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

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Abstract

This paper questions 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 continuation tuition were raised, the probability of late graduation would be reduced. This result could be of interest for those universities throughout the world that are concerned by the fact that their students typically graduate beyond the normal completion time. Using a Regression Discontinuity Design on data from Bocconi University in Italy, this paper shows that an increase of 1,000 euro in the continuation tuition reduces the probability of late graduation by 9.9 percentage points with respect to a benchmark average probability of 80%. We conclude suggesting that an increase in continuation tuition is efficient when effort is sub-optimally supplied, for instance in the presence of public subsidies to education, congestion externalities and/or peer effects.

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1 Introduction

For many students enrolled in academic programs around the world it takes longer than the normal completion time to obtain a degree. Interestingly, this typically happens in contexts where college tuition does not increase (actually, it often decreases) for students who remain in a program beyond its regular end. This paper shows that these two facts – the time profile of tuition and the speed of graduation – are related and suggests that if tuition were raised after the regular end of a program the probability of late graduation would be reduced. It also suggests that this outcome would be efficient in the presence of public subsidies to education, congestion externalities and/or peer effects.

We discuss the link between the time profile of 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 and effort. Whereas for a student who has reached the normal completion time, but has not yet graduated, the tuition paid so far is a sunk cost, and thus has no effect on incentives, students anticipate the tuition they would pay if they remained enrolled beyond the regular completion time and react accordingly. As a result, a higher continuation tuition raises students' effort and increases the overall speed of completion. The core of the paper takes this simple prediction to the data.

We base our empirical analysis on detailed administrative data from Bocconi University in Milan, Italy. During the period for which we have information (1992-2000), Bocconi, a private institution, offered a 4-year college degree in economics. This dataset is informative on the question under study not only because more than 80% of Bocconi graduates typically complete their 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 completing a degree within the normal time.

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 family 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 on time. We focus on students in the last regular year of the program exploiting the fact that their current tuition is a good predictor of the tuition they would pay if they stayed in the program one more year. Thus, students on both sides of a discontinuity threshold in the last regular year should expect to pay different tuitions in the following year if they do not graduate on time. Using this source of identification, we show that if the tuition paid by a student in the last regular year increases by 1,000 euro, the probability of late graduation decreases by at least 9.9 percentage points (with respect to an observed probability of 80%). We also show that this decline in the probability of late graduation is not associated with an increase in the dropout rate or 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. We do not know much about the optimal length of the learning period for given amount of notions to be learned − this is in fact an issue that has been rarely explored in the literature. In principle, a student could be left to decide the optimal speed at which she learns, and thus the time to graduation, and there is no reason why such a time should be the same for all students. In the absence of imperfections, private incentives would lead to completion times that are also socially optimal. We argue, however, that this is not the case at least in the presence of public subsidies to education, congestion externalities and peer effects. In the (frequent) situations in which these imperfections exist and generate externalities, tuition should be raised at the end of a program, 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 the time to degree completion and on the time profile of tuition. 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 and the institutional setting, 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 framework in which our evaluation takes place. Finally, Section 7 discusses when and why raising continuation tuition is efficient and Section 8 concludes.

2 Related Literature

There is a small old literature looking at the effect of financial incentives on the time to complete a college degree, 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.[1] A few more recent studies[2] look at the effect of tuition on the basis of exogenous variation generated by a policy change, but their identification strategy rests only on a comparison of students before and after the reform.[3]

[1] See Bowen and Rudenstine (1992), Ehrenberg and Mavros (1995), Booth and Satchell (1995).

[2] Hakkinen and Uusitalo (2003) for Finland, Heineck et al. (2006) for Germany and Groen et al. (2006) for the US.

[3] Other papers study different non-financial incentives affecting graduation times: for example, demographic characteristics in Siegfried and Stock (2001); 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.

A larger literature studies the effect of tuition and financial aid on college enrollment[4], an important question that we do not address here. Closer to our research goal are some recent papers that study, with mixed results, the effect of merit-based financial incentives on indicators of students' performance. Angrist and Lavy (2002) find that cash awards can be very effective at increasing degree completion in low-achieving schools. Dynarski (2005) finds substantial positive effects of merit aid programs in Georgia and Arkansas on the rate of degree completion. Conversely, Angrist, Lang and Oreopulos (2006) and Leuven et al. (2006) find little or negative effects of financial rewards on measures of students' performance.

Among the papers finding positive effects of merit based financial incentives, Kremer et al. (2005) is particularly relevant from our viewpoint. These authors conducted a randomized experiment in Kenya that offered exemption from school fees and large cash awards to girls who scored well on academic exams. Interestingly, they find that financial incentives that reward a student's performance have positive externalities, since boys, who were ineligible for the award, also experienced an improvement in exam scores. The same happened for girls with low pretest scores who were very unlikely to win. The 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. This is particularly relevant in our context because, as we argue in Section 7, the existence of peer effects is one of the reasons that justify an increase in continuation tuition, relative to the marginal cost of providing education, with the goal of inducing students to exert the socially optimal amount of effort.

To summarize, the mixed results of 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 require more research based on (quasi-)experimental evidence, which is our goal in this paper.

[4]For example, Van der Klaauw (2002), Kane (2003), Dynarski (2003) and the surveys in Leslie and Brinkman (1987) and Dynarsky (2002).

3 Time to degree and time profile of tuition 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 remain in educational programs beyond their normal completion times. Moreover, in many cases this tendency appears to have increased in recent years.

At the Ph.D. level in the U.S. these are well known facts that have attracted considerable attention. In the representative sample collected by Hoffer and Welch (2006), the 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. The problem extends also to the undergraduate level where, according to Bound et al. (2006), time to completion of a degree has increased markedly over the last two decades. Various papers and policy reports confirm these findings.[5]

Also Europe is not exempt from the problem. 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. According to Hakkinen and Uusitalo (2003) the problem of reducing time to graduation has been on the Finnish government agenda since at least 1969.

The problem is particularly serious in Italy, which offers the data used in this study. Among Oecd countries this is the one 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

[5] See, for example, OSEP (1990), Ehrenberg and Mavros (1995), Groen et al. (2006) and Siegfried and Stock (2001), U.S. Department of Education (2003), the State of Illinois Board of Higher Education (1999), UCDavis (2004) and Gao (2002). The situation is similar in Canada.

35-44 age bracket.[6] This is not because these Italian youths drop out from a legal point of view, otherwise there would not be too many of them registered as "non-employed, in education". The fact is that Italian students have an abnormal tendency to extend their stay in a university program beyond the normal completion time, as documented in Dornbusch at al. (2000). Ministry of Education data show that while on average the mean legal duration of an Italian university program was 4.39 years, in a representative sample of 1995 graduates, the median effective duration was 7.00 years and the mean was 7.41 and this tendency appears to be common to all fields. Moreover, out of 1,684,993 students enrolled in Italian universities during the 1999-00 academic year, 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.[7]

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 amount for each year of enrollment, whether on schedule or beyond normal completion time. In some cases – one example is 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 euro was introduced for *Fuori Corso* students in different *länder* between 1998 and 2005, at a time when 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, 2003). 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 seems to be no evidence that academic

[6] See, Education at Glance, (2002).

[7] Similar statistics can be obtained in other years.

institutions pay any attention to the possibility that the time profile of tuition and the speed of graduation might be related. In the rest of this paper we show, theoretically and empirically, that a link may instead exist with possibly important efficiency consequences.

4 A simple theory

We consider a risk neutral individual enrolled in school. The education investment takes time and has random outcome: graduation is not guaranteed and it can take one or two periods to complete the degree. Therefore, graduation – if it happens – can happen either in period 1 or in period 2. The normal completion time is period 1 while the second period is the extra-time required to graduate beyond regular completion. We assume that there is no discounting. In each period the probability of graduating 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, where w is the outside option and $\beta > 1$. Education involves both financial and psychological costs. The tuition at time $t = 1$ is indicated with τ_1 and it represents the marginal technological cost of providing education. Students in each period also face a (psychological) convex cost of education that we express as

$$C(e_t) = \frac{xe_t^2}{2}$$

where x is an ability parameter and e_t is effort at time t. The marginal cost of acquiring education, xe_t, is increasing in effort. There is thus a link between ability and effort with better students facing a lower marginal cost of effort (a lower x means higher ability). An obvious interpretation of x is a measure of "learning stress". For given effort, students with higher x find it more costly to acquire education.

A student may fail to graduate in period 1, the normal graduation time. If this happens, she faces a refinancing decision. Students who refinance education make a second attempt to graduate. The financial cost, that is tuition at time $t = 2$, is indicated with τ_2, where τ_2 is the technological cost of providing education to a student who has refinanced her education. In other words, τ_2 is the continuation tuition. Successful graduation in the second period leads to a return equal to $\beta\delta w$ with $0 < \delta < 1$ but such that $\beta\delta > 1$. The assumption that $\delta < 1$ captures the negative signal associated with a failure to graduate in time. Students who fail to graduate in $t = 2$ get the outside option 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 is solved backward, beginning with the effort choice at time $t = 2$.[8]

Our main interest is the link between continuation tuition and speed of graduation. In this section we derive testable implications concerning the relationship between these two variables. A discussion of normative implications is postponed to Section 7.[9]

Working backward, we first assume that an individual refinances education at time $t = 2$. We compute 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

$$U_2(e_2, \tau_2) = e_2\beta\delta w + (1 - e_2)w - \left(\tau_2 + \frac{xe_2^2}{2}\right)$$

With probability e_2 the individual becomes a late graduate and enjoys a market return equal to $\beta\delta w$ while with the complement probability she will accept the outside option w. The financial cost of education (the tuition) is τ_2 plus the

[8] 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 attitudes toward different fields.

