longer period than youths in other comparable countries, very few of them complete their studies and obtain a degree. This is not because these Italian youths drop out from a legal point of view, otherwise we would not see so many of them registered as “non-employed, in education”. The fact is that Italian students have an abnormal tendency to extend their permanence in a university program beyond the normal completion time.

Table 2 shows that while on average the mean legal duration of a university program was 4.39 in a representative sample of 1995 graduates, the median effective duration in the same sample was 7.00 years and the mean was 7.41. Moreover this tendency appear to be similarly true in all fields. Table 3 shows that out of 1,684,993 students enrolled in Italian universities during the academic year 1999-00, 41.1% are classified as *Fuori Corso*, i.e. they have been enrolled for more than the legal length of their university

program. Of the 171,086 graduates of the same year, 83.5% obtained their degree as *Fuori Corso* students.

Interestingly, while throughout the world obtaining a degree within the normal completion time is becoming the exception rather than the rule, university tuition is often structured in a way such that students pay the same for each year of enrollment, whether regular or beyond normal completion time. In some cases, like for example Italy, students pay less when they enroll as *Fuori Corso*. We are aware of only three cases that go in the opposite direction. In Germany a tuition ranging between 500 and 900 euros was introduced for *Fuori Corso* students in different landers between 1998 and 2005, in a period in which regular students paid no fee (see Heineck et al, 2006). Similarly, the Finnish government passed in 1992 a reform aimed at reducing financial aid for students who delayed graduation (see Hakkinen and Uusitalo, 2005). In the same spirit, the Spanish system foresees that students pay for the credits they acquire by passing exams, but the cost of each credit increases with the number of times the student tries to pass the exam.

Outside of these three cases, there seem to be no evidence that academic institution payed any attention to the possibility that the structure of tuition and the speed of graduation are related. In the rest of this paper we show theoretically and empirically, that a link may instead exist with important efficiency consequences.

4 A simple theory

We consider a risk neutral individual that is enrolled in school. The education investment takes time and has random outcome. Graduation can take place either in 1 or in 2 periods and we assume that there is no discounting. In each period the probability of graduation depends linearly on individual effort at time t and we indicate it simply with e_t . Market returns depend on whether students have graduated and on the speed at which they have completed their studies.

At time $t = 1$ there is the first attempt to graduate. Successful graduation in the first period leads to a market return equal to βw , with $\beta > 1$. Education involves both financial and psychological costs. The tuition at time $t = 1$ is indicated with τ_1 , where τ_1 indicates the marginal technological cost of providing education. Students in each period face a (psychological) convex cost of education that we express as

$$C_t(e) = \lambda + \frac{xe_t^2}{2}$$

where x is an ability parameter, e is effort and λ is a parameter that individuals take as given and will play an important role in Section 7. The marginal cost of education is increasing in effort and reads xe_t . There is a link between ability and effort with better student facing a lower marginal cost of effort (a lower x means higher ability). The individual in the first period chooses an optimal amount of effort

Education can fail in the first period. At time $t = 2$ there is a refinancing decision. The outside option of education is indicated with w . If students refinance education they have a second attempt to graduate. The financial cost of tuition at time $t = 2$ is indicated with τ_2 , where τ_2 is the technological cost of providing education to a student that is refinancing education. Successful graduation in the second period leads to a return equal to $\beta\delta w$ with $0 < \delta < 1$ but such that $\beta\delta > 1$. Unsuccessful graduation at the end of the second period leads to a market return equal to w .

The equilibrium is described by the optimal effort levels (or graduation probabilities) e_1 and e_2 at time $t = 1$ and $t = 2$. The model has to be solved backward, beginning with the effort choice at time $t = 2$

A model with sequential schooling choices, uncertainty and drop out is described by Altonji (1993). In that model there is no effort choice and the link between effort and speed of graduation is not analyzed. Most of the emphasis of that paper is on college choice, i.e. humanities versus math, and individuals have different attitude toward different fields.

Our main interest is on the link between the tuition structure and the speed of graduation, and our key objective in this section is to derive testable

implications concerning the relationship between the speed of graduation and the structure of tuition. Normative implications are left for Section 7.

Note that our discussion is completely abstracting from issues linked to the individual's ability to pay, and all our reasoning should be interpreted for a given level of income. Such restriction, admittedly relevant for the welfare analysis, is consistent with our empirical specification. We thus consider the tuition structure as a technological parameter, which reflects the marginal cost of providing education.

4.1 Optimal effort and graduation probability

Working backward, we first assume that an individual does refinance education at time $t = 2$. We look for the optimal effort at time $t = 2$, and indicate with $U_2(e_2, \tau_2)$ the lifetime utility of an individual that continues education at time $t = 2$. The expression is

$$U_2(e_2, \tau_2) = e_2\beta\delta w + (1 - e_2)w - \left(\tau_2 + \frac{x e_2^2}{2} + \lambda \right)$$

With probability e_2 the individual is a late graduate and enjoys a market return equal to $\beta\delta w$ while with the complement probability she needs to accept the outside option w . The financial cost of education (the tuition) is τ_2 plus the convex cost $C(e)$. Simple algebra shows that the optimal efforts is

$$e_2^* = \frac{w[\beta\delta - 1]}{x} \tag{1}$$

Two remarks are in order

Remark 1 *The structure of tuition does not affect optimal effort in the second period*

Remark 2 *The lower the student ability, the lower the effort in the second period*

The first remark derives from the fact that $\frac{\partial e_2^*}{\partial \tau_2} = 0$. The tuition is a sunk cost when the student chooses effort and it does not affect neither

the psychological cost nor the marginal return, so that it can not have an impact on the marginal effort. The second remark (which derives from the relationship $\frac{\partial e_2^*}{\partial x} < 0$) suggests a complementarity between ability and effort. Other things equal, the better the student the higher the effort.

Refinancing is optimal at time $t = 2$ if and only if $U_2(e_2^*, \tau_2) > w$ where e_2^* is described by equation 1. Simple algebra (see Section 9.1 in Appendix A) shows that refinancing requires

$$x \leq \frac{w^2[\beta\delta - 1]^2}{\tau_2} \quad (2)$$

a restriction on the parameter x that we assume to be satisfied. This completes the problem in the second period.

We now proceed to characterize optimal effort in the first period. We indicate with $U_1(e_1, \tau_1)$ the life time utility for an individual that has just enrolled. Its expression reads

$$U_1(e_1, \tau_1) = e_1\beta w + (1 - e_1)Max[U_2(e_2^*, \tau_2); w] - \left(\tau_1 + \frac{xe_2^2}{2} + \lambda \right)$$

where the max operator can be eliminated by virtue of equation 2. As shown in Section 9.2 of Appendix A, the optimal effort reads

$$e_1^* = \frac{[\beta w - U_2(e_2^*, \tau_2)]}{x} \quad (3)$$

Clearly the effort chosen must be a positive number. Our key empirical implication immediately follows

Proposition 1 *Larger second period tuition increases effort and the graduation probability in the first period*

Since $\frac{\partial U_2}{\partial \tau_2} < 0$ individuals tend to work harder in the first period to avoid the larger tuition. This in turn implies that, for given quality x , an increase in second period tuition increases the probability of graduation. The intertemporal structure of tuition does affect the graduation probability. Tuitions represent a fixed cost and sunk within period, but a forward looking student does take into account the continuation cost of education and responds accordingly.

We are now in a position to summarize the effect of a relative increase in tuition in the second period. An increase in the continuation tuition τ_2 leads to

- i. $\frac{\partial e_1}{\partial \tau_2} > 0$. An increase in effort and the graduation probability. This effect is our key empirical implication and motivates most of the empirical analysis that follows
- ii. $\frac{\partial U_2}{\partial \tau_2} < 0$. A reduction in the utility of refinancing. This implies that there may be an increase in drop out at the end of the first period
- iii. $\frac{\partial U_1}{\partial \tau_2} > 0$ A decrease in utility from school participation.

The second and third results are both standard and not particularly surprising. An increase in tuition reduce, other things equal, the value of education and the student incentive to refinance. The first result is the most interesting, and highlights an important link between tuition structure, effort choice, and the speed of graduation. This is the effect that we test empirically in the remaining part of the paper.

5 The Bocconi dataset and the institutional framework

Bocconi is a private Italian university which offers undergraduate and graduate degrees in economics. Although it differs in many ways from the rest of the Italian university system, which is almost entirely public, Bocconi matches national averages as far as the *Fuori Corso* problem is concerned, which is the focus of this study. The last row of Table 2 shows that the median effective time to obtain a four years degree at Bocconi is five and a half years, a difference that parallels almost exactly the national pattern. Similarly in line with the national pattern is the fraction of graduates who obtain a degree in more than 4 years (see Table 3). Slightly lower than the national average is instead the fraction of *Fuori Corso* students among all

students enrolled, suggesting that, at Bocconi, students prolong their studies beyond the regular time as frequently as elsewhere but for a shorter period. This is consistent with the finding in Table 2 that the mean effective duration is smaller than the median at Bocconi, while it is higher elsewhere.

From the viewpoint of this study, however, the reason to focus on Bocconi data is not only its similarity with the rest of the Italian university system with respect to the *Fuori Corso* problem. More importantly Bocconi offers a unique quasi-experimental setting to analyze the effect of tuition on the probability of delaying degree completion. Upon enrollment in each academic year, Bocconi students are assigned to different tuition levels on the basis of their income assessed by the university administration through the income tax declaration of the student's household and through further inquiries. A Regression Discontinuity Design (RDD) can then be used to compare students who, in terms of family income, are immediately above or below each discontinuity threshold. These two groups of students pay different tuitions to enroll, but should otherwise be identical in terms of observable and unobservable characteristics determining the outcome of interest, which in our case is the decision to complete the studies in time.

For all the 12,127 students enrolled in the four years undergraduate program at Bocconi during period 1992-1999 we received anonymized administrative records containing information on: (a) the high school final grade and type; (b) family income as declared to the government for tax purposes; (c) the theoretical tuition assigned to each student on the basis of her declared family income; (d) the tuition actually paid, which may differ from theoretical tuition for reasons to be explained below; (e) the exams passed in each year and the related grades; (f) demographic characteristics. For two specific cohorts (1992-93 and 1996-97) we obtained also additional information on family background acquired through a survey performed by the Placement Office of the university.

