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Experimental Evidence from Rural Bangladesh**

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DVD-based Distance-learning Program for University Entrance Exams: Experimental Evidence from Rural Bangladesh

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Abstract

In contrast to the remarkable improvement in basic education globally, access to higher education remains limited in many developing countries, particularly in rural areas where the quantity and quality of supply is inadequate. In this study, we evaluate a unique DVD-based distance-learning program, targeting students who aim to take university entrance exams in rural Bangladesh, by conducting two experiments: one to evaluate the impact of the program and the second to examine its price sensitivity. Our findings demonstrated that the DVD program had a considerable positive effect on the probability of students passing entrance exams. This effect does not depend on students' cognitive scores, but does depend on non-cognitive attributes – particularly self-control abilities – indicating the importance of a commitment mechanism in applying the DVD program. In the second experiment, we offered a randomized subsidy to interested participants; however, price sensitivity was not correlated with students'

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socio-economic status, suggesting that imposing a cost for such a program may not disproportionately exclude poor students. We also found evidence that a higher price induced a greater attendance rate due to the sunk cost effect.

JEL Classification: I21; I23

Keywords: Distance Learning, Computer-based teaching, Tertiary education, Bangladesh.

1 Introduction

While many developing countries have achieved remarkable progress in school enrollment and completion rates at primary and secondary levels, little effort has been invested in improving access to tertiary education, particularly in rural areas. This problem has not gone unobserved, however; indeed, the newly adopted global development goals, the so-called Sustainable Development Goals (SDGs), include a target to ensure that all women and men have equal access to affordable and quality technical, vocational, and tertiary education, including university education, by 2030. However, achieving this target is likely to prove a great challenge to many developing countries. For instance, the net enrollment rate for primary education in Bangladesh increased from 62.9% in 2000 to 98.7% in 2013 (DPE, 2014); however, the gross enrollment rate at tertiary level remains low, at 12.52% in 2012 (Bangladesh Bureau of Educational Information and Statistics, 2012), of which only 16.33% comprises enrollment in universities. The principal reason for this disparity is the low advancement rate of rural students, partly due to their difficulty in passing the entrance exams that are required to enroll in subsidized public universities. Rural students generally receive a substantially lower quality of education than their urban counterparts, owing to teacher absenteeism, a shortage of skilled teachers (Banerjee and Duflo, 2006; Chaudhury et al., 2006), and lack of access, both geographically and financially, to supplementary educational aids (Mujeri, 2010). Given the increasing wage return for tertiary education relative to primary (Colclough et al., 2010; Montenegro and Patrinos, 2014), ensuring fair and equal access to tertiary education for rural students could have a great impact on reducing poverty and inequality.¹

¹Montenegro and Patrinos (2014) reports that the return to education in Bangladesh was 8.1% in elementary and 16% in tertiary in 2005, although this estimate suffered from selection bias.

Studies that evaluate the impact of various educational interventions in developing countries mostly focus on primary or secondary level (Kremer and Holla, 2009), which are not always applicable to higher levels of education. For example, Banerjee et al. (2007) demonstrated the effectiveness of remedial education and computer-based learning on improving students' academic performances in India. However, finding remedial tutors for upper-secondary students in rural areas is difficult in most developing countries where even the quantity and quality of school teachers for this level of education are far from sufficient. Creating effective computer-based learning systems would also be difficult for many countries, because doing so requires human resources with sufficient knowledge of teaching and programming. Furthermore, one cannot simply import the software from elsewhere as the curriculum and background knowledge required differ between countries.

An alternative and more feasible option for improving the quality of education in rural areas is through distance learning using pre-recorded lectures delivered by “star” teachers. Such lectures can be distributed to rural students on off-line platforms such as DVDs, or on-line platforms, depending on the available technology. This intervention has two important properties, which can serve to overcome some of the challenges mentioned above. First, only a small number of talented teachers are required, which is much easier than finding a large number of remedial tutors or creating new computer-based learning systems. Furthermore, using this system, the quality of lectures, teacher incentive problems such as absenteeism, and adjustment for the current curriculum cease to be a cause for concern. Second, the technological requirements for such an intervention are minimal, as only DVD players or other devices such as laptops or mobile phones are required to play the lectures.² The increasing availability of such devices makes this approach more affordable and scalable. In addition, students can watch these DVD lectures as many times as they want and at their own pace, which is helpful for less able students. The DVD lectures can also be adapted for classroom use with a projector.

In this paper, we evaluate a DVD-based distance-learning program targeted at university entrance exam preparation for students in rural Bangladesh. University entrance exams in Bangladesh are highly competitive and require dedicated test preparation to ensure success. Most urban students taking university entrance exams attend prep schools called “coaching centers,” or hire private tutors for exam preparation. Such services rarely extend to rural

²The digital content of DVDs can be transferred onto mobile phones using microSD memory cards.

areas due to the limited market and the unwillingness of teachers to live in such areas. In addition, the fees charged for these services are often beyond the reach of rural households. As a result, rural students systematically underperform in entrance exams, narrowing their opportunities to receive tertiary education. To correct the accessibility gap, we created DVD lectures taught by reputable prep school teachers and provided rural students with access to these DVD lectures, using laptops together with lecture notes and problem-solving tutorial classes.

We evaluated the effect of this DVD program and the price sensitivity of the demand by conducting two randomized experiments. Our first experiment on the impact of the program demonstrates that it increased the probability of passing the entrance exams to top-ranked public universities by 13 percentage points, and of passing any public university entrance exam by 16 percentage points. The effect of the DVD program was not significantly affected by cognitive scores or socio-economic status, but was shown to depend on non-cognitive attributes, particularly on self-control, indicating the importance of implementing commitment mechanisms when providing the program.