[9] Note that our discussion is for a fixed level of income and does not consider explicitly the individual's ability to pay. In this interpretation the time profile of tuition should be read as a pure technological parameter, as if it were associated to the marginal cost of providing education. Such restriction is nevertheless consistent with our empirical specification.

convex cost $C(e_2)$. Simple algebra shows that the optimal effort is

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

Two remarks are in order

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

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

The first remark derives from the fact that $\frac{\partial e_2^*}{\partial \tau_2} = 0$. Tuition is a sunk cost when the student chooses effort and it affects 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 $\frac{\partial e_2^*}{\partial x} < 0$) 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[10] shows that refinancing requires that $x \leq \bar{x}$, where $\bar{x}$ reads

$$\bar{x} = \frac{w^2[\beta\delta - 1]^2}{2\tau_2} \tag{2}$$

The condition on the ability level $\bar{x}$ is important. It says that students need to be sufficiently able (that is with $x \leq \bar{x}$) in order to refinance education. Since the marginal ability level $\bar{x}$ depends negatively on second period tuition ($\frac{\partial \bar{x}}{\partial \tau_2} < 0$), we can easily obtain an additional result.

Remark 3 *A larger second period tuition increases drop outs at the end of the first period.*

The condition in equation (2) and the optimal effort in equation (1) fully solve the problem in the second period.

[10] See Appendix 1 of the working paper version in Garibaldi et al. (2007).

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

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

where the max operator depends on whether $x \leq \bar{x}$ or $x > \bar{x}$. The optimal first period effort is

$$e_1^* = \begin{cases} \frac{[\beta w - U_2(e_2^*, \tau_2)]}{x} & \text{if} \quad x \leq \bar{x} \\ \frac{\beta[w-1]}{x} & \text{if} \quad x > \bar{x} \end{cases} \tag{3}$$

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

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

The proof of the proposition follows from the fact that $\frac{\partial e_1^*}{\partial \tau_2} > 0$ for $x \geq \bar{x}$. The logic of the argument is as follows. 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 students with quality $x \leq \bar{x}$, an increase in second period tuition increases the probability of graduation. For students that drop out (those with $x > \bar{x}$) the increase is second period tuition is irrelevant vis-à-vis their effort in period 1. The time profile of tuition does affect the graduation probability. Tuition is a sunk cost within each period, but a forward looking student will take into account the continuation cost of education and respond 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. $\frac{\partial U_2}{\partial \tau_2} < 0$ and $\frac{\partial \bar{x}}{\partial \tau_2} < 0$: A reduction in the utility of refinancing and an increase in drop outs.

iii. $\frac{\partial U_1}{\partial \tau_2} > 0$: A decrease in utility from school participation, and thus a reduction in entry.

The second and third results are both standard and not particularly surprising. The last result simply says that an increase in second period tuition (and thus in overall tuition fees) reduces, other things equal, the value of education. The second results suggests that an increase in continuation tuition increases the drop out rate. The first result is the most interesting, and highlights an important link between the time profile of tuition, effort choice and the speed of graduation. Specifically, it shows that a higher continuation tuition increases early effort and the graduation probability. This is the key prediction that we test empirically in the remaining part of the paper, even though we will be able to have a look also to the effect of second period tuition on drop out rates.

5 The data

5.1 The institutional framework

Bocconi is a private Italian university which offers undergraduate and graduate degrees in economics. The administrative data we shall use refer to a period (1992-1999) when Bocconi offered a 4-years college degree, the same length of similar economics degrees offered by public universities at that time. Since then Italian universities – as most universities in Continental Europe – have shifted to 3-years undergraduate degrees.

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. Like in the rest of the country, the median (5.5 years) and the mean (5 years) effective time to obtain a degree are higher than the legal duration (4 years). In line with the national pattern is also the fraction of graduates who obtain a degree in more than 4 years, which is around 80%. Slightly lower than the national average is instead the fraction of *Fuori Corso* students among all students enrolled (30%

against 44%), suggesting that, at Bocconi, students prolong their studies beyond the regular time as frequently as elsewhere but for a shorter period. This will be relevant for the interpretation of our results in Section 7.

For an international audience, however, the main reason to focus on Bocconi is that this university offers a clean 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 brackets on the basis of their income assessed by the university administration through the income tax declaration of the student's family and through further inquiries. A Regression Discontinuity Design (RDD) can thus 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. As in any quasi-experimental design, the advantage of a clean identification setting has to be compared with the possibility of a limited external validity. However, we see no reason why, at least qualitatively, the specific RDD evidence provided by this study should be specific to Bocconi students only.

For all the 12,127 students enrolled in the four years undergraduate program at Bocconi during the 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 the theoretical tuition for reasons to be explained below; (e) the exams passed in each year and the related grades; (f) demographic characteristics.

Table 1 reports some descriptive statistics suggesting that *Fuori Corso* status is correlated with indicators of lower ability and educational performance.

For example, the fractions of students with top highschool grades, who graduate *cum laude*, who come from the public highschool system[11] and from top highschool tracks[12] 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.[13] 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 income may be correlated positively or negatively with students' ability.[14]

In the period covered by our data, students were admitted at Bocconi after an entry exam and then assigned to one of 12 tuition brackets defined in terms of family income. The highest bracket was reserved to students who accepted without discussion the highest tuition and who were therefore exempted from producing their family's tax form. Since we have no income information on the students assigned to this bracket, we drop them from the analysis. Note that these students are in any case likely to be located far away from any relevant discontinuity threshold. The temporal evolution of tuition in the 11 remaining brackets is described in Figure 1. It should be noted that, for Italian standards, tuition at Bocconi is fairly high, ranging, for the observed 11 brackets, between 715 and 6,101 euro per year (in constant 2000 prices). In order to focus closely on the continuation decision beyond normal completion, we restrict the analysis to students in the 4th year of the program, i.e. the last regular year of studies.[15] This restriction leaves us with 10,216 students.

[11] With 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.

[12] These are the only highschool tracks that before 1968 granted access to university programs. In 1968 access to tertiary education was completely liberalized in Italy, so that all fields and all universities could be accessed by any student independently of the previous highschool curriculum.

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

[14] Given the relatively high tuition at Bocconi, for Italian standards, students with poor family backgrounds or coming from far away with higher mobility costs, typically enroll only if they have better highschool grades, which suggest higher ability.

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

Note that students enrolled in the 4th and last regular year of the program do not know the tuition they would have to pay if they remained enrolled beyond the normal completion time. This because they do not know with certainty the future income of their parents nor they know the future possible readjustments of the tuition structure (both in terms of levels and discontinuity thresholds) implemented by Bocconi from year to year. As a consequence, to choose their optimal level of effort during the 4th year, they must rely on a prediction of what their continuation tuition would be. Nonetheless, it is still the case that the discontinuities in the tuition system allow us to test the main proposition of the theoretical model presented in Section 4. Suppose that 4th year students predict what their continuation tuition would be conditioning on their current paid tuition as well as on their current income.[16] Then, the predicted continuation tuition as a function of 4th year income will be discontinuous at each 4th year tuition threshold, even if 4th year tuition is sunk. So in our evaluation exercise we test the main proposition of the model by replacing the continuation tuition, unknown to 4th year students, with their 4th year tuition and we look at whether the latter has any causal effect on the speed of graduation. Absence of effects would still not disprove the theoretical model because it could simply indicate that the prediction based on 4th year information is too imprecise. But finding evidence of effects at the 4th year discontinuiuties, as we show below, can only be interpreted as evidence that continuation tuition affects the probability of late graduation.

5.2 Deviations from a standard RDD

All Bocconi students – with the only exception of those who accept the highest tuition bracket – are asked to produce the tax declaration from the previous fiscal year, which reports their family's income. This is the first of three institu-

[16]We estimate that the coefficient of a regression of the tuition paid by a student in a given year on the tuition paid the year before, controlling for income and year effects, is 0.81 with a standard error of 0.004. This estimate is based on all the 12,127 students enrolled at Bocconi during the period 1992-1999 for which we received the data. Thus, tuition in a given year is a good predictor of tuition in the following year.

tional features of our setting that make the RDD design of this paper different from a standard design and that require proper consideration in our analysis. Families can in principle control their 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 threshold. Although this is a possibility we find no evidence that it actually takes place, as shown in Figure 2, which plots the histogram of family income for 4th year students around two representative discontinuity thresholds, the second and the seventh, and the associated estimate of the density function obtained by smoothing the histogram by a fourth degree polynomial separately on the left and on the right of the threshold. If sorting were important we should find a discontinuity in the density function at the threshold and specifically a concentration of probability mass immediately below it. It is evident from the figure that this does not happen at these two thresholds (as well as at the others not reported to save on space): if anything, the probability mass is concentrated above the discontinuity. We also implemented a parametric version of the test proposed by McCrary (2008) to check for the continuity of the density function at the threshold. The t-statistics of the tests associated to the ten discontinuities are all largely insignificant.