Table 4 reports some descriptive statistics suggesting that *Fuori Corso* status is correlated with indicators of lower ability and educational perfor-

mance. For example, the fractions of students with top highschool grades, who graduates *cum laude*, who come from the public highschool system³ and from top highschool tracks or whose father is a graduate, are all higher for students *in time* than for students *Fuori Corso*. Interestingly, also the fraction of females is higher among those who graduate in time, while coming to Bocconi from outside Milan, where the university is located, does not seem to matter.⁴ Declared family income is on average higher for students *in time*, although this obviously does not say much on the causal relationship between ability to pay and *Fuori Corso* status, since family incomes may be correlated positively or negatively with student ability⁵ and is positively correlated with tuition as described below.

Between 1992 and 1999 students were assigned to 12 tuition brackets defined in terms of family income. The temporal evolution of the 12 brackets and of the implied tuition structure is described in Figure 1. It should be noted that, for Italian standards, tuition at Bocconi is fairly high ranging between 715 and 6101 Euros per year (in real terms, base 2000). Unless a student accepts without discussion the highest bracket, he or she is asked to present the tax declaration from the previous fiscal year, which contains a measure of family income. In these cases, Bocconi makes its own re-assessment of the ability to pay of the family, on the basis of further inquiries. As a result of this re-assessment a student may be assigned to a higher tuition level than the one implied by her declared taxable income. This is, however, not the only way in which the theoretical tuition may differ from the tuition actually paid, because for various reasons students may have a right to partial or total tuition exemptions, and may end up paying less than what would be implied by their taxable income. Bocconi gave us only

³With very few exceptions, private highschools in Italy are of a significantly lower quality, admitting those students who do not survive in the public school system.

⁴Bocconi is one of the very few Italian universities that attracts students from far away.

⁵Note that given the relatively high tuition at Bocconi, for Italian standards, students with poor family backgrounds or coming from far away and thereby encountering higher costs, typically enroll only if they have better highschool grades, which suggest higher ability.

limited information on the process determining deviations from theoretical tuition and thus we cannot fully control for it.

For the purpose of our evaluation study, this institutional setting has three important implications that differentiate our RDD from a standard design and that will require proper consideration in our analysis. First, families can in principle control declared taxable income in order to be assigned to a lower bracket. As a result, while in a typical RDD subjects cannot control the indicator that determines exposure to treatment, in our case they can and this may cause an endogenous sorting of students around a discontinuity thresholds. Second, while in the vicinity of a threshold assigned tuition is binary, tuition actually paid is potentially continuous and effectively multi-valued and this means that our RDD differs from the conventional “binary assignment – binary treatment” design in which counterfactual causal analysis is typically framed.⁶ Finally, near a threshold between two brackets, declared taxable income assigns similar students to different tuition levels, but there is non-compliance with the assignment. In our context in which treatment is multivalued, this is equivalent to a *fuzzy* RDD, but what is more problematic from our viewpoint is that nothing allows us to exclude the existence of *defiers*.⁷ In fact, as we will see, there is undisputable evidence that *defiers* exist in our setting.

We restrict the analysis to students in the fourth year of the program, i.e. the last regular year of studies.⁸ This restriction leave us with 10,216 students, whose distribution across theoretical tuition brackets by (future) *Fuori Corso* status is described in Table 5.⁹ As shown in Figure 2, many variables which are relevant for our evaluation study display a significant time variation in these years. While little can be said on the determinants

⁶See, for example, Hahn, Todd and van der Klaauw, 2001.

⁷See, Angrist, Imbens and Rubin (1996).

⁸These students are observed between 1995 and 2002, since they first enrolled between 1992 and 1999.

⁹Note that the tuition discontinuities faced by these students in the fourth year proxy for the discontinuities that they would experience in the following year if they went *Fuori Corso*, which are not observable for those who effectively finish in time.

of this time variation, our econometric analysis will have to control for it in an appropriate way when pooling together observations from different years.

6 The evidence

6.1 A Regression Discontinuity Design for our problem

Let y_j be the j -th discontinuity point corresponding to the income level that separates tuition brackets j and $j + 1$ in the theoretical assignment rule adopted by Bocconi University. We focus on the identification of causal effects for students in a neighborhood of this discontinuity point. Let Y be the student real income and τ^t be the *theoretical* tuition that the student should pay according to the assignment rule, with l and h being the values of τ^t respectively below and above the discontinuity point ($h > l$).¹⁰ Denote with τ_h^p (τ_l^p) the tuition that a student in a neighborhood of the discontinuity would *actually* pay if the theoretical tuition assigned to her were h (l). Both τ_h^p and τ_l^p are potentially continuous and effectively multi-valued, as shown in Figure 3 for two representative discontinuities. Most students pay a tuition that is equal to a low or a high theoretical assignment, but there are many students who pay substantially more or less than what is implied by their family income. The presence of students paying more than the assignment if the latter is low or less than the assignment if the latter is high, is compatible with the presence of *defiers*, a crucial issue on which we will come back in Section 6.3. Table 6 shows that paying less, the same or more than the assignment is correlated with observable characteristics, suggesting that the process converting theoretical tuitions into actual ones is far from random. Finally, let F_h (F_l) be the binary *Fuori Corso* status of a student under the theoretical tuition assignments h (l).

¹⁰In principle, a subscript j should be attached to these values of the theoretical tuition, but since in this sub-section we consider only one generic threshold j we omit this subscript to simplify notation. It will instead be needed later in Section 6.3.

Under the continuity conditions:

$$E\{F_l|Y = y_j^+\} = E\{F_l|Y = y_j^-\} \quad (4)$$

$$E\{\tau_l^p|Y = y_j^+\} = E\{\tau_l^p|Y = y_j^-\} \quad (5)$$

(see Hahn, Todd and van der Klaauw, 2001), the mean effects of being assigned to the higher theoretical tuition bracket $\tau^t = h$ (instead of the lower one $\tau^t = l$) on the tuition actually paid τ^p and on the *Fuori corso* status F for a student in a neighborhood of the cut-off point are identified as:

$$E\{\tau^p|y_j^+\} - E\{\tau^p|y_j^-\}. \quad (6)$$

$$E\{F|y_j^+\} - E\{F|y_j^-\}. \quad (7)$$

These are the so called Intention-to-Treat effects. For the sake of keeping the notation simple, here and below we omit time subscripts, but in our context, these equations hold only conditioning on time periods. This because, as we explained at the end of the previous section, the composition of the pool of Bocconi students changed over the years with respect to some observables relevant to the outcome. It is therefore necessary to condition on the time period to make the students just above the cut-off point comparable to those just below it with respect to such observables.

To convert the Intention-to-Treat effects into a meaningful causal effect of τ_p on F we rely on Angrist, Graddy and Imbens (2000). Under a *monotonicity condition* asserting that no one is induced to pay a *lower* actual tuition if exogenously moved, in terms of theoretical tuition, from l to h , the ratio

$$\Lambda(y_j) = \frac{E\{F|y_j^+\} - E\{F|y_j^-\}}{E\{\tau^p|y_j^+\} - E\{\tau^p|y_j^-\}}, \quad (8)$$

identifies the mean effect of a unit change in τ^p on the probability of going *Fuori Corso* at $Y = y_j$ for those who are induced to pay a higher actual tuition because their theoretical tuition increases from l to h . This is a *mean* effect in the following sense. At the individual level the mean is taken by averaging over the causal effect of τ^p on F specific to *that* student at each

value of τ^t in the range (l, h) . Then, such individual specific mean effects are averaged over the pool of students whose actual tuition increases with the theoretical one.

Figure 4 plots nonparametric regressions of the variables τ^t , τ^p and F on Y respectively for students at the discontinuity thresholds 2 and 7, which are representative of what we obtain in the other cases. The regressions are estimated separately above and below the cut-off points to let the possible jump at the threshold show up if it exists. Thus, these plots offer a visual image of the intention-to-treat effects 6 and 7.

The tuition τ^p effectively paid by the student is uniformly not lower than the theoretical tuition τ^t on both sides of the threshold. However, while at the cut-off point 7 the mean value of τ^p above the threshold is higher than the mean value below, the reverse happens at the cut-off point 2. This again suggests the possibility that the monotonicity condition is violated.

As for the main outcome of interest, the probability to observe $F = 1$ is higher above the cut-off point for discontinuity 7 but the opposite happens at the second discontinuity. However, the mean impact of τ^p on F , which is the ratio between the jump of $Pr(F = 1)$ and the jump of τ^p , turns out to be negative at both discontinuities. This implies that in both cases the probability of going *Fuori Corso* changes in the opposite direction with respect to the tuition effectively paid when the threshold is crossed.

As anticipated in the description of the institutional framework, a threat to our identification strategy is represented by the fact that subjects control their own declared taxable income and can therefore adjust it in order to be assigned to a lower tuition bracket. If this kind of sorting around the threshold takes place it is less plausible that the continuity conditions (4) and (5) hold. The left panels in Figure 5 show, however, that this is unlikely to happen in our case

Consider family income *before* enrollment at Bocconi for subjects below and above a given threshold in their fourth year. If family income is at least partially persistent across years, in the presence of sorting we should see that

for subjects below the cut-off point in the 4th year, average family income before enrollment is higher. This because some of the subjects observed on the left of the cut-off point are in fact richer but have manipulated their declared income just enough to pay less at Bocconi. Their (real) true income three years before should then be higher (on average), revealing the manipulation of current income. If instead average family income before enrollment at Bocconi is not lower on the left of the discontinuity, there is no sorting of this kind around the threshold.

The left panels of Figure 5 plot nonparametric regressions of the declared taxable income in the year before the first enrollment at Bocconi on the declared taxable income which determines tuition in the 4th year. There is some weak evidence of sorting for discontinuity 2 but no such evidence for discontinuity 7. Again these two discontinuities are representative of the graphical evidence that we get in the other cases. A formal test, discussed below in Section 6.2, however, rejects the presence of sorting at standard levels of statistical significance.

Even if sorting took place, our identification strategy would still be valid if the continuity conditions (4) and (5) on which it relies continued to hold independently of income manipulation by families. To gather further evidence on the validity of these conditions, we implement an over-identification test following Lee (2006). Consider the set of *pre-intervention* outcomes that meet the following two conditions: they should not be affected by the tuition system of fourth-year students at Bocconi University, but they should depend on the same unobservables (e.g. ability), likely to affect the *Fuori Corso* status F . A *pre-intervention* outcome satisfying these requirements is the grade that a student receives in her final exam at the end of high-school, and thus at least three years before she enrolls in the fourth year of her program at Bocconi University. Upon finding that students on the two sides of a discontinuity point differ with respect to this variable, we would have to conclude that our identification strategy fails since students assigned to $\tau^t = h$ are not comparable to student assigned to $\tau^t = l$ with respect to

unobservables relevant for the outcome F . The right panels of Figure 5 show that no discontinuity emerges in the regression of the final highschool grade on Y at the representative discontinuities 2 and 7. Also in this case, a formal test, discussed below in Section 6.2, confirms this conclusion at standard levels of statistical significance.