While the DVD program was found to be effective at improving access to tertiary education, its implementation costs can be high, particularly in poor areas where most students do not have access to a device on which to play DVDs. In order to expand coverage of the DVD lectures, cost sharing with the beneficiary students should also be considered. Collecting fees from students, however, may exclude poor students from uptake of the service, if such students are more price-sensitive in their uptake behavior. To examine this possibility, we performed a second experiment to evaluate price sensitivity two years after the initial intervention and found that it was not correlated with students' socio-economic status and thus that imposing a cost would not disproportionately exclude poor students.³ Imposing higher prices may also exclude less motivated students (selection effect) from participating or induce students to make more efforts through the sunk cost effect (Thaler, 1980; Arkes and Blumer, 1985), of which our finding is supportive.

Our work is related to the extant literature that examines the effect of technology on learning, for which, thus far, the evidence has been mixed. While Linden (2008), Barrera-Osorio and Linden (2009), and Angrist and Lavy (2002) found that computers have either

³Cohen and Dupas (2010) investigated the uptake behavior of bed nets, finding no significant heterogeneity in price sensitivity due to health risk.

no effect or mixed effects on learning outcomes, Banerjee et al. (2007) and Barrow et al. (2009) found positive effects on learning among school children. Computer-aided teaching (Lai et al., 2015) and One Laptop One Child programs (Beuermann et al., 2015; Mo et al., 2013) did not improve learning outcomes for school children. The way in which the program is implemented is as important as the program content itself (Bold et al., 2013), and simply providing the technology has not been found to improve students' performance. In our study, therefore, we considered how the students would use the technology, and our distance-learning program aimed to ensure that students would use the technology solely for study purposes. To the best of our knowledge, our study was also the first to evaluate a distance-learning program for tertiary education, and the findings of this paper are therefore important for guiding policy makers, and international agencies and donors.

The paper is organized as follows. Section 2 discusses the background of the project and the details of the intervention while section 3 presents the experimental design. Section 4 reports the empirical results of the effect of the DVD program and the uptake decision. Finally, section 5 offers concluding remarks.

2 Background and Intervention

Bangladesh has three types of university: public, national, and private. Public universities are government-subsidized institutions and are the most prestigious tertiary educational institutions in Bangladesh. The National University is the central governing authority for all the affiliated private and public colleges offering bachelor's and master's courses in Bangladesh. Affiliated colleges are located in almost all sub-districts of Bangladesh, unlike public universities, which are located mainly in large cities. Private universities are the most expensive institutions and are located in the major cities. As of 2014, there are 29 public universities, 51 private universities, and 1490 colleges affiliated with the National University in Bangladesh. Bangladesh Bureau of Educational Information and Statistics (2012) reports that of those who are enrolled in tertiary education after 12 years of schooling, only 16.44% are enrolled in universities (either public or private), while 79.21% are enrolled in National University-affiliated colleges.

Entering a public university is often the first choice for those who have completed higher secondary qualifications due to the low cost, high prestige, and good job prospects. As a

result, admission to these universities is extremely competitive, requiring students to have specialized test-taking skills to pass the entrance exams. For example, Dhaka University, the top-ranked university in Bangladesh, received 244,937 applications in 2014 against a total capacity of 6540, making an applicant-to-seat ratio of approximately 37. Admission to other major public universities is also highly competitive, as depicted in Appendix Table 1. The application to seat-ratio exceeds 30 for any general public university, except for engineering universities where eligibility for application is restricted to high achieving students. In contrast, admission to National University-affiliated colleges is less competitive, and, on average, approximately half of applicants pass the entrance exam. Admission to private universities is also less competitive due to their high tuition fees.

In addition, each university has a different entrance exam system and the number of tests students need to take also depends on the choice of subject division (e.g., science, social science, arts, commerce). While exam formats vary across universities, major public universities use a similar format. Students require dedicated preparation and test-taking skills for the entrance exams. For example, Dhaka University's entrance exam for the commerce subject division requires students to solve 120 questions in 60 minutes, which would be impossible if students were to read all the sentences of the exam questions. To prepare for the entrance exams for public universities, urban students typically attend prep schools, known locally as coaching centers, which specialize in preparation for public university entrance exams. However, these coaching centers rarely extend their branches to rural areas, and even in the occasional case that they do, the quality of teaching is not comparable to their main centers in the cities. Hence, well-off families send their children to nearby major cities to attend popular, famous coaching centers to prepare adequately for university entrance exams.

Our initial focus group discussion with students who had recently been admitted to public universities revealed the importance of these quality coaching centers for admission success. Approximately 81% of the Dhaka University students whom we interviewed had either attended coaching centers or hired individual tutors for preparation. Poor rural families typically cannot afford to send their children to cities to attend these coaching centers. For example, the lowest fee for attending a coaching center is 7,000 BDT (approximately 90 US\$⁴), and transport to and accommodation in an urban location, for a minimum of three months, costs on an average nearly 30,000 BDT (387 US\$). Thus, the total cost amounts

⁴We used the conversion rate of 1 US\$ = 77.56 BDT as of 15 May 2014

to 37,000 BDT (477 US\$), a sum that is approximately four times higher than the average household monthly expenditure in rural areas.⁵ Although various test-solving books for university entrance exams are available in bookstores, their contents are not sufficient to achieve the required skills.

To make coaching center lectures accessible to rural poor students, e-Education Bangladesh,⁶ our counterpart organization, has run an off-line distance-learning program using DVD lectures since 2010. They identified the most popular coaching center teachers in Dhaka for several subjects such as commerce, accounting, and English, and, with permission, filmed these teachers' lectures to create DVD copies. Following the popular prep school models, they designed two-month courses of DVD lectures with monthly tests, supplemented by reading materials used in the regular classes of the coaching center teachers. The courses are designed for the entrance exam of Dhaka University, which is the most competitive exam and held earlier than those of other public universities. Acquiring test-taking skills for Dhaka University is also useful for other universities' entrance exams, and students typically prepare for Dhaka University entrance exams first, after which they prepare for other university entrance exams.⁷

Nevertheless, there are two potential concerns with regard to DVD lectures. The first is the lack of direct interaction with lecturers. Because DVD lectures are pre-recorded, students cannot ask their teachers questions directly. Second, the lack of interpersonal contact could reduce students' involvement and commitment to the classes. If DVD lectures can be watched at any time, present-biased students might procrastinate about watching DVD classes (O'Donoghue and Rabin, 2001). To tackle these issues, e-Education Bangladesh introduced regular problem-solving classes taught by tutors who were university students that return home regularly at weekends.⁸ These tutors also played the role of mentors and role models, encouraging students to advance to higher level education to secure their future. Moreover, e-Education Bangladesh created timetables for each content type and imposed a strict attendance requirement: if a student was absent for three consecutive classes without

⁵According to the Household Income and Expenditure Survey 2010, the average total expenditure per household was 9,612 BDT in rural Bangladesh in 2010.