The second institutional feature that differentiates our RDD from the standard design relates to the fact that Bocconi reserves the right to make its own re-assessment of a family's ability to pay 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. Moreover, for a variety of reasons (e.g. merit, orphan because of "war or assimilated reasons", child of emigrants, etc.), students may have a right to partial or total tuition exemptions, and may also end up paying less than what would be implied by their taxable income.

Figure 3 gives examples of the consequences of this institutional feature, using data for 4th year students with family incomes near the second and the seventh discontinuities. Results are similar for other years and other thresholds. Starting with the top left panel, we plot the histogram of the tuition actually paid by students with family income immediately below the second discontinuity (who therefore belong to the second income bracket). These students should all pay a theoretical tuition of 0.9 thousand euro, indicated by the corresponding light bar. The dark bar of the histogram at the same level indicates that less than 25% of these students actually pay this theoretical tuition. The other dark bars measure the fractions of students that effectively pay other tuition levels, ranging between 0 and slightly more than 4 thousand euro. The bottom left panel gives the corresponding plot for students on the right of the same discontinuity (and therefore in the third income bracket). In this case the theoretical tuition is higher (1.1 thousand euro) and is paid by more than 50% of the students who should pay it in principle. The remaining students effectively pay very different tuition levels ranging again between 0 and slightly more than 4 thousand euro. The evidence in the right panels, for the the seventh discontinuity, is similar. Bocconi, unfortunately, did not give us full information on the specific reasons of deviation from the theoretical tuitions for the cases in which this happens and thus we cannot control for it. Nevertheless, our analysis must take into account that 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.[17].

The third important way in which the RDD of this paper deviates from the standard design is a direct consequence of the second. It is evident from Figure 3 that our experimental framework features a large amount of *non-compliance*

[17] See Hahn, Todd and van der Klaauw, 2001.

with the assignment: in other words many students pay a tuition level that differs from the one that they should pay theoretically as a function of where their income is located with respect to the discontinuity points. Moreover, our evidence suggests that this *non-compliance* is correlated with relevant (i.e. *non-ignorable*) observable characteristics.[18] In our context, in which treatment is multivalued, this is equivalent to a *fuzzy* RDD, but what is potentially more problematic is that it may imply a significant violation of the *monotonicity* assumption. While this is not a problem for the identification of the causal effect of *theoretical* tuition on the probability of late graduation, a violation of *monotonicity* could be a problem for the identification of the causal effect of tuition *effectively paid* (see Section 6).[19] This assumption requires that, at each threshold, students assigned to the lower theoretical tuition do not effectively pay more than if they had been assigned to the higher theoretical tuition of the same threshold. Consider a student with a family income immediately below a threshold. Bocconi has a stronger incentive to open her file and re-assess her income than if the student had been located immediately above the threshold, because in the first case a small re-assesment would be enough to increase the tuition obtained from this student. However, once the file is open the re-assesment may be large and imply a large increase in tuition. As a result, it is possible that the same student pays effectively more if assigned immediately below a threshold than if assigned immediately above, and this would imply a violation of *monotonicity*. A similar reasoning holds for the case of a student assigned immediately above a threshold. In this cases she will have a stronger incentive to ask for a tuition exemption than if she had been assigned by family income to a threshold immediately below. In Section 6.4 we will perform a formal test suggesting that *monotonicity* is effectively violated in our context, but we will also show that our data feature a specific case in

[18] For example, students paying less than their theoretical tuition have on average higher highschool grades and are more likely to come from better highschool tracks (see footnote 12 and the working paper version in Garibaldi et al. (2007)).

[19] See, Angrist, Imbens and Rubin (1996) and Hahn, Todd and van der Klaauw (2001).

which this violation does not prevent the identification and interpretation of the causal effect of tuition effectively paid.

Finally, 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 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. To illustrate our identification strategy we focus on the identification of causal effects for students in a neighborhood of this discontinuity point. Let Y be the student's 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 ($h > l$).[20] Denote with τ_h^p and τ_l^p the *potential* treatment values, i.e. the tuitions that a student in a neighborhood of the discontinuity would actually pay if the theoretical tuitions assigned to her were h or l, respectively. As explained in Section 5, both τ_h^p and τ_l^p are in principle continuous, effectively multi-valued and possibly different from h and l respectively. Let F_h and F_l be the potential binary *Fuori Corso* outcomes of a student under the theoretical tuition assignment h and l, respectively. Finally, let $\tau^p = I(\tau^t = h)\tau_h^p + I(\tau^t = l)\tau_l^p$ be the *observed* tuition actually paid and $F = I(\tau^t = h)F_h + I(\tau^t = l)F_l$ be the *observed Fuori Corso* status, where $I(.)$ is the indicator function.

[20] In principle, a subscript j should be attached to the 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 6.4.

Under the continuity conditions[21]

$$E\{F_l|Y = y_j^+\} = E\{F_l|Y = y_j^-\} \tag{4}$$

$$E\{\tau_l^p|Y = y_j^+\} = E\{\tau_l^p|Y = y_j^-\} \tag{5}$$

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 *observed* tuition actually paid τ^p and on the *observed Fuori Corso* outcome F for a student in a neighborhood of the cut-off point are

$$E\{\tau^p|y_j^+\} - E\{\tau^p|y_j^-\}, \tag{6}$$

$$E\{F|y_j^+\} - E\{F|y_j^-\}. \tag{7}$$

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 Section 5, 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). The *exclusion restriction* requires that the theoretical tuition τ_t affects the *Fuori Corso* status F only through the tuition effectively paid τ_p. This is a plausible restriction in our context. More critical is the *monotonicity condition* that we will discuss in Section 6.4, asserting that no one is induced to pay a *lower* (*higher*) actual tuition if exogenously moved, in terms of theoretical tuition, from l to h (from h to l). Under these assumptions, the ratio

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

[21] See Hahn, Todd and van der Klaauw (2001) and note that equivalent conditions on F_h and τ_h^p are not needed for the effects defined below.

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.

6.2 Graphical evidence

Figure 4 plots nonparametric regressions of the variables τ^t, τ^p and F on Y respectively for 4th year 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 defined in equations (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 its mean value below it, 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 below 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.

To gather evidence on the validity of the continuity conditions (4) and (5) on which our identification strategy relies, 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. Two *pre-intervention* outcomes satisfying these requirements are family income *before* enrollment at Bocconi and the grade that a student receives in her final exam at the end of highschool. Both these variables are observed at least three years before the fourth year at Bocconi in which our quasi-experiment is framed. If we found that students on the two sides of a discontinuity point differed with respect to these variables, we would have to conclude that our identification strategy fails since students assigned to $\tau^t = h$ are presumably not comparable to student assigned to $\tau^t = l$ with respect to unobservables relevant for the outcome F. Figure 5 shows that no significant discontinuity of this kind emerges at the representative discontinuities 2 and 7. A formal test confirming this evidence is described below in Section 6.3.

More generally, in the next Section we go beyond the visual evidence presented so far, showing how the estimates obtained separately at each threshold can be aggregated in a single overall estimate. In Section 6.4 we will then assess the robustness of these estimates with respect to violations of monotonicity.

6.3 Aggregation of the mean effects at different thresholds

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

$$F = h(Y) + \alpha\tau^t + \delta_t + u \tag{9}$$

where $h(Y)$ is a high order polynomial in Y and $\tau^t \perp u$. The overall estimate of the causal effect of the tuition effectively paid can be obtained from the equation

$$F = g(Y) + \beta\tau^p + \gamma_t + \epsilon \tag{10}$$

where $g(Y)$ is a high order 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 δ_t and γ_t in these equations. These IV estimates of the mean effects are weighted averages of the RDD estimates at each discontinuity point, where the weights are proportional to the *local* covariances $\text{cov}(\tau^p, \tau^t | Y = y_j)$, $j = 1, 10$.[22]

In the top panel of Table 2 we report the Intention-to-Treat, the OLS and the IV results for the analysis of the *Fuori Corso* outcome based on equations (9) and (10) estimated pooling together the observations around the ten discontinuity points. To improve the comparability of treated and control subjects the analysis is restricted to observations within a window of at most ±3000 euros with respect to each threshold.[23]

The Intention-to-Treat effect of τ^t on τ^p – i.e. the "first stage" of the IV estimation of equation (10) – is reported in the first panel of the table and indicates that each additional euro of theoretical tuition converts into .53 euro of tuition actually paid (with a standard error of .05). This because, in the data, the downward readjustment for students on the right of a threshold is on average more frequent and/or larger than the upward readjustment for students on the left. However, despite this dilution, the Intention-to-Treat effect of τ^t on F (column 1, second panel of Table 2) suggests that a 1,000 euro increase of the *theoretical* tuition in the 4th year would decrease by 5.2 percentage points the probability of going *Fuori Corso*, with respect to a sample average of approximately 80%, with a standard error of .023. It is worth stressing that the causal interpretation of this result rests only on the continuity conditions (4) and (5).