In the next Section we go beyond the visual evidence presented so far, showing how the estimates obtained separately at each discontinuity point can be aggregated in a single overall estimate. In Section 6.3 we will then assess the robustness of these estimates with respect to violations of the monotonicity condition like the one highlighted above for the discontinuity point 2.

6.2 Aggregation of the mean effects at different discontinuity points

By aiming at an overall estimate of the causal effect of the tuition effectively paid on the probability of going *Fuori Corso* we gain precision at the expenses of some insight into how the mean effect of interest varies with Y . Following Angrist and Lavy (1999), an overall estimate can be obtained with the equation

$$F = g(Y) + \beta\tau^p + \gamma_t + \epsilon \quad (9)$$

where $g(Y)$ is a polynomial in Y and $\tau^t \perp \epsilon$ is used as an instrument for τ^p . For the reasons explained at the end of Section 5, we include year-specific effects γ_t in this regression. This IV estimate of the mean effect is a weighted average of the RDD estimates at each discontinuity point, where the weights are proportional to the *local* covariances $\text{cov}(\tau^p, \tau^t | Y = y_j)$, $j = 1, 10$.

In Table 7 we report the Intention-to-Treat, the OLS and the IV results for the analysis of the *Fuori Corso* outcome based on equation (9) estimated separately at each discontinuity point. The final row contains aggregate results based on the entire sample. There is not enough precision to trust the estimates obtained separately for each discontinuity point, but when we focus on the overall estimates in the last row results are sufficiently precise.

The overall Intention-to-Treat effect of τ^t on τ^p (column 1) indicates that each additional euro of theoretical tuition converts into .59 euro of tuition actually paid by students. This because students assigned to the right of a threshold are more likely to request financial aid and other forms of tuition discounts. However, despite this dilution, the overall Intention-to-Treat effect of τ^t on F (column 2) suggests that if Bocconi raises the theoretical tuition by 1000 Euros the probability of going *Fuori Corso* decreases by 3.6 percentage points, with respect to a sample average of approximately 80%.

While the OLS regression of F on τ^p suggests a positive effect of the tuition effectively paid on the probability of going *Fuori Corso* (column 3), the IV estimate of the same effect is -.061 and is statistically significant (column 4). This means that a 1,000 Euros increase in paid tuition reduces the probability of late graduation by 6.1 percentage points, an effect that should again be evaluated with respect to a sample average of 80% *Fuori Corso* students. The large bias of the OLS result is due to the confounding factors (e.g. ability) which are instead controlled for by our Regression Discontinuity Design.

These results rest of course on the validity of the continuity conditions (4) and (5) for which we now provide formal support following Lee (2006). The test is implemented by running the same IV regression (9) using as a dependent variable a battery of *pre-intervention* outcomes. The first of these outcomes is family income before enrollment at Bocconi. As suggested in our comment to Figure 5, a negative estimate of the IV coefficient on τ^p in this equation (and of the corresponding ITT) using τ_t as an instrument, would indicate that subjects below the cut-off points in their fourth year have a disproportionally higher (real) family income three years before. This would suggest the possibility that some of these subjects are in fact richer but have manipulated their income just enough to pay less at Bocconi. No such evidence emerges in the first row of Table 8. The intention to treat estimate in the first column indicates that a 1000 euros increase of the theoretical tuition τ^t is associated with an increase of 380 euros of family income before

enrollment. This estimate is small, statistically not different from zero and its sign is opposite to the one expected under the sorting hypothesis. Similarly insignificant is the IV estimate in the third column. We can, therefore, exclude the possibility of sorting around the thresholds on the basis of family income.

The rest of the Table presents evidence on other *pre-intervention* outcomes that should not be affected by the tuition system of fourth-year students at Bocconi University but that should depend on the same unobservables (e.g. ability), likely to affect the *Fuori Corso* status F . In addition to the final highschool grade, that we already examined in Figure 5 for discontinuities 2 and 7, here we consider also three other *pre-intervention* outcomes: the type of highschool attended by the student, her regional origin and her GPA in the first year at Bocconi. Attending a highschool designed to prepare for a university curriculum (*Liceo*), as opposed to one designed to prepare for direct entrance in the labor market (*Istituto Tecnico e professionale*), is likely to be an outcome that depends on ability without being affected by tuition at Bocconi.¹¹ Going to Bocconi from outside Milan has significantly higher relocation costs and is typically correlated with a higher student's quality in terms of highschool and university performance. Similarly correlated with ability is the students' GPA in the first year, but note that this variable is arguably less likely to be unaffected by the tuition structure at Bocconi.

As in the first row of Table 8, also in the other rows of the same table each coefficient comes from a separate regression. For example, the left cell of the row corresponding to the final highschool grade indicates that a 1000 euros increase of the theoretical tuition τ^t is associated with an increase of 0.19 percentage points of the grade and this estimate is not only small but also statistically not different from zero. This is exactly what we should find if our identification strategy is correct and such conclusion is confirmed in the rest of the table. No systematic difference with respect to these proxies

¹¹ Although the Italian highschool system is organized according to tracks that should determine the access to college education, since 1968 all highschool graduates can access any university in any field, independently of the track chosen during secondary education.

of individual ability emerges between students assigned to alternative level of the theoretical tuition τ^t in the first column. Moreover, no systematic difference emerges with respect to the levels of tuition effectively paid τ^p in the IV estimates of the third column, although τ^p and *pre-intervention* outcomes appear to be correlated in the OLS regressions reported in the second column. The last row of the table presents results in which the gender of the worker is used as the dependent variable in regression 9. Although finding the same proportion of females on both sides of the discontinuities would not support our identification assumption because gender is not obviously correlated with ability, it is still the case that finding the opposite would cast doubts on such assumption. It is therefore reassuring to find no evidence of a threat for our identification strategy from this test.

Table 8 supports the validity of the continuity conditions (4) and (5) on which our identification strategy is based. However, before concluding that we have identified a negative and significant *causal* effect of continuation tuition on the probability of late graduation, we need to address the possibility of violations of monotonicity suggested by the institutional framework and by the visual evidence presented so far. This is done in the next section.

6.3 Testing for defiance and assessing its consequences

While the assumption that defiers are absent is reasonable in many applications, it cannot be safely made in our context since we have both theoretical reasons and empirical evidence that defiance does occur at least at some discontinuity points.

In our context, *defiers* are students who would pay a *higher* actual tuition if their theoretical tuition were to decrease from $\tau^t = h$ to $\tau^t = l$ and viceversa. This may happen if a theoretical assignment to a lower bracket (based on declared family income) induces the administration of Bocconi to search more actively for proofs of a student's effective higher ability to pay, or if a theoretical assignment to a higher bracket induces the student to search more actively for ways to obtain financial aid and tuition exemptions.

As already noted in Section 6.1, an indication that the problem might exist in our case is offered by the fact that at the second discontinuity threshold the mean actual tuition paid by students assigned to the lower bracket $\tau^t = l$ exceeds the mean actual tuition paid by students assigned to the higher bracket $\tau^t = h$ (see Figure 4). Similar evidence can be found at some other thresholds.

A formal test for the occurrence of defiance has been proposed by Angrist and Imbens (1995). The monotonicity condition in our case asserts that $\tau_h^p \geq \tau_l^p$ with the strict inequality holding at least for some subjects. In words, no one is induced to pay a lower actual tuition if her theoretical tuition shifts from low to high, while at least one subject must be induced to pay a high tuition in this event. This condition is not directly testable since the two potential outcomes τ_h^p and τ_l^p are not simultaneously observable. However, a testable implication of the inequality is that at each discontinuity the tuition effectively paid by those in a right neighborhood of the cut-off point must be stochastically larger than the tuition effectively paid by those in a left neighborhood of the same cut-off point. That is, the cumulative distribution function (cdf) for those on the right of the discontinuity should stochastically dominate the cdf for those on the left. In our case this implication is violated at some discontinuities, like for example the second and the seventh for which the relevant cdfs are displayed in the two panels of Figure 6.

In general, the occurrence of defiance prevents a causal interpretation of the IV estimand. This happens because, under the continuity restrictions (4) and (5), the IV estimand (8) is equal to:

$$\Lambda(y_j) = \frac{E\{F_h - F_l|y_j, C\}}{E\{\tau_h^p - \tau_l^p|y_j, C\}}\alpha(y_j) + \frac{E\{F_h - F_l|y_j, D\}}{E\{\tau_h^p - \tau_l^p|y_j, D\}}(1 - \alpha(y_j)), \quad (10)$$

where

$$\alpha(y_j) = \frac{E\{\tau_h^p - \tau_l^p|y_j, C\}Pr(C|y_j)}{E\{\tau_h^p - \tau_l^p|y_j, C\}Pr(C|y_j) + E\{\tau_h^p - \tau_l^p|y_j, D\}Pr(D|y_j)}, \quad (11)$$

with D and C being the pools of *defiers* and *compliers*, respectively. In words, $\Lambda(y_j)$ is a weighted average of the mean effects of τ^p on F for compliers and

defiers. In this expression, the weights add to one but do *not* satisfy the non-negativity condition since $E\{\tau_h^p - \tau_l^p | y_j, C\}$ is by definition positive while $E\{\tau_h^p - t_l^p | y_j, D\}$ is by definition negative. It is therefore in general possible that even if the mean effect for compliers has the same sign as the mean effect for defiers, the IV estimand $\Lambda(y_j)$ has the opposite sign. In this case IV would estimate a totally uninteresting and uninformative parameter.

To deal with this problem, in Appendix B we propose a simple model of the occurrence of defiance in our context and show that it has a crucial implication for our analysis: the weight $\alpha(y_j)$ in equation (11) must depend on y_j .