⁶e-Education was established by Atsuyoshi Saisho (Japan) and Abdul Matin Sheikh (Bangladesh), with the collaboration of the UCC, a leading university admission coaching center in Bangladesh.

⁷It should be noted that the course did not include natural science subjects because most students in rural areas had no experience in laboratory instruments and, as a result, would have had difficulty understanding the contents from DVD lectures alone.

⁸Tutors were also available for urgent problems over the phone during weekdays.

prior notice, except for a legitimate reason such as illness, he or she would not be allowed to continue. Hence, it should be noted that the estimated impact of our DVD-based learning program comprised the combined impact of commitment and encouragement effects, together with the impact of the DVD lectures themselves.⁹

3 Experimental Procedures and Survey Design

The study site was in Chandpur District of Chittagong Division, located 220 km away from the capital city of Bangladesh, Dhaka. Chandpur is an undeveloped district with a literacy rate of 50.3% (Bangladesh Bureau of Statistics Population Census 2001), which is ranked among the lowest in Bangladesh. The main economic activity in this region is agricultural production.¹⁰

E-Education Bangladesh established four sub-district centers in Chandpur, namely Baburhat, Chandpur Sadar, Faridganj, and Haimchar, with different enrollment capacities.¹¹ Each center had one classroom with laptops for watching the DVD lectures, which were managed by a center administrator. Four tutors, who were Dhaka University students, provided a weekend tutoring service for the students in these four centers. The administrator announced the timetable for the DVD lectures, took the attendance record, and noted learning problems and questions, which were then addressed by tutors in the weekend solving classes.

The timeline for both experiments (experiment 1 in 2012-13 and experiment 2 in 2014-15) was as follows: First, we advertised our program at various Higher Secondary Educational Institutions (HSCI) in Chandpur from March to May, when students were preparing for or taking the Higher Secondary Certificate (HSC) exams. After completing the HSC exam in June, we began accepting applications for our DVD program at the four centers in early July. We then implemented randomization in August, followed by the DVD program for two months. Public university entrance exams are typically held from November to February. We conducted two surveys for each experiment, one during the registration period (baseline)

⁹Due to the budget limitation, we could not conduct an experiment to evaluate the importance of the strict scheduling and tutors, which would have required branch level randomization and is left for future research. With this caveat, we will use the word “DVD program” instead of “DVD lectures” where appropriate.

¹⁰Chandpur is located next to the Meghna River, which had frequent seasonal flooding, and river erosion is damaging the property and assets of residents. River transportation is the main mode of transport from Chandpur to the rest of the country. The inner road network of Chandpur is inadequate and poorly maintained, thus isolating the rural areas of Chandpur.

¹¹42 places in Baburhat; 80 places in Chandpur Sadar; 30 places in Faridganj; and 30 places in Haimchar.

and one after all the public university exams had ended (end-line).

3.1 Experiment I: Effect of DVD-based Distance-learning

To investigate the effect of the DVD-based distance-learning program on success in university entrance exams, we conducted the first experiment in 2012. After completion of the HSC exam, we began accepting applications for our program, with an eligibility condition that students' grade point average (GPA) scores in the Secondary School Certificate (SSC) exam should exceed 3.88 out of 5.00, as students with low SSC and HSC exam GPAs are not eligible to take the entrance exams for Dhaka University.¹²

In total, we received applications from 245 eligible students. In accordance with the advice of local HSCI teachers who helped to advertise our program, we enrolled their best 67 students whose SSC exam GPA exceeded 4.9.¹³ Since all of these 67 students were admitted to the program, we excluded them from our analysis. Among the remaining 178 students whose SSC exam GPAs ranged from 3.88 to 4.9, we randomized admission to our program at the individual student level, with stratification based on gender and SSC exam GPA. Note that the treatment probability for each student varied depending on two factors. First, female students and students with SSC exam GPAs above the median were prioritized, with a 1.25-fold higher chance of admission, owing to the request from our implementing partner. The second factor comprised the difference in capacity of each center, which was fixed. Excluding the positions guaranteed to students with SSC exam GPAs of greater than 4.9, we had 78 eligible applicants for the Chandpur Sadar center, which had a capacity of 35, and 26 applications to the Haimchar center, which had a capacity of 18. To control for the difference in treatment probabilities, we used a weighting method, as explained later in this section.

The treated students were provided with free access to the full package, which included the DVD lectures, lecture notes, and problem-solving tutorial classes. We also had a control

¹²Major public universities base their application eligibility on the SSC and HSC exam GPA. For example, Dhaka University only allows students with an average SSC and HSC exam GPA of no less than 4.00 to sit the entrance exam. Because the HSC exam GPA was unavailable at the time of receiving applications, we only used the SSC exam GPA to determine eligibility. Given that the SSC and HSC exam GPAs are highly correlated, students with an SSC exam GPA of less than 3.88 would have little chance of being eligible to apply for Dhaka University.

¹³These teachers strongly believed that their best students deserved to study at university, and we obtained their cooperation on the condition of accepting their best students with extremely high GPAs.

group, to whom we provided only the lecture notes, to control for the effect of access to learning materials. Since regular academic classes at HSCI ended before the HSC exams, students did not meet each other regularly. However, it remains possible that some students in the treatment group interacted with control students in the same village. If we assume that this spill-over effect was positive, then our estimated impact would be a conservative one.