[22] As an alternative, we have also aggregated the estimates at the ten thresholds by weighting them with the inverse of their sampling variance. Results are very close to those we report.

[23] The estimates become slightly smaller in absolute size but still statistically significant at conventional levels when other window sizes (up to ±1000) are used. Results available on request.

The occurrence of non-compliance to the assigned theoretical tuition, whatever its features (see Section 6.4), does not compromise the causal interpretation of the Intention-to-Treat effects.

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 2, second panel), the IV estimate of the same effect is -.099 and is statistically significant (column 3, second panel). This means that a 1,000 euro increase in the 4th year *paid* tuition reduces the probability of late graduation by 9.9 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 estimate is due to the confounding factors (e.g. ability) which are instead controlled for by our Regression Discontinuity Design.

Since 4th year tuition is sunk, it should not have an effect on the speed of graduation. But, as we explained at the end of Section 5.1, since 4th year students do not know the tuition they would pay if they go *Fuori Corso*, this evidence suggests that they use the 4th year tuition to predict what their continuation tuition might be. So even if what we estimate is just the causal effect of the 4th year tuition, the fact that it is positive and statistically significant indicates that students use their 4th year tuition to predict their continuation tuition and that the latter increases the speed of graduation, as suggested by the theoretical model presented in Section 4.

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 (10) using as a dependent variable a battery of *pre-intervention* outcomes. The evidence is reported in the third panel of Table 2. The first pre-intervention outcome that we consider is family income before enrollment at Bocconi. Testing the continuity condition with respect to this outcome provides further evidence on the possible sorting of subjects below the thresholds, an issue we already dealt with commenting on

Figure 2. A negative estimate of the IV estimate of τ^p in this equation (and of the corresponding ITT) using τ_t as an instrument, would indicate that students below the cut-off points in their 4th year have a disproportionally higher (real) family income three years before. This would suggest the possibility that some of these students are in fact richer but have manipulated their income just enough to pay less once they enroll at Bocconi. No such evidence emerges in the first row of the third panel of Table 2. The intention to treat estimate in the first column indicates that a 1,000 euro increase in the theoretical tuition τ^t is associated with an increase of 440 euro in yearly 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 existence of sorting around the thresholds on the basis of family income.

The rest of the third panel of the table presents evidence on other *pre-intervention* outcomes that should not be affected by the tuition system of fourth-year students while depending 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 two other *pre-intervention* outcomes: the type of highschool attended by the student and her regional origin. Attending a highschool designed to prepare for a university curriculum (*Liceo*), as opposed to one designed to prepare for direct entry into the labor market (*Istituto Tecnico e professionale*), is likely to be an outcome that depends on ability without being affected by tuition at Bocconi.[24] 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.

As in the second panel of Table 2, also in the other rows each coefficient

[24] 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.

comes from a separate regression. For example, the left cell of the row corresponding to the final highschool grade indicates that a 1,000 euro increase of the theoretical tuition τ^t is associated with a decrease of -0.13 percentage points of the grade: 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: these proxies of individual ability do not differ across students assigned to different levels of the theoretical tuition τ^t (see 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 intermediate panel of this table presents results in which the gender of the student is used as the dependent variable in the regression (10). 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.

Summing up, the third panel of Table 2 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 *paid* 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 but it should be noted that it matters only for the effect of *paid* tuition, because the occurrence of non-compliance does not compromise the causal interpretation of the effect of *theoretical* tuition (the ITT), which we have alredy shown to reduce significantly the probability of late graduation.

6.4 Testing for monotonicity and assessing the consequences of its failure

Even if the causal interpretation of the Intention-to-Treat effects is robust to violation of the monotonicity condition and thus sufficient to suggest policy conclusions for the question of interest, in the following we explore whether we can make more out of our experiment. In particular, we aim at assessing whether a causal interpretation can be given also for the IV estimand. The critical condition that in our setting may prevent this interpretation is lack of *monotonicity*, which is reasonable in many applications but cannot be safely made in our context since we have both theoretical reasons for the occurrence of *defiance*[25] and empirical evidence that it 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. As discussed in Section 5 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 a tuition discount.

As already noted in Section 6.2, 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 $\tau^p_h \geq \tau^p_l$ with the strict inequality holding at least for some subjects. In words, no one would be induced to pay a lower actual tuition if her theoretical tuition shifted from low to high, while at least one subject should be induced to pay a higher tuition in this

[25]See Angrist, Imbens an Rubin (2006).

event. This condition is not directly testable since the two potential outcomes τ_h^p and τ_l^p of a specific student are not simultaneously observable. However, a testable implication of the inequality is that the cumulative distribution function (cdf) for those in a right neighborhood of the cut-off point should not be above the cdf for those in a left neighborhood of it at any value of its support. In our case this implication is violated at some cut-off points. In Figure 6 we present the estimated difference between the cdf on the left and the corresponding cdf on the right at the second and the seventh discontinuities (.95 confidence intervals are plotted). It is evident that the stochastic dominance hypohesis is rejected at these thresholds suggesting that *defiance* occurs at least here.[26]

In general, the failure of *monotonicity* 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:

$$\Lambda(y_j) = \frac{E\{F_h - F_l|y_j, C\}}{E\{\tau_h^p - \tau_l^p|y_j, C\}}\alpha(y_j) + \frac{E\{F_h - F_l|y_j, D\}}{E\{\tau_h^p - \tau_l^p|y_j, D\}}(1 - \alpha(y_j)), \tag{11}$$

where

$$\alpha(y_j) = \frac{E\{\tau_h^p - \tau_l^p|y_j, C\}Pr(C|y_j)}{E\{\tau_h^p - \tau_l^p|y_j, C\}Pr(C|y_j) + E\{\tau_h^p - \tau_l^p|y_j, D\}Pr(D|y_j)}, \tag{12}$$

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*, respectively. 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 $E\{\tau_h^p - \tau_l^p|y_j, D\}$ 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 the Appendix we propose a simple model of the

[26] To control for year specific effects at each discontinuity point we estimated the difference among the two cdfs and their standard errors separately for each calendar year. Then we evaluated the weighted mean of such year-specific differences using as weights the inverse of the sampling variances.

occurrence of *defiance* in our context and show that it has a crucial implication for our analysis: the weight $\alpha(y_j)$ in equation (12) should change with j.

On the other hand, our empirical evidence suggests that $\Lambda(y_j)$ in (8) does *not* change with j in the data. This is shown in Table 3 that reports estimates based on equations (9) and (10) 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 discontinuities. The other two rows report the difference with respect to the first row, corresponding, respectively, to the discontinuities 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.[27]

By inspection of equation (11), for this empirical finding to be consistent with the existence of *defiers*, suggested by theory and by the institutional framework, it must be the case that the mean effect for *compliers* is equal to the mean effect for *defiers* and both of them do not depend on j.

We can therefore conclude that the IV estimates of the first panel of Table 2 can be interpreted causally as estimates of Local Average Treatment Effects (LATE).[28] A 1,000 euro increase in the theoretical tuition in the last year of the program reduces the probability of late graduation by 5.2 percentage points, while an increase of the tuition actually paid reduces the same probability by 9.9 percentage points, in a context in which late graduation occurs for approximately 80% of students.

6.5 Collateral effects

It could be argued that in order to interpret these findings and draw policy conclusions one should know whether a higher tuition makes it more likely that students drop out and whether those students who try to graduate in time do

[27] As already mentioned, the data do not contain enough information to disaggregate the estimates for a larger number of threshold groups. We tried with alternative groupings of thresholds ending up with the same results.

[28] See Imbens and Angrist (1994).

so at the expense of the quality of the learning process. The last panel of Table 2 rejects both these hypothesis.

The first row in this panel presents estimates based on an equations like (9) and (10) in which the dependent variable is a dummy taking value 1 if the student drops out after the 4th year. The IV estimate in the last column suggests that an increase of 1,000 euro in the tuition actually paid reduces the probability of dropping out by 0.07 percentage points. This effect is however statistically insignificant: there is no evidence that students assigned to a higher theoretical tuition (first column, last panel) or effectively paying a higher tuition (third column, last panel) are more likely to drop out.[29]

In the second row of the table the dependent variable is the final graduation mark received by the 4th year students in our sample who had already graduated by the time we obtained the data from Bocconi.[30]. This final graduation mark in principle ranges between 66 (passing level) and 110 plus honors (*Laude*). [31] In our sample 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 row and column suggests that an increase of 1,000 euro in the tuition actually paid reduces the final mark only by 1.2 points and this estimate is again statistically insignificant. The ITT estimate in the last row, first column points to the same conclusion. We conclude from this result that if a higher tuition induces students to speed up their coursework in order to finish earlier, this does not happen at the expense of the quality of the learning process inasmuch as this is measured by the final grade.