On the other hand, our empirical evidence suggests that $\Lambda(y_j)$ in (8) does *not* depend on Y . This is shown in Table 9 that reports estimates based on equation 9 for the entire sample, in which the coefficient β is allowed to differ between three groups of discontinuity thresholds. The first row of the table reports the estimate for the first three cut-off points. The other two rows report the difference with respect to the first row, corresponding, respectively, to the cut-off points 4-7 and 8-10. Inasmuch as β estimates $\Lambda(y_j)$ consistently, we observe no statistically significant difference in this parameter across these three groups of thresholds.¹²

The implication of this empirical finding, in the light of the model for the occurrence of defiance described in Appendix B, is as follows. By taking the derivative of (10) with respect to Y we get

$$\alpha(Y) * \frac{\partial(\Lambda_C(Y) - \Lambda_D(Y))}{\partial Y} + (\Lambda_C(Y) - \Lambda_D(Y)) * \frac{\partial a(Y)}{\partial Y} + \frac{\partial \Lambda_D(Y)}{\partial Y}. \quad (12)$$

where Λ_C and Λ_D are the mean effects for compliers and defiers, respectively. The empirical evidence tells us that this derivative is zero. Since $\alpha(Y)$ is not zero at least at some points of the support of Y and the model for defiance tells us that the derivative $\partial a(Y)/\partial Y$ is not zero, then it must be that:

$$\frac{\partial(\Lambda_C(Y) - \Lambda_D(Y))}{\partial Y} = 0, \quad (13)$$

¹²As already mentioned, the data do not contain enough information to disaggregate the estimates for a larger number of threshold groups.

$$\Lambda_C(Y) - \Lambda_D(Y) = 0 \tag{14}$$

and

$$\frac{\partial \Lambda_D(Y)}{\partial Y} = 0. \tag{15}$$

That is, $\Lambda_C(Y) = \Lambda_D(Y) = \Lambda$.¹³ In words, the mean effect for compliers is equal to the mean effect for defiers and they do not depend on Y .

We can therefore conclude that the IV estimates of Table 7 can be interpreted causally as LATE estimates. A 1000 increase of the theoretical tuition reduces the probability of late graduation by 3.6 percentage points, while an increase of the tuition actually paid reduces the same probability by 6.1 percentage point, in a context in which late graduation occurs for approximately 80% of students.

One could argue that in order to interpret these findings and draw policy conclusions it is necessary to know whether those students who try to graduate in time do so at the expenses of the quality of the learning process. Table 10 suggests that this is not the case. In this Table we present estimates based on an equation like (9) in which the dependent variable is the final graduation mark received by the fourth year students in our sample that had graduated by the time we obtained the data from Bocconi¹⁴. This final graduation mark is a number between 66 (passing level) and 110 plus honors (*Laude*).¹⁵ It ranges effectively between 77 and honors with a standard deviation of 7 points, and it is determined by a committee of faculty members on the basis of the grades obtained in all the exams of the four years and in the final dissertation. The IV estimate in the last column of the Table suggests that an increase of 1000 Euros of tuition actually paid reduces the final mark only by 0.46 points and this effect is statistically insignificant. Note that a significant, but still small, negative effect is instead estimated by OLS in the second column. We conclude from these results that if a higher

¹³ For this conclusion to hold true we need to exclude that the terms of the summation 12 are non-zero but add to zero at *each* cut-off point. Arguably, this is very unlikely to happen.

¹⁴1010 students had not graduated yet by 2004.

¹⁵We consider honors as an additional point in our data.

tuition induces students to take more courses and pass more exams in order to finish earlier, this is not done at the expenses of the quality of the learning process inasmuch as this is measured by grades.

7 Tuition Structure and Peer Effects

The empirical analysis has clearly established that an increase in tuition towards the end of the program decreases the probability of late graduation without reducing the quality of students' performance at least as measured by the final graduation mark. In other words, students who pay more just because they are exogenously assigned to a higher theoretical tuition, seem to exert more effort in order to pass sooner their exams but do not seem to learn less as a consequence of this acceleration of the learning process.

The link between second period tuition and first period effort and (thus late graduation probability) is at the hearth of our modeling perspective. In this section we argue why, from a theoretical and normative perspective, it may be optimal to alter the tuition structure relative to the marginal cost of providing education.

We focus on peer effects. Peer effects in school emerge whenever there is a link between the individual cost of exercising effort and the average effort elicited by the rest of the class. Whenever peer effects exist an increase in tuition towards the end of the program may be desirable.¹⁶

We assume that there is a continuum of identical individuals, or a continuum of individuals with ability parameter x . We assume that the psychological cost of education depends not only on an individual choice of effort, but also on the effort exercised by the average student. In this section we assume that larger average effort reduces the cost of education.

Formally, we assume that the constant λ that each individual takes as

¹⁶Optimal tuition structure has been recently analysed by Gary-Bobo and Tyrannoy (2004) in a model in which both students and universities face imperfect information on individuals' ability.

given can be described as

$$\lambda = \lambda_0 - \lambda_1 \bar{e}$$

where \bar{e} is the average effort. The cost of education is

$$C_t(x, e) = \lambda_0 - \lambda_1 \bar{e} + \frac{x e_t^2}{2}$$

The cost function implies a positive externality between the effort decision of each individual and the effort of the other students. Studying requires less fatigue when other people work hard. We call this effect a *peer externality*.¹⁷ Since each individual takes as given the average effort, the decentralized equilibrium is identical to the model solved in the previous section. The optimal effort is thus described by equations (3) and (1).

A central planner that maximizes average effort would internalize the peer externality. Let's indicate with \tilde{e}_2 the choice of effort by the central planner that takes into account the peer externality. Section 9.3 in Appendix A shows that the effort at time $t = 2$ for the central planner is

$$\tilde{e}_2^* = \frac{w[\beta\delta - 1]}{x} + \frac{\lambda_1}{x}$$

where it is immediately evident that $\tilde{e}_2^* > e_2^*$. In other words, effort is suboptimal in the decentralized equilibrium. Moving backward to the first period, one can show that

$$\tilde{e}_1^* = e_1^* + \frac{\lambda_1 \tilde{e}_2}{x}$$

Proposition 2 *Effort is suboptimal in both periods when there are peer effects.*

Suppose that the only instrument available to restore efficiency is the tuition structure. The natural question is whether there exist a tuition increase that restore efficiency. The presence of peer effects, and the discussion

¹⁷There is a large and growing literature on peer effects in education. A recent paper on peer effects and student achievements in China is Ding and Lehrer (2006) while Sacerdote (2001) presents evidence for the U.S. Particularly relevant from our viewpoint is Kremer (2005) which links peer effects and incentives in education (see Section 2).

of the simple model in section 2, naturally calls for an increase in tuition in the second period. In the decentralized equilibrium, effort in the first period can not be increased by the tuition in the first period, since τ_1 tuitions are sunk and do not enter in the determination of effort, either in the first or in the second period. Conversely, an increase in second period tuition increases effort in the first period. It is easy to show that in the decentralized equilibrium tuition in the second period are equal to

$$\tau_2 + \Delta$$

where

$$\begin{aligned} \Delta &= \frac{\lambda_1 \tilde{e}_2}{x} \\ \Delta &= \frac{\lambda_1}{x} \left[\frac{[\beta w - U_2(e_2^*, x, \tau_2)]}{x} + \frac{\lambda_1}{x} \right] \end{aligned}$$

leads to optimal effort in the second period

Proposition 3 *With peer effects, an increase in second period tuition leads to an optimal effort in the first period.*

Note that second period effort would still be suboptimally exercised, but tuitions have no role to play.

8 Conclusions

This paper challenges the way in which university tuition is typically structured as a function of the year of enrollment of a student. The claim is that if tuition were raised towards the end of the program, keeping constant the total cost of education, the probability of late graduation would be reduced with positive social effects. This result is important given that for many university students throughout the world the time to obtain a degree extends beyond the normal completion time, and this tendency, if anything, appears to have become more pronounced recently.

We have supported this conclusion in three steps. First, we have shown in a simple model of human capital accumulation that there exists a negative causal effect of the size of continuation tuition on the probability of late graduation. Second we have exploited data from Bocconi University, where students are assigned to one of 12 tuition levels on the basis of their declared family income, to implement a Regression Discontinuity Design (RDD) which allows us to compare students with similar family income immediately above or below each discontinuity threshold. We show that these two groups of students pay different tuitions, but are otherwise identical in terms of observable characteristics determining the probability of late graduation. Using this source of identification of the causal effect of a tuition increase, we find that if students in the last regular year had to pay 1000 more Euros, the probability of late completion for them would decrease by 6.1 percentage points. We also show that this effect does not occur at the expenses of the quality of the learning process inasmuch as this is measured by grades. Third, we went back to the theoretical model and showed that when peer effects are important, efficiency consideration suggest that continuation tuition should be raised relative to the marginal cost of providing education.

We do not have data to evaluate the extent to which an upward sloping profile of university tuition would increase enrollment rates of students who decide to enter the first year just to give it a try if the cost is low, and would not do it otherwise. Such an effect would increase congestion and possibly reduce the average quality of first year students. On the other hand an upward sloping profile could facilitate the access to higher education of smart but poor students. More theoretical research and different data are needed to explore these important extensions of our analysis.

9 APPENDIX A

9.1 Optimal Refinancing at $t = 2$

Refinancing is optimal at time $t = 2$ if and only if

$$U_2(e_2^*, x, \tau_2) > w$$

which implies

$$e_2^* w [\beta \delta - 1] + w - \tau_2 - \frac{x e_2^{*2}}{2} - \lambda > w$$

where e_2^* is described by equation 1

Simple algebra shows that the condition reads

$$U_2(e_2^*, x, \tau_2) = \frac{w^2 [\beta(s) \delta - 1]^2}{x} - \tau_2 - \lambda + w > w \quad (16)$$

which is satisfied if

$$x \leq \frac{w^2 [\beta(s) \delta - 1]^2}{\tau_2}$$

a condition that we assume to be satisfied

9.2 Optimal Effort at $t=1$

Let's indicate with $U_1(e_1, x, \tau_1)$ the life time utility for an individual at time $t = 1$ that has decided to enroll. Its expression reads

$$U_1(e_1, x, \tau_1) = e_1 \beta w + (1 - e_1) \text{Max}[U_2(e_2^*, x, \tau_2); w] - (1 - \tau_2) - \frac{x e_1^2}{2} - \lambda$$

which by virtue of equation 16 can be written as

$$U_1(e_1, x, \tau_1) = e_1 \beta w + (1 - e_1) U_2(e_2^*, x, \tau_2) - (1 - \tau_2) - \frac{x e_1^2}{2} - \lambda$$

The optimal effort reads

$$e_1^* = \frac{[\beta w - U_2(e_2^*, x, \tau_2)]}{x}$$

9.3 The Model with Peer Effects

Let's indicate with \tilde{e}_2 the choice of effort by the central planner. At time $t = 2$, the central planner would maximize

$$U_2(\tilde{e}_2, x, \tau_2) = \tilde{e}_2 w [\beta \delta - 1] - \tau_2 - \frac{x \tilde{e}_2^2}{2} + w - \lambda_0 + \lambda_1 \tilde{e}_2$$

$$\tilde{e}_2^* = \frac{w[\beta \delta - 1]}{x} + \frac{\lambda_1}{x}$$

Where it is clear that

$$\tilde{e}_2^* > e_2^*$$

So that effort in period 2 is larger. This implies that there is a suboptimal amount of effort in the decentralized equilibrium.

$$U_2(e_2^*, x, \tau_2) = \frac{w^2[\beta \delta - 1]^2}{x} - \tau_2 - \lambda_0 + \lambda_1 \tilde{e}_2^* + w$$

Let's now consider the optimal amount of effort in first period

$$\tilde{e}_1^* = \frac{[\beta w - U_2(\tilde{e}_2, x, \tau_2)]}{x} + \frac{\lambda_1}{x}$$

There are two effects at work, so that it is difficult to see the effects but we can write

$$\tilde{e}_1^* = e_1^* + \frac{\lambda_1 \tilde{e}_2}{x}$$

10 Appendix B

Let Y_p be the permanent income of the student and let it differ from Y because of a transitory shock. The theoretical tuition is assigned on the basis of Y according to the function $\tau^t(Y)$, but the administration can acquire collateral information on the student's permanent income on the basis of which it can decide to change the student's tuition according to the rule $\tau^p = \tau^t(Y_p)$. We assume that the administration changes the student's tuition if and only if the gain for the administration is large enough, i.e. if $\tau^t(Y_p) - \tau^t(Y) > c$ with c a positive scalar.