We conducted the baseline survey before the intervention in June 2012 and the follow-up survey in March 2013 when all the major public universities had completed their entrance exams. In the baseline survey, we collected detailed personal and family information from students and measured their IQ scores using Raven’s Progressive Matrices. We also collected measures of non-cognitive skills such as present bias and grit.¹⁴ The present-biasness was elicited from the hypothetical questions developed by Ashraf et al. (2006). Grit, which is defined as passion and perseverance for long-term goals, was measured using the Duckworth eight-item grit scale (Duckworth et al., 2007).¹⁵ We predicted that students with present bias and low grit scores would be more likely to procrastinate in watching DVD lectures and studying without a strict commitment device, resulting in the DVD lectures having a lesser impact. However, if the strict scheduling imposed by our program worked, they could gain the additional benefit of adhering to the schedule from the intervention. To complement the present bias and grit measure, we also adopted the conscientiousness measure in McKenzie’s Big Five Psychological traits, which captures self-discipline, diligence, and a focus on achievement.¹⁶ In the follow-up survey, we collected information on students’ entrance exam results, together with other related information about university exams. Among our sample, three students (two in the treatment group and one in the control group) failed the HSC exam and became ineligible for our program. Five students, all of whom were in the treatment group, could not be reached for the follow-up survey, and thus were not used in the

¹⁴The importance of non-cognitive ability has been well documented by Almlund et al. (2011), Chetty et al. (2011), and Heckman et al. (2013). Unlike cognitive ability, which is almost fixed before primary school, non-cognitive ability can be improved or altered throughout life.

¹⁵Eskreis-Winkler et al. (2014) showed that grit predicts high school graduation and job retention better than IQ score.

¹⁶Psychology categorizes personal traits into five categories, called the Big Five: extraversion (energy, positive emotions, assertiveness, sociability), openness to experience (intellectual curiosity, creativity, appreciation of art, preference for novelty and variety), conscientiousness (self-discipline, organization, diligence, dutifulness, focus on achievement), agreeableness (compassion and cooperation rather than suspicion and antagonism towards others, trust, helpfulness), and neuroticism (tendency to experience unpleasant emotions easily, such as anger, anxiety, depression, and vulnerability).

analysis.¹⁷

As mentioned above, the treatment probability differed across individuals. In particular, the small number of female applicants whose SSC exam GPA exceeded the median had a treatment probability close to 1. To satisfy the common support condition, we excluded students from the analysis whose treatment probability exceeded 0.9, following the standard procedure of the propensity score methods,¹⁸ leaving us with 160 students for the analysis. The summary statistics of this sample of the first experiment are reported in Table 1. The socio-economic status (SES) score was computed by factor analysis based on housing conditions, source of drinking water, sanitary conditions, access to electricity, and self-reported SES. The IQ score, grit measure, and conscientiousness measure are standardized. The average students sat for 2.7 entrance exams, and 11% and 9% of the sample students passed the entrance exams for public universities and first-tier public universities, respectively.¹⁹ 85% of the students passed the entrance exams for some universities (including public, private, or national universities).²⁰

3.2 Experiment II: Demand for DVD-based Distance-learning

The second experiment investigated the price sensitivity of demand for the DVD program. If students from poor families were more price-sensitive, then imposing a participation fee would have disproportionately excluded such students, who are the main target of aided education intervention. Hence, our focus in this experiment was to test the existence of heterogeneity in price sensitivity between students from poor and better-off families.

To ensure that our target population understood the program well, we conducted this experiment in 2014, two years after the first experiment in the same location.²¹ During

¹⁷We checked the robustness of our results by imputing zero (failure in the university entrance exam) for these attrited students and found results similar to those reported in the paper. We also checked the sample selection issue but these attrited students were not systematically different than the non-attrited students, although the statistical power was relatively small given the small number of attrited students.

¹⁸Crump et al. (2009) recommended that all units with estimated propensity scores outside the range of [0.1, 0.9] should be discarded to ensure overlap. Because there were no units whose treatment probability was less than 0.1, we only discarded those units whose treatment probability exceeded 0.9.

¹⁹The first-tier public universities are Dhaka University, Jahangirnagar University, Chittagong University, Rajshahi University, Hazrat Shahjalal University of Science and Technology, and Khulna University.

²⁰Given that the number of treated students was 85 out of 160 students in total, the power analysis demonstrates that, with a significance level of .05 and power of 0.8, the effect sizes that the statistical analysis by simple comparison can detect are 14.3 and 12.9 percentage point changes in the probability of passing the entrance exams for public university and first-tier public university entrance exams, respectively.

²¹E-education Bangladesh also ran the same program in 2013. By 2014, our program was well recognized

Table 1: Summary statistics of the first experiment

	count	mean	sd	min	max
DVD	160	0.53	0.50	0.00	1.00
SES score	160	-0.01	0.77	-0.84	1.28
Female	160	0.34	0.47	0.00	1.00
SSC GPA	160	4.44	0.28	3.88	4.88
IQ score	160	0.00	1.00	-3.31	2.58
Present bias	160	0.23	0.42	0.00	1.00
Grit	160	-0.00	1.00	-2.69	1.87
Conscientiousness	160	0.00	1.00	-3.38	1.77
# of exams taken	160	2.71	1.40	0.00	8.00
Pass public university exam	160	0.11	0.32	0.00	1.00
Pass 1st-tier public university exam	160	0.09	0.29	0.00	1.00
Pass National University exam	160	0.82	0.38	0.00	1.00
Pass any university exam	160	0.85	0.36	0.00	1.00

The SES score was computed by factor analysis based on housing conditions, source of drinking water, sanitary conditions, access to electricity, and self-reported SES. IQ, grit, and conscientiousness scores were standardized.

the marketing campaign for the second experiment, we announced that the program was no longer free due to the budget limitation, but that all students who registered within three days of a set period would be given a discount price, either 25%, 50%, or 75% of the full price, at a rate to be randomly selected after registration. The full price was set at 3600 BDT (approximately 46 US\$), which was still well below the cost of available alternatives such as local coaching centers.

One potential mechanism that may have made the poor students more price sensitive was the liquidity constraint. If such a constraint was caused by difficulty in saving (Dupas and Robinson, 2013), dividing the payment amount into several installments would help to alleviate the problem as in most existing micro-credit programs (Armendáriz and Morduch, 2010). Hence, we also randomized the offer allowing students to pay the fee in three equal monthly installments.