[29] This result differs from the evidence of Dynarsky (2005) who exploits the introduction of two large merit scholarship programs in Georgia and Arkansas to show that a reduction of college costs increases significantly the probability of completing a degree. The difference between our and her findings, concerning the effect of college costs on dropout rates, may be explained by the fact that the two studies are based on different quasi-experimental situations and identification assumptions. In particular, her study focuses on tuition differences based on merit (a minimum GPA in highschool and in college), while in our case tuition differences are independent of merit.

[30] 1010 students had not graduated yet by 2004.

[31] We consider honors as an additional point.

7 Discussion and extensions

The empirical analysis has established that an increase in continuation tuition decreases the probability of late graduation. In other words, students who expect to pay more in case of delayed graduation just because they are exogenously assigned to a higher theoretical tuition, seem to exert more effort and increase graduation speed, exactly as our model predicted.

The analysis has also showed that the increase in graduation speed does not induce an increase in dropouts and does not affect significantly the quality of students' performance, at least as measured by the final graduation mark. The increase in the drop out rate was predicted by our model but does not seem empirically relevant.

The size of the effect we have estimated – a mere 1,000 euro increase in tuition actually paid reduces the probability of late graduation by 9.9 percentage points, in a context in which late graduation occurs for approximately 80% of students – may look at first puzzling. By postponing graduation a student delays the moment she joins the labor market. This has an immediate direct cost in terms of foregone earnings during the additional time spent in school and also an indirect long term (signalling) cost in terms of wages and time to find the first job after graduation.[32] We have no estimate of the indirect cost for Bocconi students, but the direct cost is likely to be large. One year after graduation Bocconi students earn on average 25,000 euro (at 2001 prices) and most of them find a job in few months.[33] Not surprisingly, as reported in Section 5, the effective time to degree at Bocconi, albeit longer than the legal time to

[32] Using as instruments "quarter of birth" and "distance from nearest college at entry in junior highschool", Brodaty et al. (2006) estimate for France that a year of delay with respect to average completion time causes a significant 3% decrease of the wage and a significant 15% decrease of the probability of employment in the first five years after graduation.

[33] Ichino and Filippin (2005) compare data on a sample of Bocconi graduates with similar data on graduates from the State University of Milan studied by Checchi (2002). Their most conservative estimate suggests that in 2001 Bocconi graduates who had first enrolled in 1997 earned at least 1.5 times more than State University graduates of the same year. And 92% of Bocconi graduates had found a job within one year while the same happened for only 46% of the gratuates at the other institution.

degree, is significantly shorter than in the rest of the Italian university system. In comparison with these figures, 1,000 euro of additional tuition may look like a very small cost. What we have estimated, however is a *marginal* effect. The expected foregone income from delaying graduation by one year determines the speed at which students graduate given the existing tuition profile. What we find is that 1,000 euro make a significant difference at the margin, once the effect of the expected foregone income is already taken into account.

One thousand euro could still look too small an amount to produce such a large shift in the incentive to graduate on time. A possible additional justification is that the "value" of a given sum of money depends on how the student earns it. One thousand euro earned on a job could indeed be a relatively small sum – compared with the effect it has on the incentive to speed up graduation – but for most students the money to finance education comes effectively from their parents. An interpretation of our results is then that the psychological cost of asking one's parents, when falling behind school work, can be quite large.

Our finding – that the speed at which students decide to learn is affected by the tuition they pay – does not necessarily mean that it is socially optimal to increase continuation tuition. We do not know much about the optimal length of the learning period for a given amount of notions to be learned – this is in fact an issue rarely explored in the literature.[34] Each student could choose the speed that she considers optimal for herself, and different individual characteristics (including different preferences for work and leisure) could result in quite different "optimal" learning speeds. To make a normative argument we need to point to reasons why individual decisions might be sub-optimal. We see at least three reasons why this might happen.

The most obvious one is that students, even in some private universities,

[34] A related issue, also rarely explored, is the choice between a system, such as in undergraduate U.K. courses, in which almost all students finish in time (because it is fairly easy to get a passing grade) and quality is signalled by grades, and the alternative, more common in continental Europe, in which passing grades are harder to get, thus resulting in delayed graduation.

are often subsidized. If students (or their families) fail to pay the marginal technological cost of their education they will not internalize the cost to society of keeping them one more year in school and will make decisions that are socially sub-optimal. Using the tuition profile to affect their incentives can then improve society's welfare.[35]

Another example is suggested by the evidence of "peer effects" in education. Peer effects in school are at work whenever there is a link between the individual cost of exercising effort and the average effort elicited by the rest of the class. There is a large and growing literature on peer effects (Kremer et al., 2005; Ding and Lehrer, 2005; Sacerdote 2001 for the U.S.). The presence of peer effects offers a reason why it may be efficient to increase continuation tutition in order to modify students' incentives.[36]

Externalities, however, can also be negative. By postponing graduation students can produce congestion, in the classroom, the libraries, etc. This can negatively affect the learning process of their colleagues. Although our empirical work is mute on these normative issues, they each suggest relevant arguments why using the time profile of tuition to change the speed at which a student learns could be optimal.

[35] The optimal time profile of tuition has been recently analysed by Gary-Bobo and Trannoy (2004) in a model in which both students and universities face imperfect information on individuals' ability.

[36] The model presented in Section 4 can easily be extended to study peer effects. Assume there is a continuum of identical individuals and that the psychological cost of education depends not only on an individual choice of effort, but also on the average effort exercised by the class. Let the psychological cost education be described as $C(e_t) = \frac{xe^2}{2} - \lambda_1 \bar{e}$, where $\bar{e}$ is the average effort in the class taken as given and λ_1 a positive parameter. This modified cost function implies a positive externality between the effort decision of each individual and the effort of other students. Studying requires less fatigue when other people also work hard: a *peer externality*. Since each individual takes as given the average effort, the decentralized equilibrium is identical to the model solved in the Section 4. A central planner that maximizes average effort would however internalize the peer externality. Let $\tilde{e}_2$ be the choice of effort by the central planner that takes into account the peer externality. It is striaghforwrd to show that $\tilde{e}_2^* = e_2^* + \frac{\lambda_1}{x} > e_2^*$. In other words, effort is suboptimal in the decentralized equilibrium. The presence of peer effects naturally calls for an increase in tuition in the second period: As we established in Section 4, first-period tuition can not increase effort since first-period tuition is sunk and does 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 there exists a time profile of tuition that implements the efficient outcome. Setting second period tuition to $\tau_2 + \frac{\lambda_1 \tilde{e}_2}{x}$ leads to optimal effort in the second period.

Having said this, a proper evaluation of the optimal policy to deal with the *Time to Degree* problem is beyond the goal of this empirical study. We are aware that there may be policies, other than the level of tuition, available at the university level that can lead to a reduction of *Fuori Corso* students. Moreover, in order to fully address efficiency issues, the welfare of the university should also be considered. In this respect, *Fuori Corso* students may provide revenues and be less costly for the administration if they do not attend classes and only come for exams. Finally, a higher continuation tuition is likely to affect the decision to enroll in a university, an issue on which our data are silent. If such a profile were implemented keeping constant early tuition, fewer people would enter. Conversely, if the early tuition were reduced, keeping the expected total cost of enrollment constant, the effect on entry would be difficult to predict. This because it would depend on the students' assessment of their own ability and on the odds of graduation for given ability. We leave the discussion of these issues to future research.

8 Conclusions

This paper questions 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 continuation tuition were raised, the probability of late graduation would be reduced. This result could be of interest for those universities throughout the world that are concerned by the fact that their students typically graduate beyond the normal completion time – a tendency that appears to have become more pronounced recently.

We have first 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. Next 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, we find that 1,000 additional Euro of tuition paid in the last regular year of the program have a negative causal effect on the probability of late graduation as large as 9.9 percentage points. Since students in the last regular year use their current tuition to predict their future tuition in case of delayed graduation, we interpret this result as an estimate of the causal effect of continuation tuition on the speed of graduation. Such a tuition increase does not induce more students to drop out and its effect on the speed of completion does not occur at the expense of the quality of the learning process.

We have also discussed why it might be optimal to increase continuation tuition with the goal of changing students' incentives inducing them to speed up their studies and graduate in time. We have argued that when students are subsidized, when peer effects are important or when congestion externalities are relevant, efficiency considerations suggest that continuation tuition should be raised relative to the marginal cost of providing education. More theoretical research and different data would be needed to explore the robustness of these policy conclusions.

Appendix

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 move the student's tuition to $\tau^p = \tau^t(Y_p)$. 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 actually paid by a student whose current income is in a neighbourhood of the j-th cut-off point, its current income and its theoretical tuition is:

$$\tau^p = \tau^t(Y_p) \iff \tau^t(Y_p) > c + l_j + (h_j - l_j)Z. \tag{13}$$

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 raises her actual tuition to $\tau^t(Y_p)$ no matter for 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 tuition 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 modify the result of the theoretical 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 raises 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 $c + l_j < \tau^t(Y_p) < h_j$[37], 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 exemption from tuition or not. Applying for an exemption is worthwhile 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 (12) depends on j. 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 (12) are evaluated, depend on j.