As a result, the link between the tuition a specific student actually pays, its current income and its theoretical tuition is:

$$\tau^p = \tau^t(Y_p) \iff \tau^t(Y_p) > c + l_j + (h_j - l_j)Z. \quad (17)$$

otherwise she pays $\tau^p = \tau^t(Y)$, where $Z = I(Y \geq y_j)$.

We can now distinguish between different relevant cases. The first one is the case in which $\tau^t(Y_p) > c + h_j$. This is the case in which the administration believes that the student has a high permanent income and finds convenient to raise the actual tuition of the student to $\tau^t(Y_p)$, independently of the theoretical assignment Z and therefore independently of the side of the discontinuity threshold to which the students is assigned by transitory income. This is a case in which tuitions actually paid by the student would be the same on the two sides of the cut-off point.

A second case is the one in which $\tau^t(Y_p) < c + l_j$, meaning that the administration does not find it convenient to modify the theoretical random assignment Z . This is a case in which perfect compliance occurs.

The third and intermediate case, in which $c + l_j < \tau^t(Y_p) < c + h_j$, is the one that can generate defiance. In this case the administration finds it convenient to raise the tuition of the student to $\tau^t(Y_p)$ only if transitory income assigns the student to the lower tuition bracket (i.e. if $Z = 0$). If instead transitory income assigns the student above the threshold (i.e. if $Z = 1$), Bocconi is willing to leave the tuition unchanged. As a consequence, defiance occurs if $h_j < \tau^t(Y_p) < c + h_j$, because in this case if $Z = 1$ Bocconi leaves tuition at h_j , while if $Z = 0$ Bocconi raises tuition above h_j . On the contrary, compliance prevails if $c + l_j < \tau^t(Y_p) < h_j$ ¹⁸, because in this case Bocconi leaves tuition at h_j if $Z = 1$, while if $Z = 0$ tuition is raised above l_j but not above h_j .

A similar line of reasoning, applies to the behaviour of the student who has to decide whether to ask for financial aid or not. Applying for financial aid is convenient only if the gain is sufficiently large to overcome the cost of the application, that is if $\tau^t(Y) - \tau^t(Y_p) > b$ with b a positive constant.

An obvious implication of this model is that in general the weight $\alpha(y_j)$ in (11) depends on Y . This because the distribution of $Y_p|y_j$ and of $\tau^t(Y_p)|y_j$ as well as the theoretical tuitions h_j and l_j , which are relevant to define the domains of integration over which the expected values in (11) are evaluated, depend on y_j .

¹⁸Provided that $c + l_j < h_j$. To simplify the discussion, we maintain that this condition is satisfied in what follows.

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Table 1: Employment, educational enrollment and educational attainment of Italian youth older than 25

	25-29 years old:		35-44 years old:	
	Employed	In education	Male graduates	Female graduates
Italy	61.1	14.7	11.0	11.0
Finland	61.1	10.7	32.0	42.0
Greece	68.7	6.4	24.0	19.0
Spain	69.7	10.4	25.0	25.0
Germany	74.9	7	30.0	21.0
France	76.3	5.4	21.0	24.0
Australia	78.4	4.5	27.0	32.0
Canada	78.6	5.6	39.0	46.0
Norway	78.7	11	28.0	30.0
Sweden	80.1	13	31.0	35.0
United Kingdom	80.3	3.6	28.0	26.0
Belgium	80.6	3.9	28.0	31.0
Austria	80.7	6.6	19.0	14.0
Denmark	80.8	11.5	24.0	32.0
United States	81.2	2.9	37.0	38.0
Portugal	83.9	4.8	7.0	11.0
Switzerland	85.1	5.1	37.0	21.0
Ireland	85.4	8.9	37.0	36.0
Netherlands	85.9	2.2	27.0	22.0
Country Average	77.4	7.3	26.9	27.2

Source: OECD Education at a Glance

Table 2: Legal and effective duration of university programs in Italy

	Mean legal duration	Median effective duration	Mean effective duration
Sciences	4.01	6.0	6.94
Chemistry and Pharmacy	4.66	6.0	6.95
Geo-biology	4.17	7.0	7.63
Medical school	5.77	7.0	8.28
Engineering	4.99	7.0	7.73
Architecture	4.99	8.0	8.79
Agrarian sciences	4.83	7.0	8.21
Economics and statistics	4.04	6.0	6.74
Political sciences	4.02	6.0	7.23
Law	4.02	6.0	7.04
Arts	4.02	7.0	7.61
Literature	4.02	7.0	7.38
Teaching	4.01	7.0	8.55
Psychology	4.92	6.0	6.71
Total	4.39	7.0	7.41
Bocconi University	4.00	5.5	5.00

Source: Representative sample of graduates in 1995 surveyed in 1998 - Standard sample file "Indagine sull'inserimento professionale dei laureati dell'anno 1995" , ISTAT. Our sample for statistics concerning Bocconi.

Table 3: Fraction of *Fuori Corso* students in Italy

	All Italy	Economics in Italy	Bocconi University
Enrolled in year 99-00	1684993	237893	8298
% of <i>Fuori corso</i>	41.1	43.6	28.9
Graduates in year 99-00	171806	28106	1182
% of <i>Fuori corso</i>	83.5	89.9	81.2

Source: Italian Ministry of Education and our sample for statistics concerning Bocconi..

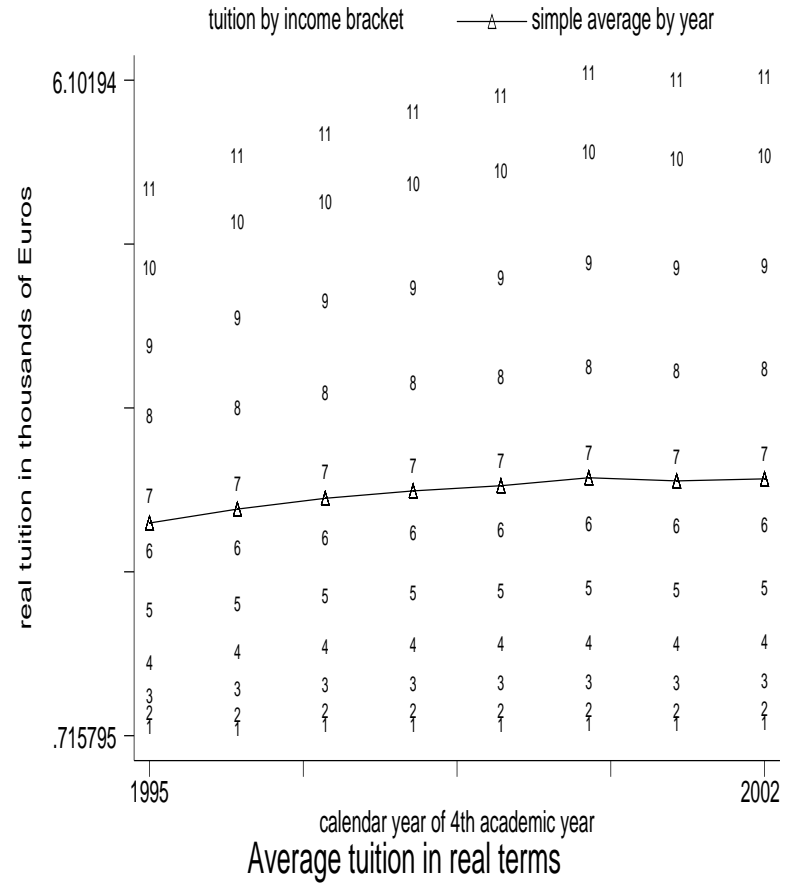
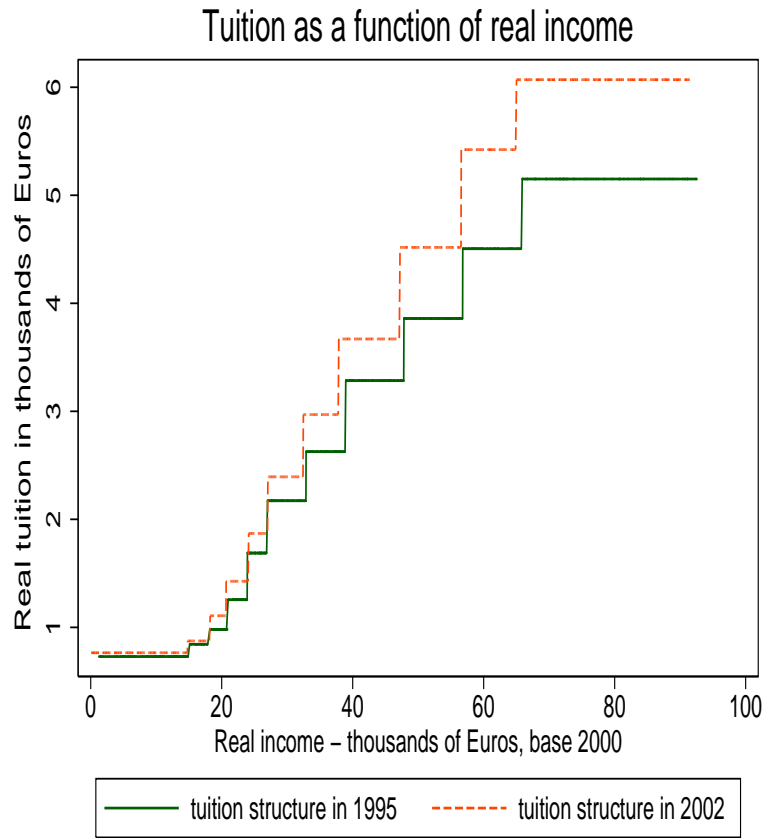
Table 4: Descriptive statistics by *fuori corso* status

	Conditional on being <i>in time fuori corso</i>		Of the total
% of the 12127 enrolled from 1992 to 1999 who are			
Females	44.62	39.57	40.92
From Milan area	40.58	40.84	40.77
With top highschool grade	28.83	22.01	23.83
From top highschool tracks	70.40	65.98	67.16
Family income in Euros	41872	38637	39502
Total	26.74	73.26	100.00
% of the 1823 graduates of 92-93 and 96-97 who are			
Females	45.00	36.96	38.01
From south	16.25	18.70	18.38
From Milan area	37.50	44.03	43.17
From public highschool	77.08	69.43	70.43
With top highschool grade	39.58	26.09	27.87
With father graduate	43.75	29.75	31.60
Graduated <i>cum laude</i>	41.25	14.40	17.94
Worked during university	16.25	18.57	18.27
Total	13.17	86.83	100.00

Source: Statistics for all the students who enrolled in the first year at Bocconi between 1992 and 1999.