In total, we received 244 registrations at our main branch at Chandpur Sadar within three days of the set period.²² We conducted a short survey of the registered students when they submitted their registration forms. The price discount and payment options were randomized at the student level and stratified based on their SES scores, which were calculated in the same way as in the first experiment. The treatment probability did not vary

by rural students and HSCI teachers.

²²In the second experiment, we did not impose the eligibility condition based on the SSC exam GPA.

across students in this experiment, where the probability of receiving a 25% discount, 50% discount, or 75% discount was 0.3, 0.3, or 0.4, respectively. As the full price was 3,600 BDT (approximately 46 US\$), the fee was 2,700 BDT (35 US\$) with a 25% discount, 1,800 BDT (23 US\$) with a 50% discount, and 900 BDT (12 US\$) with a 75% discount. These payment options were randomized independent of the subsidy amount, with equal probability of two options: upfront full payment and monthly installment payment.

After informing the students of the discount and payment options, they (and their parents) were given a week in which to decide to participate or not. Those who accepted the offer came to our centers, filled in the admission form, and made the payment (either full payment or the first installment). The summary statistics of our sample in the second experiment are reported in Table 2. Of the students that showed interest by registering for the program, 75% ultimately elected to participate by paying the initial required amount. For those who eventually joined the program, their average attendance rate in DVD classes was 80%, but only 6% succeeded in the public university entrance exams.²³

Table 2: Summary statistics of the second experiment

	count	mean	sd	min	max
Uptake	244	0.75	0.43	0.00	1.00
25% discount offer	244	0.27	0.45	0.00	1.00
50% discount offer	244	0.30	0.46	0.00	1.00
75% discount offer	244	0.43	0.50	0.00	1.00
Installment	244	0.44	0.50	0.00	1.00
SES score	244	0.00	0.79	-1.32	1.45
SSC GPA	244	4.44	0.44	3.19	5.00
Female	244	0.43	0.50	0.00	1.00
Subject devision: Commerce	244	0.66	0.48	0.00	1.00
Attendance rate	180	0.80	0.13	0.31	0.95
Average of standardized mock test scores	175	-0.01	0.80	-1.50	2.54
Pass public university exam	180	0.06	0.23	0.00	1.00

The SES score was computed by factor analysis based on housing conditions, source of drinking water, sanitary conditions, access to electricity, and self-reported SES. The variables of attendance rate and passing any public university exams only applied to students who participated in the DVD program.

We should note that the statistical power for the analysis is not necessarily strong. Given

²³Of the 183 students who participated in the DVD program, three students (two in the $P = 1$ group and one in the $P = 1/3$ group) failed the HSC exam and dropped out of our program. We counted these students for the uptake analysis but excluded them for the purposes of computing the attendance rate and public university admission rate.

that the numbers of students were 66, 73, and 105 in the 25%, 50%, and 75% discount offer groups, respectively, the power analysis shows that, with a significance level of .05 and a power of 0.8, the effect sizes were 18.2, 16.8, and 16.3 percentage point changes in uptake rate for the comparison between the 25% and 50% discount groups, between the 25% and 75% discount groups, and the 50% and 75% discount groups, respectively. Further, in the analysis in which we split the sample into richer and poorer students based on their SES scores, the statistical power reduced even further. For the poorer students whose SES scores did not exceed the median, the effect sizes were 26.7, 24.5, and 24.1 percentage point changes for the comparison between the 25% and 50% discount groups, between the 25% and 75% discount groups, and the 50% and 75% discount groups, respectively. Hence, the insignificant results should be interpreted with caution.

Another concern was related to the representativeness of the sample. Since our sample comprised students who registered during the registration period, it may have been a selected sample. To understand the potential difference between our sample and the general population of college students who sat the university entrance exams, we conducted a short but more extensive sample survey in the HSCIs located in the project site.²⁴ The summary statistics of the surveyed students and students who intended to study at university are reported in Appendix Table 2. Compared to these students, the students in our experiment earned higher SSC exam GPAs and tended to have chosen commerce as their subject division.²⁵ The proportion of male students was higher in our sample, reflecting the fact that female students tend to attend local colleges affiliated with the National University. This tendency may reflect the fact that parents are reluctant to have their daughters study outside their home districts due to their conservativeness and the lack of residential facilities in some public universities. On the other hand, the SES scores of the students in our experiment were relatively similar to those of the students who intended to study at any university. Since our main focus was on the heterogeneity of price sensitivity between poor and better-off students, this similarity has suggestive supporting evidence to validate our results.

²⁴We could not conduct a random sampling survey because the schools had been suspended and contacting selected students was quite costly. Instead, we surveyed students who came to the school for the HSC exam registration. Although this was still a selected sample, it was more representative than our experimental sample.

²⁵This is not surprising since the DVD lectures were primarily designed for the entrance exam for the commerce subject division of Dhaka University, as described above.

3.3 Empirical Strategy and Balance Test

As mentioned above, the treatment probability varied across students in the first experiment. To adjust for this difference in the treatment probability, we applied inverse probability weighting (IPW), which was developed by Robins et al. (1995) to address the sample selection problem, and employed propensity score weighting (Wooldridge, 2010). While the IPW in the propensity score weighting used the estimated treatment probability, we used the exact treatment probability for each individual, which was known from our experimental setting.²⁶