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

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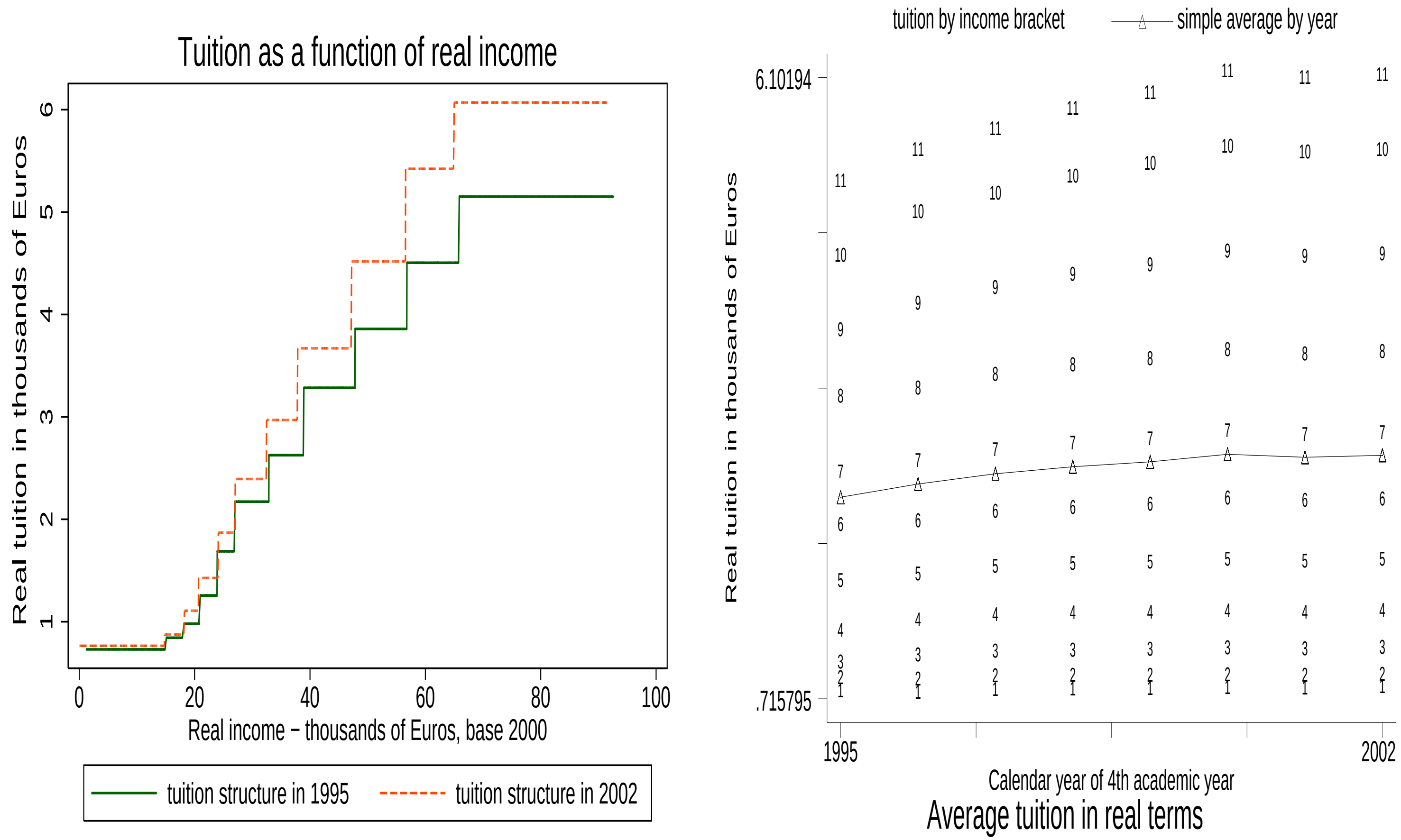
Table 1: Descriptive statistics by *fuori corso* status

	Conditional on being		Of the total
	in time	*fuori corso*	
% of the 12127 enrolled from 1992 to 1999 who:			
are females	44.62	39.57	40.92
are from the Milan area	40.58	40.84	40.77
graduated from highschool with top grades	28.83	22.01	23.83
attended top highschool tracks	70.40	65.98	67.16
graduated *cum laude* from Bocconi	57.76	23.67	32.79
have family income (in euro) equal to	41872	38637	39502
Total	26.74	73.26	100.00

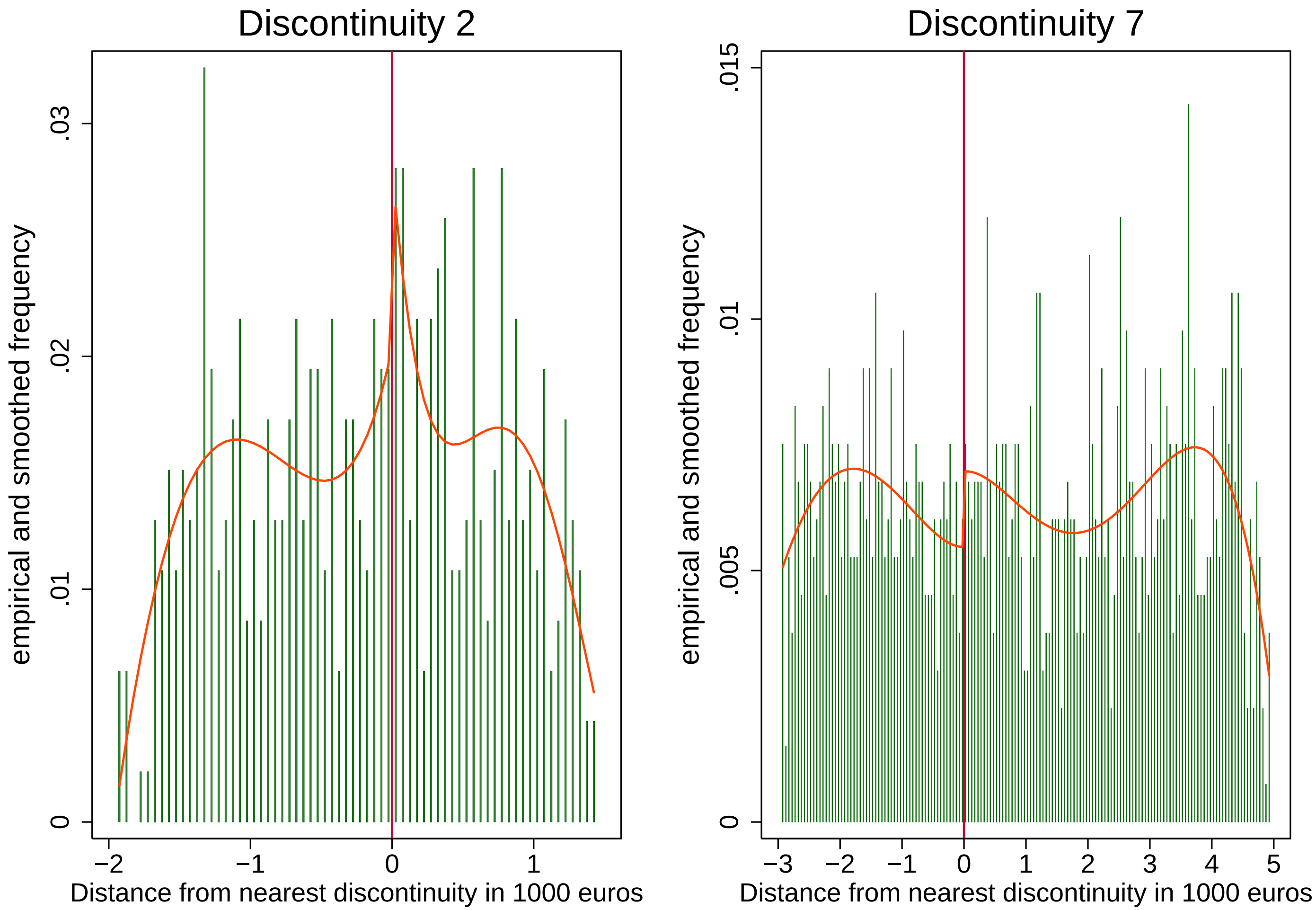
Source: Statistics for all the students who enrolled in the first year at Bocconi between 1992 and 1999.