Figure 1: Tuition structure at Bocconi

42



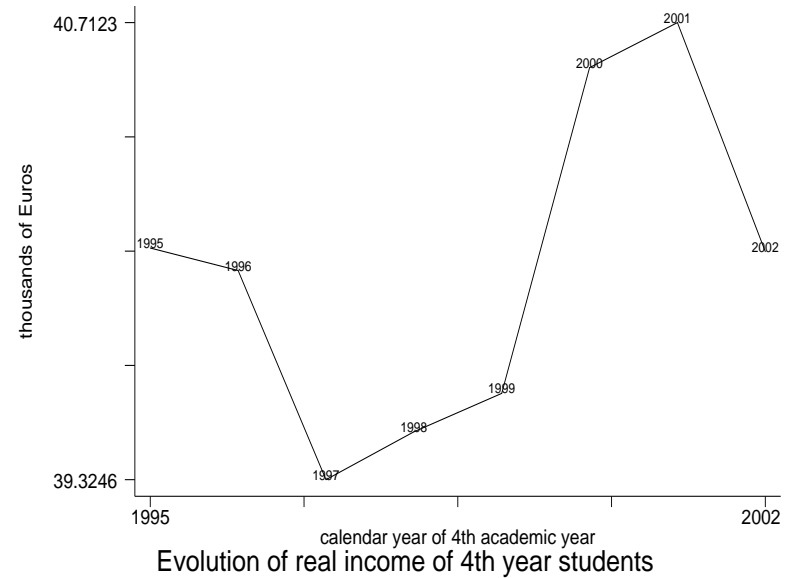
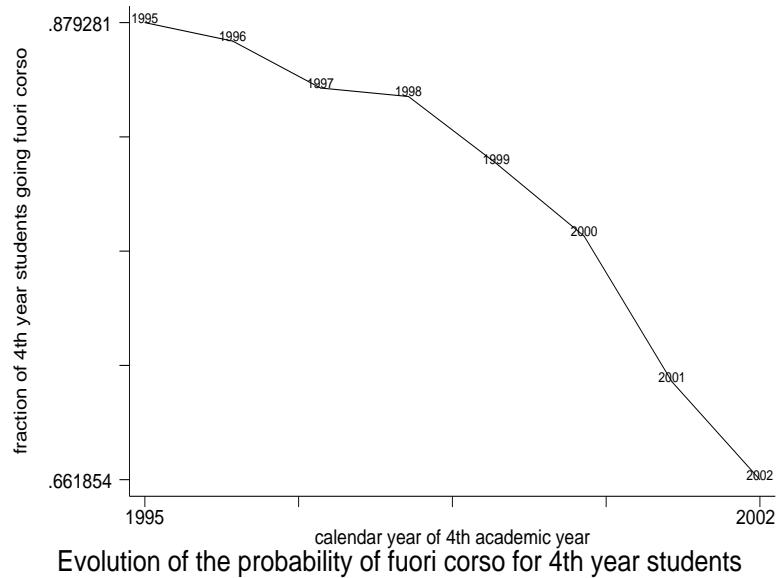
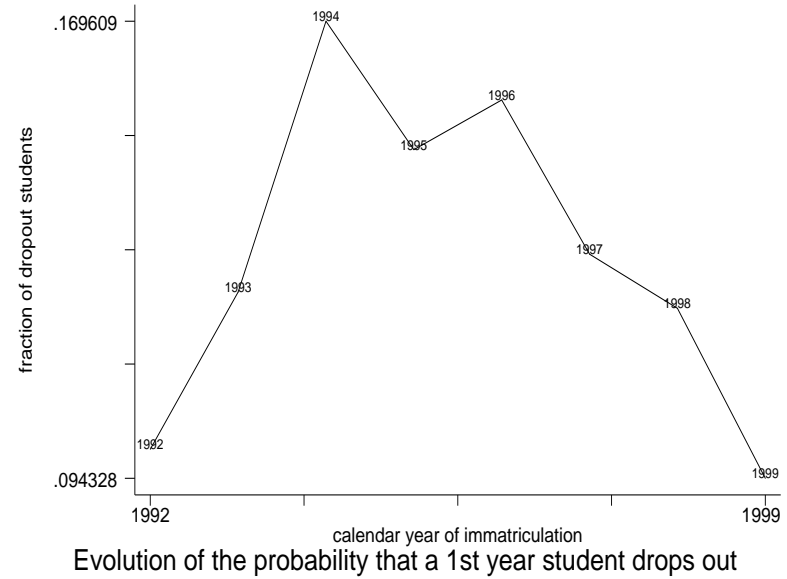
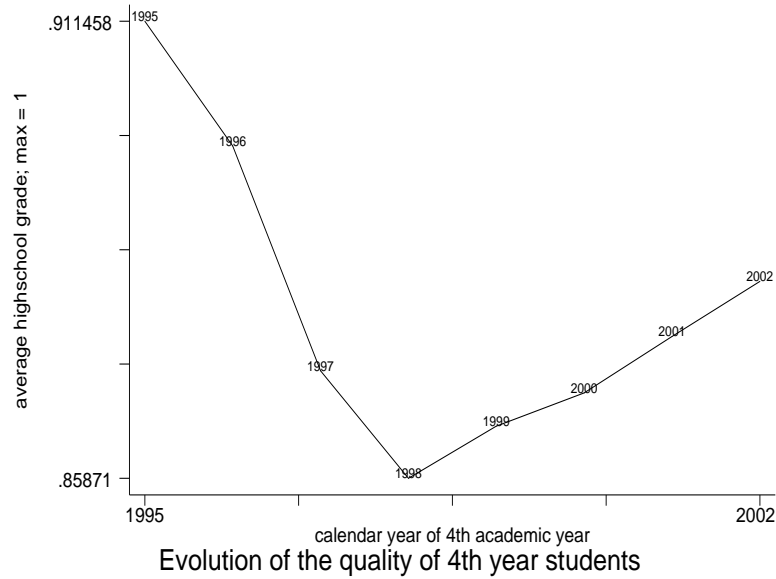
Source: Statistics for all the students who enrolled in the first year at Bocconi between 1992 and 1999.

Table 5: 4th year students by theoretical tuition bracket and *Fuori Corso* status

Tuition bracket	"in time"		<i>Fuori Corso</i>		All students	
	n.obs.	%	n.obs.	%	n.obs	%
1	167	14.67	971	85.33	1,138	100.00
2	79	16.09	412	83.91	491	100.00
3	63	14.58	369	85.42	432	100.00
4	117	17.84	539	82.16	656	100.00
5	86	14.60	503	85.40	589	100.00
6	174	18.20	782	81.80	956	100.00
7	182	18.69	792	81.31	974	100.00
8	356	21.65	1,288	78.35	1,644	100.00
9	303	25.83	870	74.17	1,173	100.00
10	194	24.56	596	75.44	790	100.00
11	342	24.91	1,031	75.09	1,373	100.00
Total	2,063	20.19	8,153	79.81	10,216	100.00

Source: Statistics for the 4th year students who enrolled in the first year at Bocconi between 1992 and 1999.

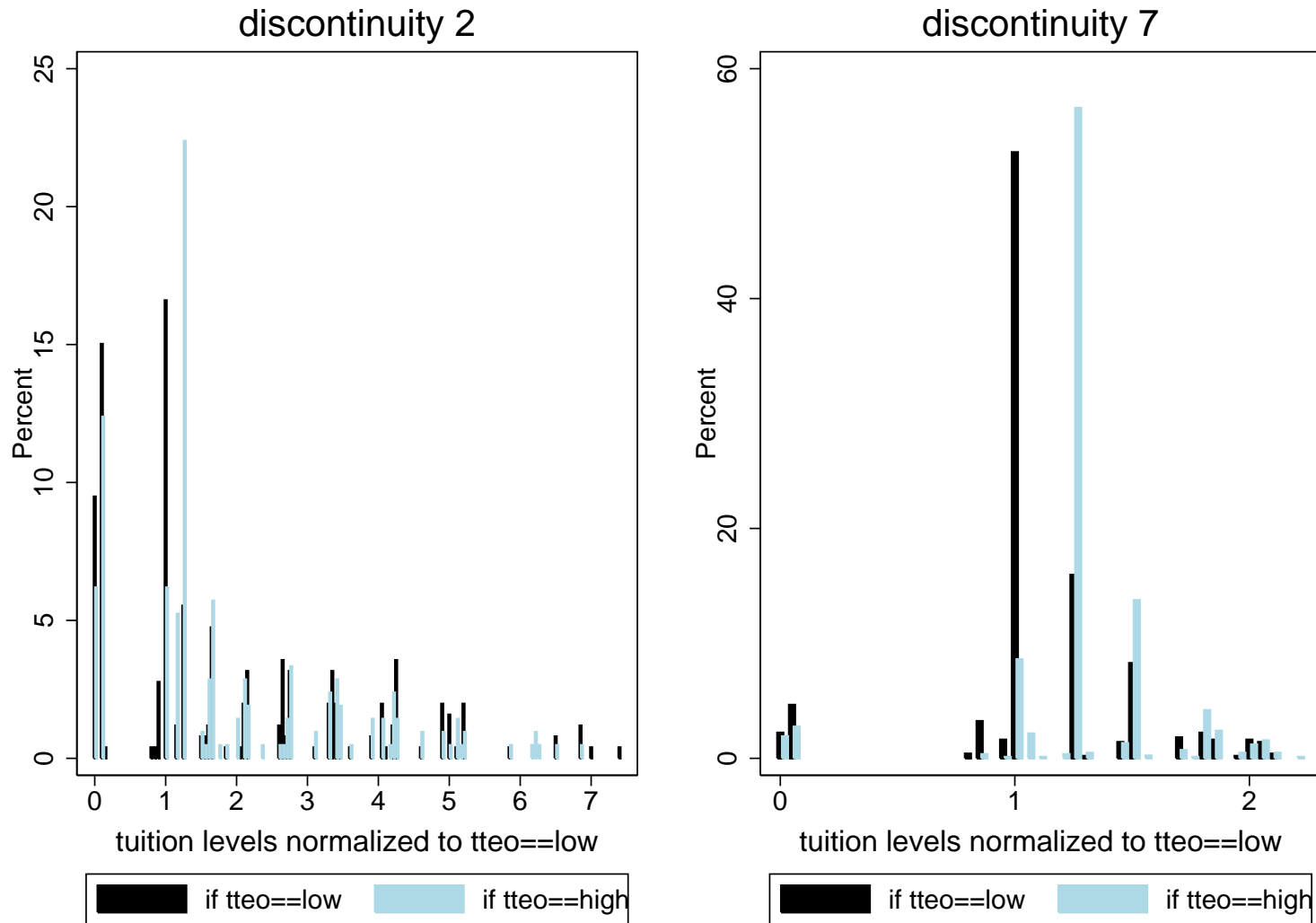
Figure 2: Time trends of relevant variables



Source: Statistics for the 4th year students who enrolled in the first year at Bocconi between 1992 and 1999.