Let w be the treatment indicator, and $p(\mathbf{X}) = \Pr[w = 1|\mathbf{X}] = E[w|\mathbf{X}]$ be the treatment probability, where \mathbf{X} is the vector of variables affecting the treatment probability. A different treatment probability implies that for $\mathbf{X} \neq \mathbf{X}'$, $p(\mathbf{X}) \neq p(\mathbf{X}')$ and $E[\mathbf{X}|w = 1] \neq E[\mathbf{X}|w = 0]$, suggesting the difference in characteristics between the treatment and control groups. Let $y = y_0 + w(y_1 - y_0)$, where y_1 is the outcome with treatment and y_0 is the outcome without treatment.²⁷ The stratified randomization ensures that $E(y_0|\mathbf{X}, w) = E(y_0|\mathbf{X})$ and $E(y_1|\mathbf{X}, w) = E(y_1|\mathbf{X})$. Then, by the law of iterated expectation,

$$\begin{aligned} E \left[\frac{wy}{p(\mathbf{X})} \middle| \mathbf{X} \right] &= \frac{E[wy|\mathbf{X}]}{p(\mathbf{X})} = \frac{E\{E[wy|\mathbf{X}, w]|\mathbf{X}\}}{p(\mathbf{X})} = \frac{E\{wE[y_1|\mathbf{X}, w]|\mathbf{X}\}}{p(\mathbf{X})} \\ &= \frac{E\{wE[y_1|\mathbf{X}]|\mathbf{X}\}}{p(\mathbf{X})} = \frac{E[w|\mathbf{X}]}{p(\mathbf{X})} E[y_1|\mathbf{X}] = E[y_1|\mathbf{X}]. \end{aligned}$$

Similarly, we can obtain

$$E \left[\frac{(1-w)y}{1-p(\mathbf{X})} \middle| \mathbf{X} \right] = E[y_0|\mathbf{X}].$$

Hence, the IPW procedure can produce consistent estimates in our first experiment.

We reported the balance test result (after the IPW adjustment for the first experiment) in Table 3, where we simply regressed each of the treatment indicator variables on the observed characteristics of students. We also reported the F statistics and associated p values in parentheses, testing the joint hypothesis that the coefficients of all regressors were zero. The estimated coefficients were not significantly different from zero in most cases, and the F values were also small, indicating successful randomization. One exception was the coefficient

²⁶This eliminated the necessity to adjust for standard errors.

²⁷Note that $w^2 = w$ and $w(1-w) = w - w^2 = 0$ because $w \in \{0, 1\}$. This implies that $wy = wy_0 + w^2(y_1 - y_0) = wy_1$ and $(1-w)y = (1-w)y_0 + (1-w)w(y_1 - y_0) = (1-w)y_0$.

on the SSC exam GPA in column (4), indicating that students with a higher GPA tended to have been assigned to the installment payment group. To mitigate potential biases caused by this imbalance, we included the SSC exam GPA in all regressions.²⁸ We also controlled for the variables affecting the treatment probability along with the variables listed in Tables 3, making our empirical specification similar to the doubly robust estimator (Bang and Robins, 2005), which combined the propensity score weighting and regression adjustment. The doubly robust estimator was consistent if either the propensity score specification or regression specification was correct. Since we knew the exact propensity score, we believe that our estimates provided us with consistent results.

Table 3: Balance test

	(1)	(2)	(3)	(4)
	Experiment 1	Experiment 2		
	DVD	25% discount offer	50% discount offer	Installment
SES score	-0.032 (0.057)	0.020 (0.042)	0.015 (0.042)	-0.022 (0.035)
SSC GPA	0.025 (0.043)	-0.046 (0.039)	-0.029 (0.037)	0.087*** (0.029)
Female	0.022 (0.091)	-0.008 (0.079)	0.000 (0.078)	-0.039 (0.067)
IQ score	0.003 (0.042)			
Present bias	0.062 (0.106)			
Grit	0.058 (0.049)			
Conscientiousness	-0.055 (0.050)			
Subject division: Commerce		-0.147* (0.085)	-0.083 (0.085)	0.014 (0.072)
Observations	160	171	178	244
F statistics	0.381 (0.913)	0.949 (0.658)	0.338 (0.994)	2.360 (0.102)

The estimated results of the linear probability models are reported. The dependent variable was an indicator variable for each treatment. In column (1), we used the IPW to adjust for the difference in treatment probability caused by our experimental design. In columns (2) and (3), the base category is the 75% discount offer. In column (4), the base category is the upfront payment group. Robust standard errors are in parentheses. Asterisks indicate statistical significance: * $p < .10$, ** $p < .05$, *** $p < .01$.

²⁸Variables used for the balancing test were partially different between the first and second experiments, as the baseline questionnaire in the second experiment was substantially shorter than in the first experiment.

4 Results

4.1 Experiment I: Impact of DVD Program

The estimated impact of the DVD program in the first experiment is shown in Table 4. We employed the probit model with standard errors clustered at the branch level to report the estimated average marginal effects. The branch dummies were included in all estimations. The control variables included student's gender, SES score, SSC exam GPA, standardized IQ score, and noncognitive ability measures such as present bias, grit, and conscientiousness. Columns (1) and (2) estimate the effect of the DVD program on the probability of passing the entrance exams for any public universities and first-tier public universities, respectively. The DVD program increased the probability of passing the entrance exams by 16.1 percentage points for any public universities, and by 13.4 percentage points for the first-tier public universities, both of which were statistically significant at the 5% level. Given that the probability of passing the entrance exams in the control group was 2.6 percent for any public university and 1.3 percent for the first-tier public universities, the impact of the DVD program was substantial. Our intervention also increased the probability of passing the National University entrance exams by 28 percentage points, which was significant at the 1% level, as reported in column (3). With the large returns to university education,²⁹ this substantial effect of our intervention on the university admission is remarkable.

One potential concern was that the positive effect of the DVD program could be driven by students becoming more motivated to study at university and taking more university entrance exams to increase their probability of success. To check this possibility, we estimated the negative binomial model of number of exams taken. The result reported in column (4) of Table 4 shows that the DVD program did not significantly increase the number of exams taken. Even if we include the number of exams taken as the control variable, the estimated impact of the DVD program is similar to the basic results (columns (5) and (6)). Hence, the increased probability of passing the entrance exams was caused by the DVD programs themselves.

²⁹In the Web Appendix, we calculated that the internal rate of returns to university education was 23.7 percent, and the net discounted present benefit was 413,707 BDT (5,334 US\$) if the discount rate was 0.15 and 120,440 BDT (1,553 US\$) if the discount rate was 0.2. Hence, the expected benefit of this DVD program, which increased the probability of public university admission by 16 percentage points, was quite large, which was far higher than its implementation costs.