Figure 1: Time profile of tuition at Bocconi



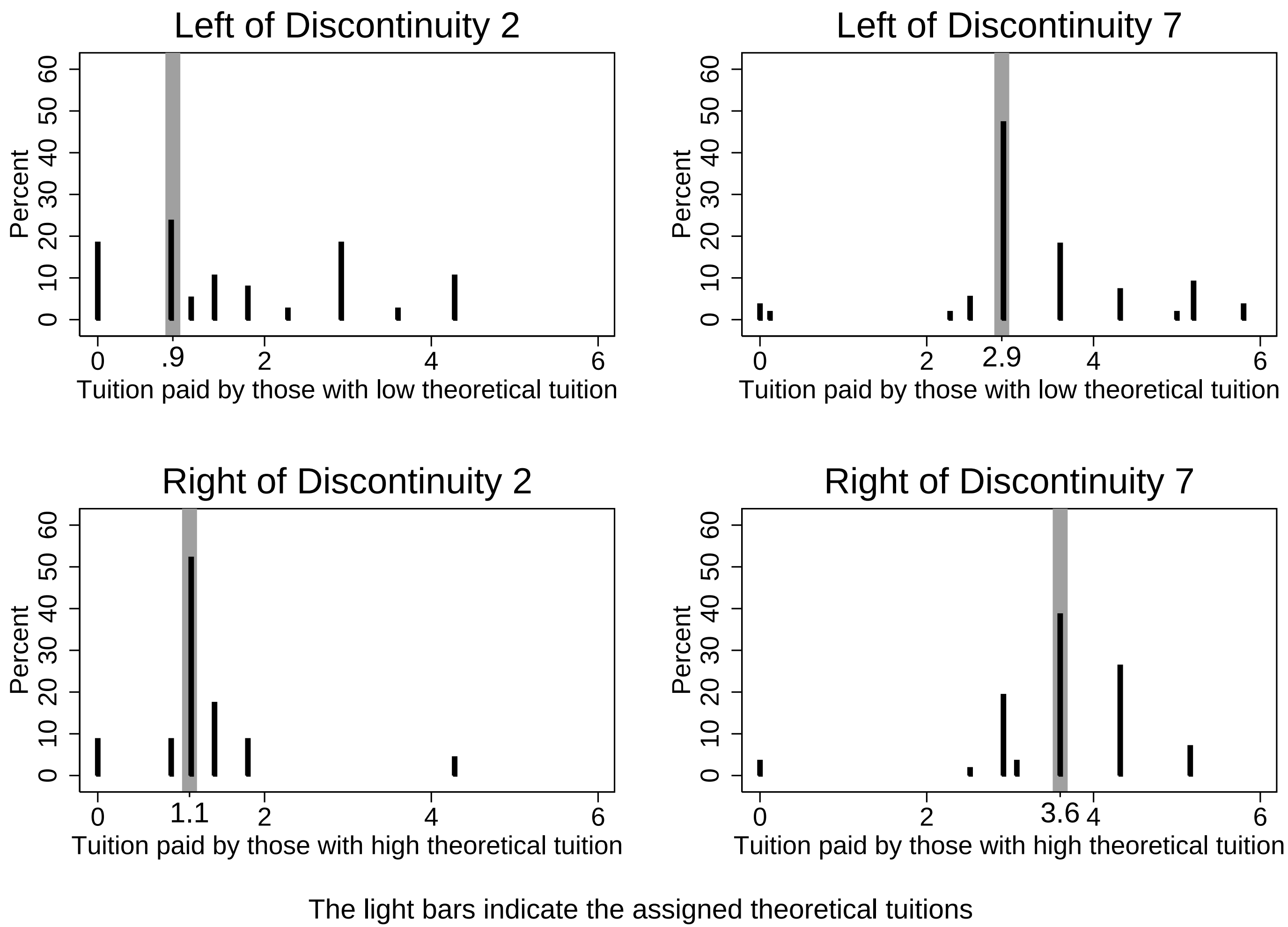
Source: Statistics for all the students who enrolled in the first year at Bocconi between 1992 and 1999.

Figure 2: Histogram of family income around thresholds



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

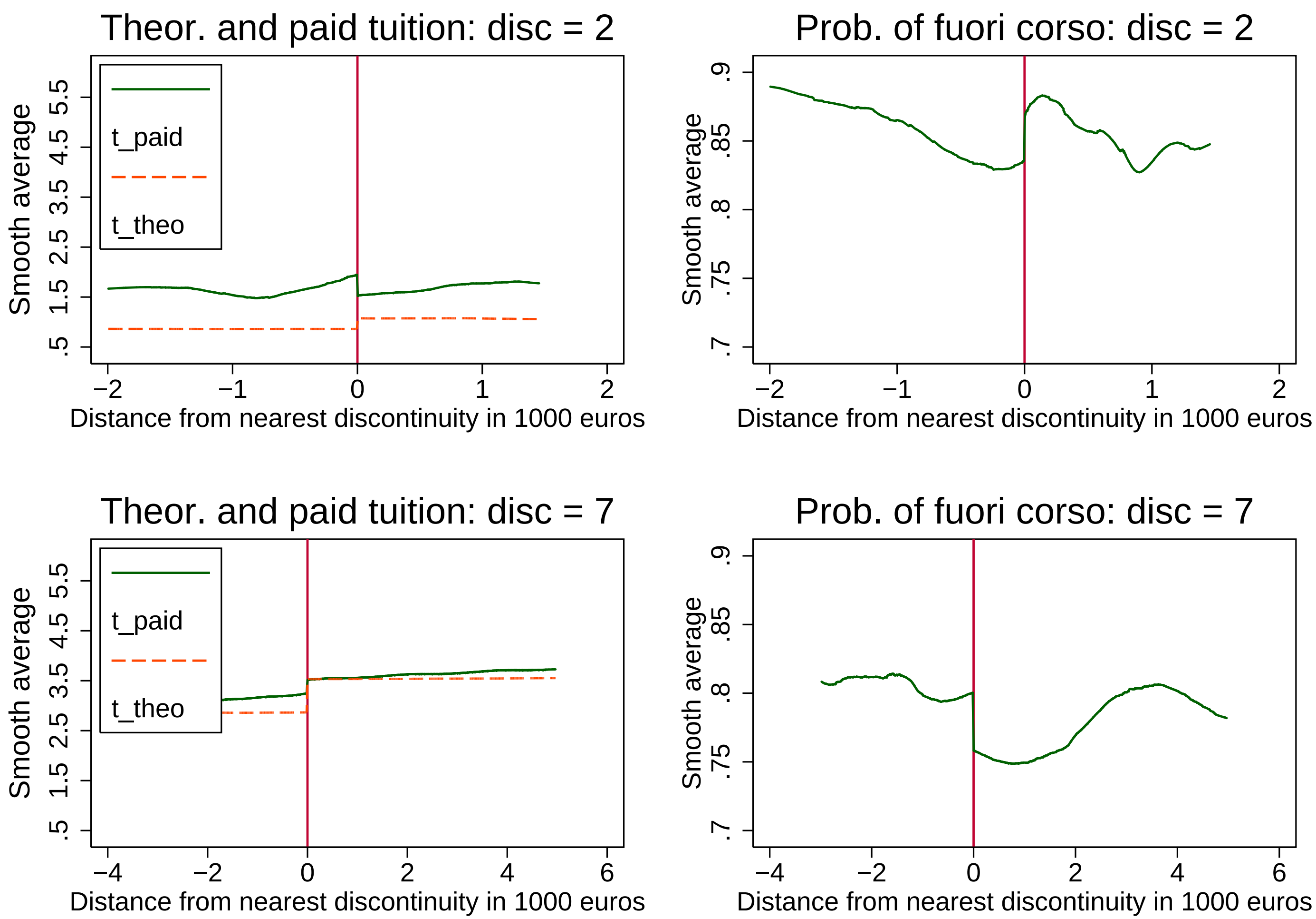
Figure 3: Histogram of paid and theoretical tuitions for two discontinuities in 1998



Note: Histograms of the tuition actually paid by students with family income immediately to the left or to the right of the second and seventh discontinuities. The light bars indicate the theoretical tuition that each group of students should pay. The dark bars indicate the fraction of students who actually pay the corresponding tuition. For example, in the top left panel, students on the left of the second discontinuity should all pay a theoretical tuition of 0.9 thousand euro, indicated by the corresponding light bar. The dark bar of the histogram at the same level indicates that less than 25% of these students actually pay this theoretical tuition. The other dark bars measure the fractions of students in this group who effectively pay other tuition levels, ranging between 0 and slightly more than 4 thousand euro.