Figure 3: Histogram of paid tuition given a theoretical tuition

45



Note: For each discontinuity, all tuition levels (whether theoretical or actually paid) have been divided by $\tau^t = l$. Thus, for example, the histogram bar at 1 is for $\tau^t = l$ while the highest light bar on the right of 1 is for $\tau^t = h$.

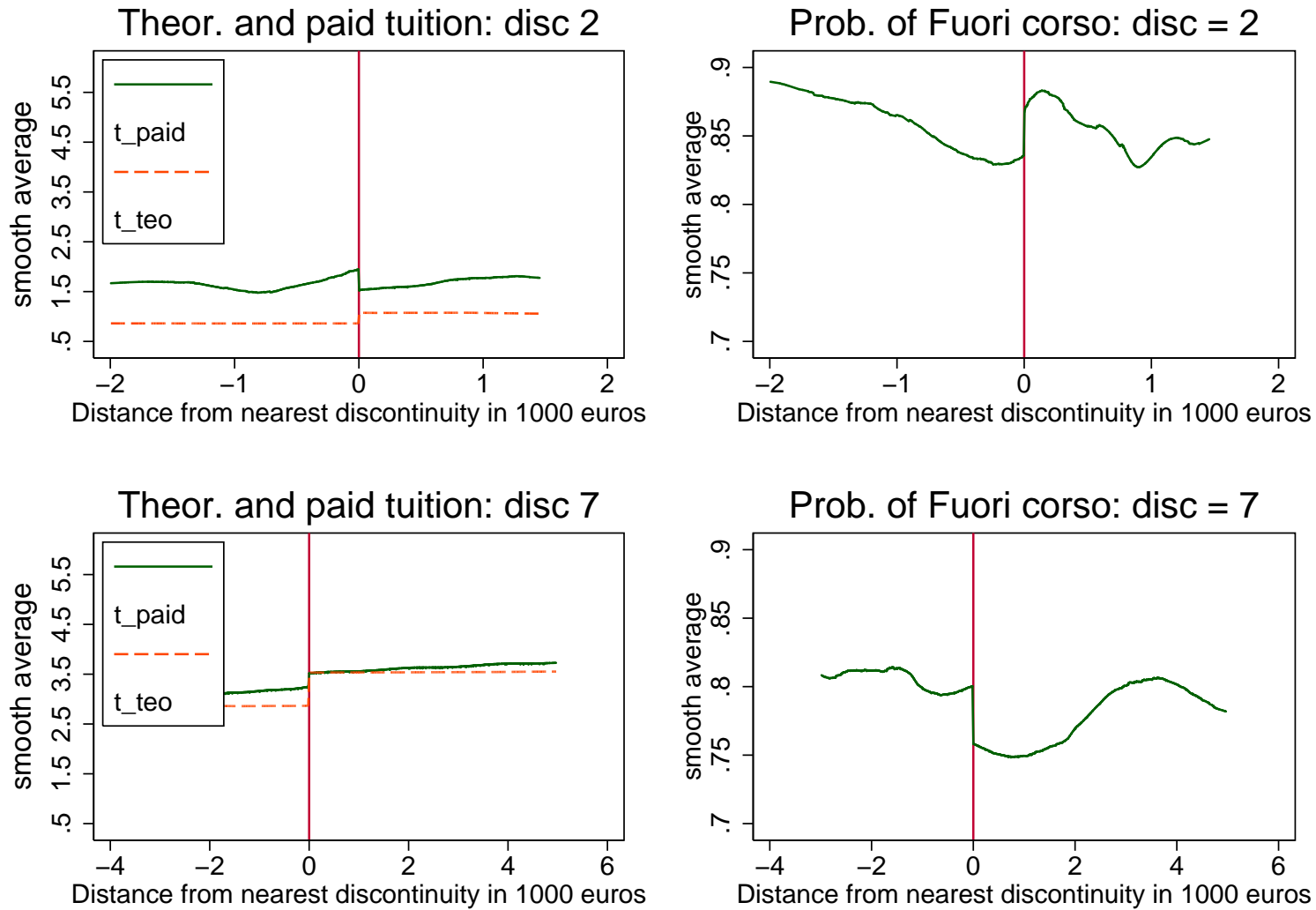
Source: Statistics for the 4th year students who enrolled in the first year at Bocconi between 1992 and 1999.

Table 6: Characteristics of 4th year students according to whether their actual tuition is equal to, larger than or smaller than the theoretical one

	For given theoretical tuition, fraction paying:		
	less	same	more
Females	44.02	40.87	42.22
From Milan area	27.39	44.69	38.50
With top highschool grade	39.34	25.03	21.76
From top highschool tracks	56.99	71.08	67.06

Source: Statistics for the 4th year students who enrolled in the first year at Bocconi between 1992 and 1999. The sample size is 10,216.

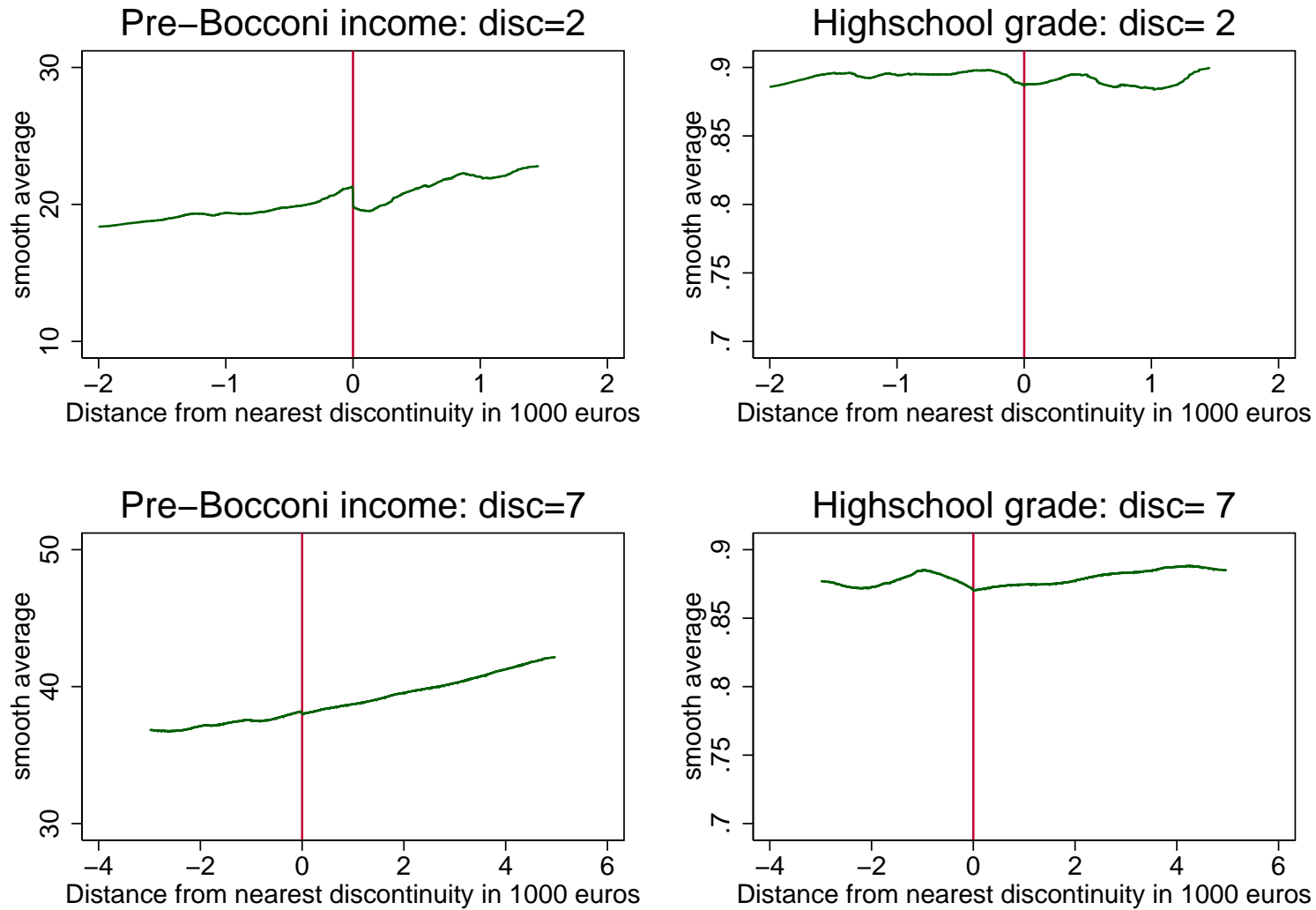
Figure 4: Intention-to-treat effects



47

Source: Statistics for the 4th year students who enrolled in the first year at Bocconi between 1992 and 1999.

Figure 5: Evidence on sorting and continuity conditions



48

Source: Statistics for the 4th year students who enrolled in the first year at Bocconi between 1992 and 1999.