Table 4: Impact of the DVD program

	(1)	(2)	(3)	(4)	(5)	(6)
	Pass any public univ.	Pass 1st tier pub- lic univ.	Pass National univ.	# exams	Pass any public univ.	Pass 1st tier pub- lic univ.
DVD	0.161** (0.070)	0.134** (0.056)	0.280*** (0.013)	0.248 (0.166)	0.153** (0.072)	0.131** (0.057)
Female	-0.040 (0.044)	-0.055*** (0.007)	0.054 (0.093)	-0.876*** (0.230)	-0.007 (0.054)	-0.045*** (0.006)
# of exams taken					0.031*** (0.011)	0.010 (0.007)
Other controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	160	160	160	160	160	160
Mean_Control	0.026	0.013	0.671	2.592	0.026	0.013

The estimated average marginal effects of the probit models are reported except for column (4), with the dependent variable being an indicator variable for passing the entrance exams for any public universities or first-tier public universities. Column (4) reports the result of the negative binomial model is reported, where the dependent variable is the number of exams taken. The control variables included student's gender, SES score, SSC exam GPA, standardized IQ score, present biasness, grit, conscientiousness, and the branch dummies. The clustered standard errors are given in parentheses. Asterisks indicate statistical significance: * $p < .10$, ** $p < .05$, *** $p < .01$.

In Table 5, we investigated the heterogeneous impact of the DVD program with respect to gender, cognitive ability, and economic conditions.³⁰ Under homogenous treatment specification, female students had a lower probability of passing the entrance exams of first-tier public universities (Table 4). We investigated whether the DVD program could narrow this gender gap by including the interaction term $DVD \times Female$ in columns (1) and (2) of Table 5. We found no evidence of impact heterogeneity for female students for any public university entrance exams (column (1)). However, for first-tier public universities, we found a strong impact heterogeneity: the DVD program substantially increased the success rate for female students. The linear combination of $Female$ and $DVD \times Female$ was 0.356, which is significant at the 1% level, indicating that female students with the DVD program performed better than male students in the first-tier public university entrance exam. During our focus group discussion with female students, they noted that their parents would allow them to leave the district for higher studies only if they were admitted to first-tier universities. This

³⁰Due to the small sample size and low rate of passing the public university entrance exams, identifying the impact heterogeneity depended on a small number of observations, and hence the following results should be interpreted with caution.

might have provided additional motivation to the female students treated by our program. However, we should be cautious in making this interpretation because this estimation result depended on the very small number of female students who passed the first-tier public university entrance exams.³¹

Table 5: Effectiveness of the DVD program: cognitive ability and SES score

	(1)	(2)	(3)	(4)	(5)	(6)
	Pass any public univ.	Pass 1st tier pub- lic univ.	Pass any public univ.	Pass 1st tier pub- lic univ.	Pass any public univ.	Pass 1st tier pub- lic univ.
DVD	0.203** (0.103)	0.113* (0.059)	0.162** (0.072)	0.136** (0.056)	0.190** (0.082)	0.134** (0.054)
SES score	0.011 (0.039)	-0.002 (0.011)	0.007 (0.035)	-0.000 (0.012)	0.079 (0.069)	-0.000 (0.020)
Female	0.047 (0.138)	-0.231*** (0.007)	-0.038 (0.040)	-0.057*** (0.008)	-0.040 (0.036)	-0.055*** (0.006)
IQ score	-0.011 (0.021)	-0.002 (0.008)	-0.062 (0.050)	0.010 (0.008)	-0.006 (0.019)	-0.004 (0.008)
DVD× Female	-0.105 (0.093)	0.588*** (0.048)				
DVD× IQ score			0.078 (0.060)	-0.017 (0.014)		
DVD× SES score					-0.091* (0.053)	0.001 (0.011)
Other controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	160	160	160	160	160	160
Mean_Control	0.026	0.013	0.026	0.013	0.026	0.013

The estimated average marginal effects of the probit models are reported. The dependent variable is an indicator variable for passing the entrance exams for any public universities or first-tier public universities. The control variables included student’s gender, SES score, SSC exam GPA, standardized IQ score, present biasness, grit, conscientiousness, and the branch dummies. Clustered standard errors are given in parentheses. Asterisks indicate statistical significance: * $p < .10$, ** $p < .05$, *** $p < .01$.

Columns (3)-(6) investigate whether or not the DVD program could also work for low-performing and poor students by examining the impact heterogeneity based on IQ and SES scores. We standardized these variables, and hence the coefficient on the DVD program was similar to that reported in Table 4. Columns (3) and (4) demonstrate that the effect of the DVD program did not depend on the students’ cognitive ability, as measured by their IQ

³¹Three female students in the treatment group passed the entrance exams for the first-tier public universities, compared to only one in the control group. The possibility that the DVD program could reduce the gender gap should be examined in future research with a much larger sample size.

scores. Even if we used the interaction term with the SSC exam GPA instead of the IQ score, the results remained the same qualitatively.³² These results imply the wide applicability of the program. For the SES score, we found weak evidence that the impact of the DVD program was less for students from better-off families, as the interaction term was significant at 10% in column (5). This was probably due to the fact that well-off families in the control group could afford to send their children to coaching centers to increase their probability of passing the exams. For the first-tier universities, we did not find a difference in the impact between poor and well-off students, as reported in column (6), probably because the quality of local coaching centers was inadequate to meet the needs of entrance exams for first-tier public universities.

Next, we investigated whether or not the effectiveness of the DVD program depended on non-cognitive abilities, such as present bias, grit, and self-discipline. The results are reported in Table 6. Columns (1) and (2) examine the effects of present bias. As expected, students with present bias were less likely to pass the public university entrance exams. However, they also benefited more from our DVD program and the overall program impact on the students without present bias became insignificant. As our program incorporated a strict scheduling that required students to attend classes regularly, our findings indicate the importance of scheduling and commitment in improving students' academic success. We found a similar effect for the first-tier public universities entrance exam, demonstrating the consistency of our finding.