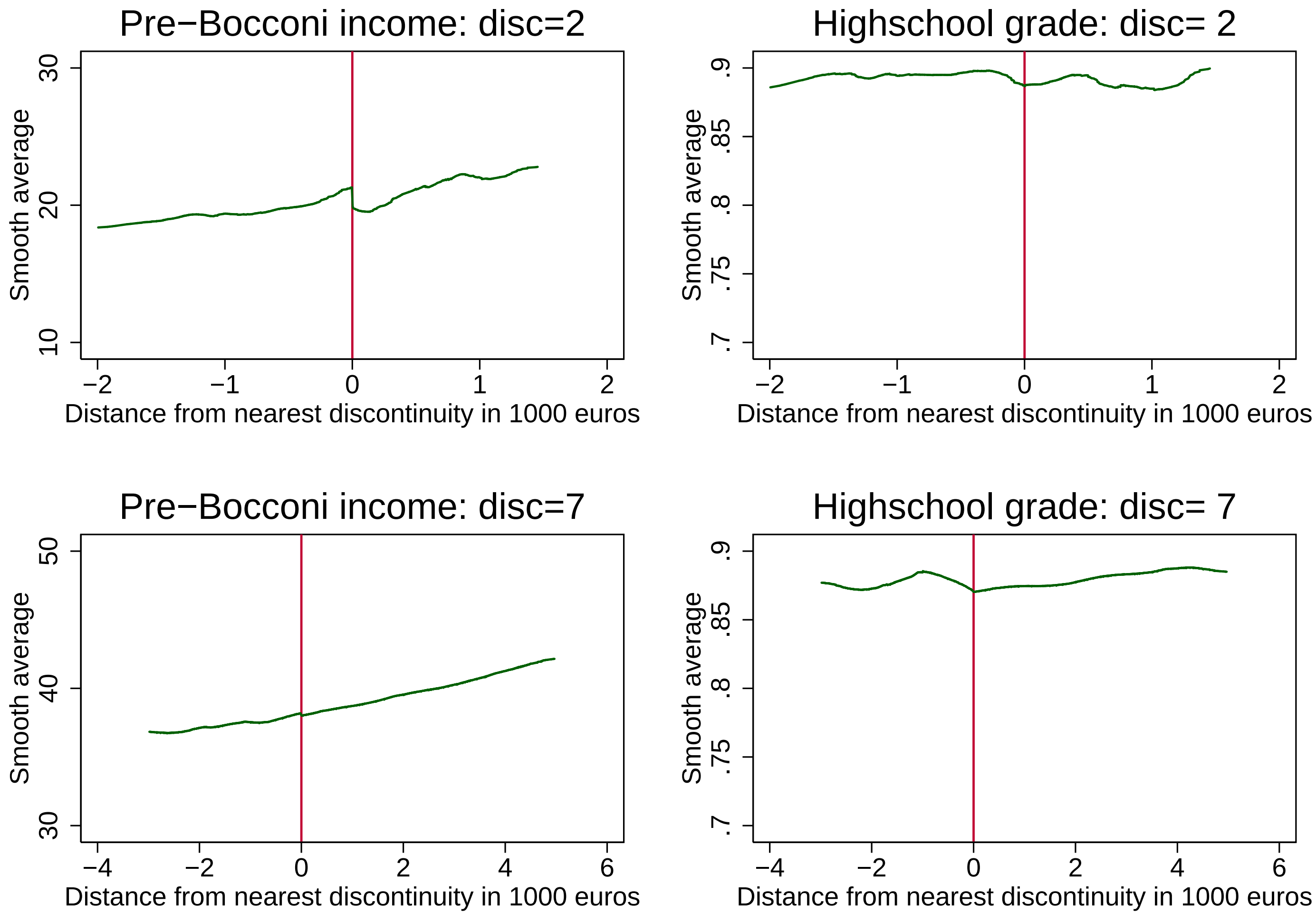
Source: Statistics for the 4th year students in 1998 at discontinuities 2 and 7. Results are qualitatively similar at other discontinuities and years.

Figure 4: Intention-to-treat effects



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



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

Table 2: Regression discontinuity estimates of the effects of tuition

Method	OLS-ITT	OLS	IV-LATE	N. of obs.
Treatment		Paid Tuition	Paid Tuition	
Instrument	Theoretical Tuition		Theoretical Tuition	
First Stage				
Paid tuition	.530			6985
	(.055)			
Main outcome				
Fuori corso status	-.052	.004	-.099	6985
	(.023)	(.004)	(.044)	
Pre-treatment characteristics				
Income before Bocconi	.44	.75	.82	6790
	(.63)	(.12)	(1.2)	
Highschool grade	-.0013	-.014	-.0024	6985
	(.0059)	(.001)	(.011)	
Highschool type	-.035	.025	-.066	6985
	(.024)	(.0047)	(.047)	
Family of origin outside Milan	-.028	-.017	-.053	6985
	(.027)	(.0047)	(.052)	
Female	.029	-.0072	.056	6985
	(.027)	(.0051)	(.052)	
Collateral effects				
Drop-out	-.003	.005	-.007	6982
	(.010)	(.002)	(.019)	
Final graduation mark	-.67	-.90	-1.2	6262
(min= 66; max= 110)	(.40)	(.07)	(.70)	

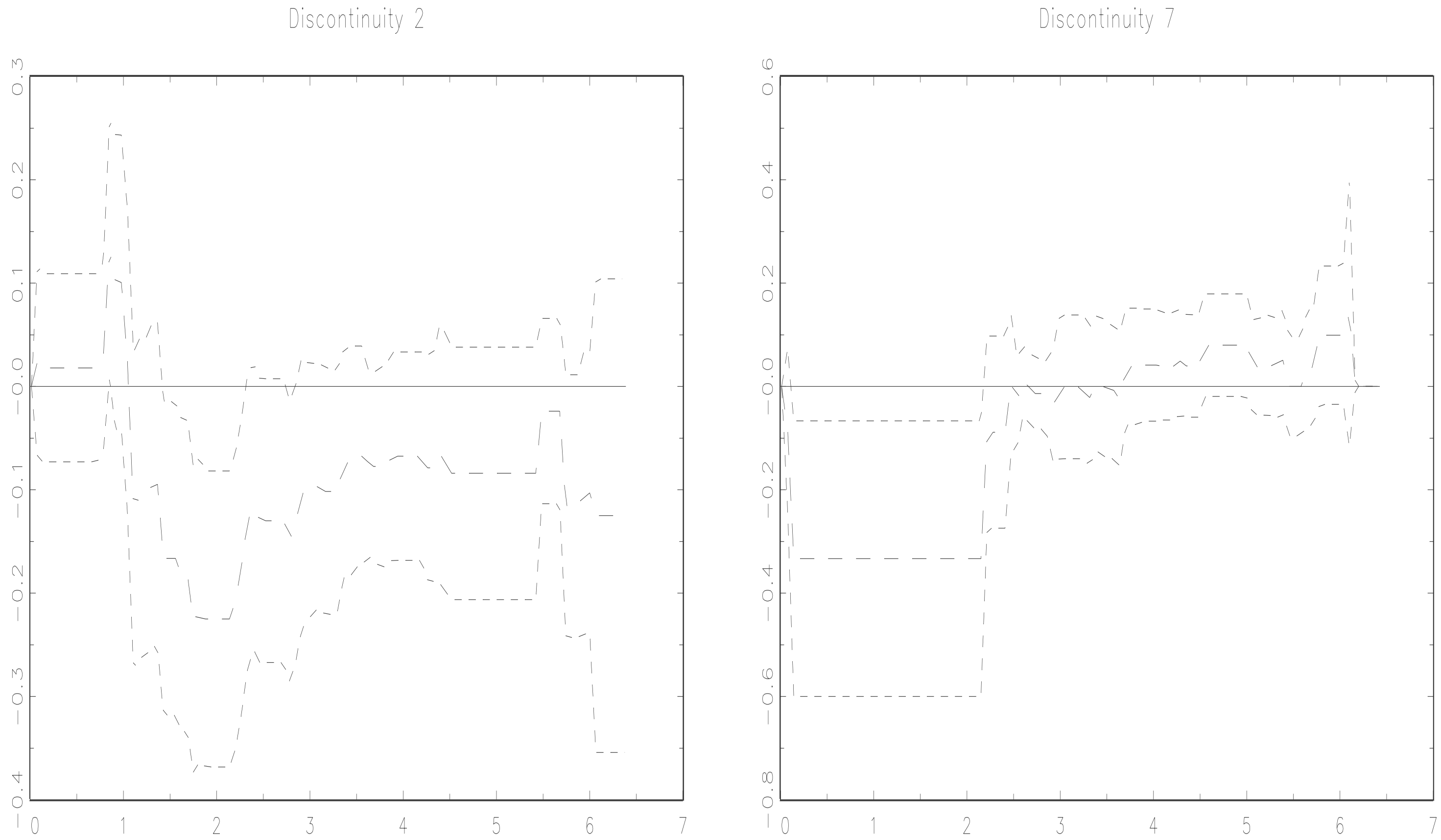
Note: Each coefficient (and related robust standard error in parenthesis) is an estimate of β obtained from separate regressions of the form:

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

where S is the 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 test of monotonicity: CDF crossing



For each discontinuity the figure plots the estimated difference between the cdf of the tuition actually paid by students in a left neighbourhood of the cut-off point and the corresponding cdf paid by students in a right neighbourhood. 0.95 confidence intervals are plotted as well. The left (right) neighbourhood is defined selecting students whose family income is below (above) the cut-off point by no more than 500 euro.

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

Table 3: 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	-0.066	-0.003	-0.115
	(0.029)	(0.006)	(0.051)
Deviation of the IV estimand $\Lambda(y_j)$ at the discontinuities 4, 5, 6 and 7	0.013	0.009	0.016
	(0.017)	(0.007)	(0.014)
Deviation of the IV estimand $\Lambda(y_j)$ at the discontinuities 8, 9 and 10	0.015	0.013	0.020
	(0.019)	(0.009)	(0.017)

Note: The rows of the table report respectively the coefficients on τ^k, $\tau^k D_{4,7}$ and $\tau^k D_{8,10}$ of the regression

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

where F is the *Fuori Corso* status; the dummies $D_{i,j}$ take value 1 for 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.