Table 7: Regression discontinuity estimates of the effect of tuition on the probability of late graduation (*Fuori corso*)

Method	OLS-ITT	OLS-ITT	OLS	IV-LATE	N. of obs.
Outcome	Paid Tuition	Fuori Corso	Fuori Corso	Fuori Corso	
Treatment			Paid Tuition	Paid Tuition	
Instrument	Theoretical Tuition	Theoretical Tuition		Theoretical Tuition	
Discontinuity 1	-2.5	.42	-.0086	-.17	1376
s.e.	(2.2)	(.54)	(.007)	(.26)	
Discontinuity 2	-2.4	.21	.0047	-.088	463
s.e.	(1.5)	(.37)	(.011)	(.16)	
Discontinuity 3	.64	-.13	-.012	-.2	563
s.e.	(1.2)	(.31)	(.013)	(.59)	
Discontinuity 4	.51	.17	-.0058	.33	636
s.e.	(.64)	(.17)	(.01)	(.54)	
Discontinuity 5	-.4	-.2	.017	.5	742
s.e.	(.54)	(.14)	(.01)	(.77)	
Discontinuity 6	.52	-.078	.0063	-.15	961
s.e.	(.41)	(.11)	(.01)	(.25)	
Discontinuity 7	.11	-.06	.011	-.56	1331
s.e.	(.25)	(.10)	(.01)	(1.6)	
Discontinuity 8	.38	-.07	.017	-.19	1453
s.e.	(.14)	(.076)	(.014)	(.21)	
Discontinuity 9	.24	-.022	.027	-.095	957
s.e.	(.12)	(.09)	(.02)	(.38)	
Discontinuity 10	.57	.11	.046	.2	1734
s.e.	(.12)	(.09)	(.022)	(.17)	
All	.59	-.036	.0021	-.061	10216
s.e.	(.05)	(.018)	(.004)	(.031)	

Note: Each coefficient (and related robust standard error in parenthesis) is an estimate of β obtained from separate regressions of the form:

$$W = g(Y) + \beta\tau^K + \gamma_t + \epsilon$$

where W is the tuition actually paid τ^p in column 1 and the *Fuori Corso* status F in the other columns; τ^k is the theoretical tuition τ^t in column 1 and 2, and the tuition actually paid τ^p in column 3 and 4. Estimates in columns 1,2 and 3 are obtained with OLS; in column 4 with IV using τ^t as an instrument for τ^p . γ_t are time dummies.

Source: Statistics for the 4th year students who enrolled in the first year at Bocconi between 1992 and 1999.

Table 8: Tests for the presence of sorting and for the validity of the continuity conditions

Method	OLS-ITT	OLS	IV-LATE	N. of obs.
Treatment		Paid Tuition	Paid Tuition	
Instrument	Theoretical Tuition		Theoretical Tuition	
Sorting				
Income before Bocconi	.38 (.46)	.75 (.11)	.66 (.81)	9800
Continuity conditions				
Highschool grade	.0019 (.0048)	-.013 (.00096)	.0032 (.0082)	10216
Highschool type	-.032 (.02)	.029 (.0042)	-.055 (.034)	10216
Family of origin outside Milan	-.025 (.022)	-.017 (.0041)	-.042 (.038)	10216
GPA in first year at Bocconi	-.0024 (.0033)	-.0075 (.00066)	-.0041 (.0057)	10153
Female	.029 (.022)	-.0068 (.0044)	.05 (.038)	10216

Note: Each coefficient (and related robust standard error in parenthesis) is an estimate of β obtained from separate regressions of the form:

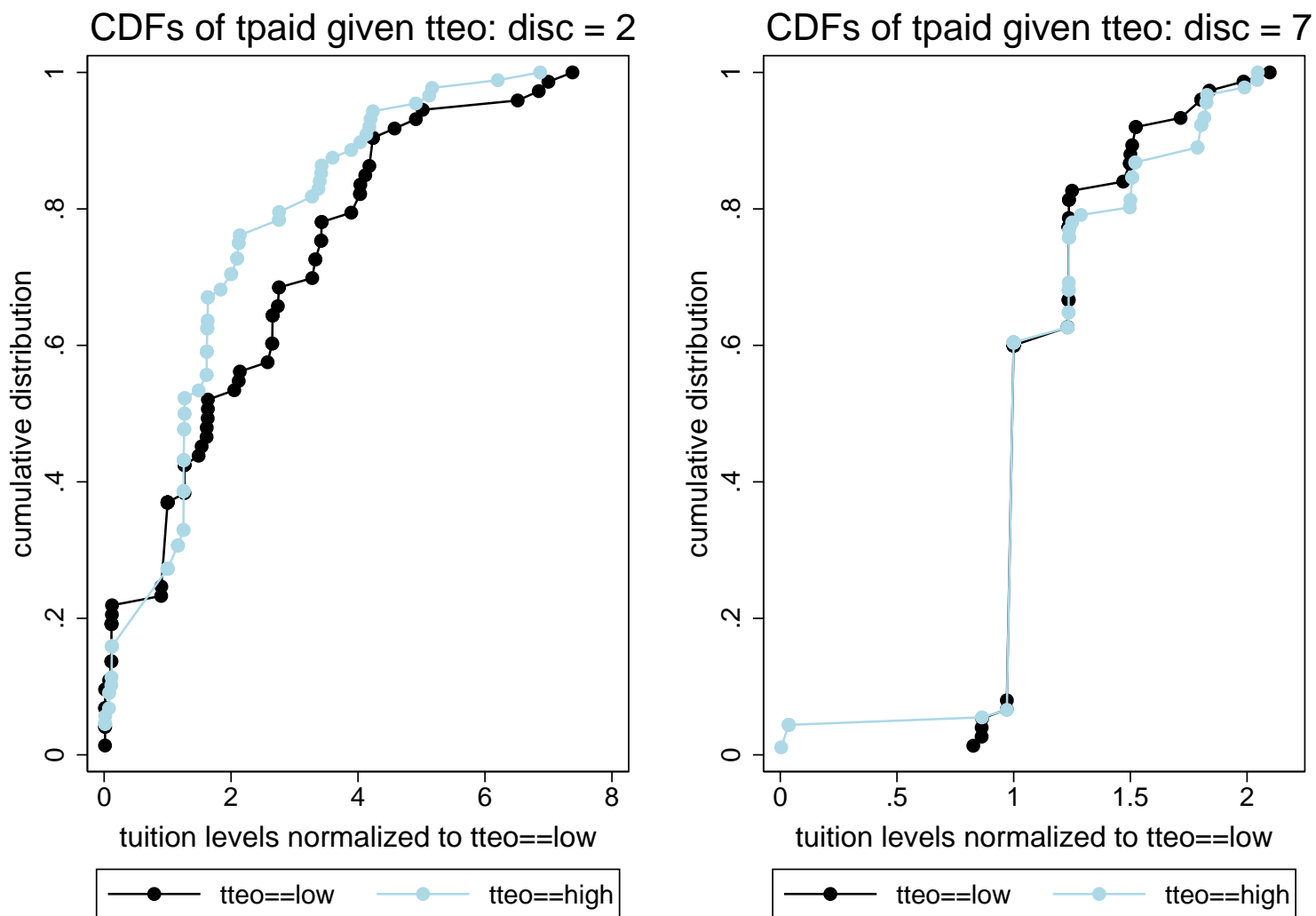
$$S = g(Y) + \beta\tau^K + \gamma_t + \epsilon$$

where S is the pre-intervention outcome indicated in the corresponding row of the table; τ^k is the theoretical tuition τ^t in column 1 and the tuition actually paid τ^p in column 2 and 3. Estimates in columns 1 and 2 are obtained with OLS; in column 3 with IV using τ^t as an instrument for τ^p . γ_t are time dummies.

Source: Statistics for the 4th year students who enrolled in the first year at Bocconi between 1992 and 1999.

Figure 6: A failure of monotonicity: CDF crossing

51



Note: For each discontinuity, all tuition levels (whether theoretical or actually paid) have been divided by $\tau^t = l$
 Source: Statistics for the 4th year students who enrolled in the first year at Bocconi between 1992 and 1999.

Table 9: Test for the equality of the IV estimand $\Lambda(y_j)$ at different discontinuity thresholds

Method	OLS-ITT	OLS	IV-LATE
Outcome	Fuori Corso	Fuori Corso	Fuori Corso
Treatment	Theoretical Tuition	Paid Tuition	Paid Tuition
Instrument			Theoretical Tuition
IV estimand $\Lambda(y_j)$ at the discontinuities 1 2 and 3	-0.065 (0.027)	-0.008 (0.005)	-0.090 (0.036)
Deviation of the IV estimand $\Lambda(y_j)$ at the discontinuities 4, 5, 6 and 7	0.019 (0.016)	0.016 (0.006)	0.015 (0.013)
Deviation of the IV estimand $\Lambda(y_j)$ at the discontinuities 8, 9 and 10	0.013 (0.018)	0.017 (0.007)	0.014 (0.015)

Note: The rows of the table report respectively the coefficients $\beta_{1,3}$ $\beta_{4,7}$ and $\beta_{8,10}$ of the regression

$$F = g(Y) + \beta_{1,3}\tau^K D_{1,3} + \beta_{4,7}\tau^K D_{4,7} + \beta_{8,10}\tau^K D_{8,10} + \gamma_t + \epsilon$$

where F is the *Fuori Corso* status; the dummies $D_{i,j}$ denote the discontinuity thresholds from i to j ; τ^k is the theoretical tuition τ^t in column 1, and the tuition actually paid τ^p in column 2 and 3. Estimates in columns 1 and 2 are obtained with OLS; in column 3 with IV using τ^t as an instrument for τ^p . γ_t are time dummies.

Source: Statistics for the 4th year students who enrolled in the first year at Bocconi between 1992 and 1999.

Table 10: Effect of tuition on final graduation marks

Method	OLS-ITT	OLS	IV-LATE	N. of obs.
Treatment		Paid Tuition	Paid Tuition	
Instrument	Theoretical Tuition		Theoretical Tuition	
Final graduation mark (min= 66; max= 110)	-.29 (.33)	-.83 (.06)	-.46 (.52)	9206

Note: Each coefficient (and related robust standard error in parenthesis) is an estimate of β obtained from separate regressions of the form:

$$W = g(Y) + \beta\tau^K + \gamma_t + \epsilon$$

where W is the final graduation mark ranging between 66 and 110 (111 in case of honors) with a standard deviation of 7 points; τ^k is the theoretical tuition τ^t in column 1, and the tuition actually paid τ^p in column 2 and 3. Estimates in columns 1 and 2 are obtained with OLS; in column 3 with IV using τ^t as an instrument for τ^p . γ_t are time dummies.

Source: Statistics for the 4th year students who enrolled in the first year at Bocconi between 1992 and 1999. The smaller sample size in this table originates from the fact that 1010 students had not graduated yet by 2004, when we received the data from Bocconi.