In columns (3) and (4), we instead used the grit measure. While students with more grit were more likely to pass the entrance exams in general, the impact of the DVD program was less for these students. This finding suggests that students with more grit could study hard without the scheduling and commitment imposed by the program, which is consistent with the discussion of present bias given earlier. Columns (5) and (6), wherein we instead used the conscientiousness measure, show a similar pattern: students who were less self-disciplined and less hard-working benefited more from the DVD program, suggesting the importance of providing commitment devices for students with hyperbolic discounting preferences and low levels of grit and self-controllability.

³²The results are available upon request from the corresponding author.

Table 6: Effectiveness of the DVD program and non-cognitive ability

	(1)	(2)	(3)	(4)	(5)	(6)
	Pass any public univ.	Pass 1st tier pub- lic univ.	Pass any public univ.	Pass 1st tier pub- lic univ.	Pass any public univ.	Pass 1st tier pub- lic univ.
DVD	0.091 (0.076)	0.070 (0.059)	0.167*** (0.062)	0.135*** (0.052)	0.187*** (0.055)	0.146*** (0.045)
Present bias	-0.136*** (0.020)	-0.110*** (0.024)	0.132*** (0.032)	0.162*** (0.046)	0.142*** (0.041)	0.166*** (0.046)
Grit	-0.032*** (0.012)	-0.020** (0.009)	0.035* (0.020)	0.009 (0.010)	-0.033*** (0.011)	-0.020** (0.009)
Conscientiousness	0.065*** (0.015)	0.037** (0.015)	0.076*** (0.023)	0.040** (0.020)	0.135*** (0.043)	0.078*** (0.029)
DVD× Present bias	0.781*** (0.027)	0.799*** (0.020)				
DVD× grit			-0.090*** (0.031)	-0.036* (0.021)		
DVD× Conscientious					-0.084** (0.037)	-0.049** (0.020)
Other controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	160	160	160	160	160	160
Mean_Control	0.026	0.013	0.026	0.013	0.026	0.013

The estimated average marginal effects of the probit models are reported. The dependent variable is an indicator variable for passing the entrance exams for any public universities or first-tier public universities. The control variables included student's gender, SES score, SSC exam GPA, standardized IQ score, present biasness, grit, conscientiousness, and the branch dummies. Clustered standard errors are in parentheses. Asterisks indicate statistical significance: * $p < .10$, ** $p < .05$, *** $p < .01$.

4.2 Experiment II: Demand for DVD Learning

Next, we investigated the price sensitivity of the DVD program. We randomized the 25%, 50%, and 75% price tuition discount offers and the availability of payment in monthly installments at the student level. We set the 25% discount group as the base category for the price discount. We referred to the 50% and 75% discount offers as the 2/3 price treatment ($P = 2/3$) and 1/3 price treatment ($P = 1/3$), respectively. Letting MI_i be an indicator for the monthly installment payment treatment, we estimated the following probit model with robust standard errors,³³

$$\Pr(y_i = 1|\mathbf{X}_i) = \Phi[\alpha + \beta_{p2}I\{P_i = 2/3\} + \beta_{p1}I\{P_i = 1/3\} + \beta_I MI_i + \mathbf{X}_i^c \boldsymbol{\delta}], \quad (1)$$

and also including the interaction terms to accommodate treatment heterogeneities from payment methods,

$$\begin{aligned} \Pr(y_i = 1|\mathbf{X}_i) = & \Phi [\alpha + \beta_{p2}I\{P_i = 2/3\} + \beta_{p1}I\{P_i = 1/3\} + \beta_I MI_i \\ & + \beta_{p2,I}(I\{P_i = 2/3\} \times MI_i) + \beta_{p1,I}(I\{P_i = 1/3\} \times MI_i) + \mathbf{X}_i^c \boldsymbol{\delta}], \quad (2) \end{aligned}$$

where y_i is an indicator of taking up the DVD program, Φ is the cumulative standard normal distribution function, $I\{\cdot\}$ is the indicator function, the covariates \mathbf{X}_i^c include SES score, student's gender, SSC exam GPA, and an indicator of the subject division being commerce, and we let $\mathbf{X}_i = (P_i, MI_i, \mathbf{X}_i^c)$. We report the average marginal effects of the treatment variables in Table 7.

As equation (2) includes several interaction terms of the treatment variables, we should be aware of what is captured by the linear combination of the estimated coefficients. For example, the difference in uptake rate between $P = 2/3$ and $P = 1$ under the monthly installment option was

$$\begin{aligned} & \Pr(y_i = 1|P_i = 2/3, MI_i = 1, \mathbf{X}_i^c) - \Pr(y_i = 1|P_i = 1, MI_i = 1, \mathbf{X}_i^c) \\ & = \Phi [\alpha + \beta_{p2} + \beta_I + \beta_{p2,I} + \mathbf{X}_i^c \boldsymbol{\delta}] - \Phi [\alpha + \beta_I + \mathbf{X}_i^c \boldsymbol{\delta}] \equiv \Delta\Phi_{\beta_{p2} + \beta_{p2,I}}, \end{aligned}$$

³³We did not cluster the standard errors at the branch level because we did not know which branch a student who did not take up the offer would have enrolled in if they had taken up the offer.

where $\Delta\Phi_{\beta_{p2}+\beta_{p2,I}}$ indicates that $\Phi[\alpha + \beta_{p2} + \beta_I + \beta_{p2,I} + \mathbf{X}_i^c\boldsymbol{\delta}]$ and $\Phi[\alpha + \beta_I + \mathbf{X}_i^c\boldsymbol{\delta}]$ differ by $\beta_{p2} + \beta_{p2,I}$ in their arguments. Hence, $\beta_{p2} + \beta_{p2,I}$ captures the impact of the 2/3 price discount under the monthly installment option. The lower panel of Table 7 reports a p -value of the null hypothesis testing $\beta_{p2} + \beta_{p2,I} = 0$. Similarly,

$$\begin{aligned} \Pr(y_i = 1|P_i = 1/3, MI_i = 1, \mathbf{X}_i^c) - \Pr(y_i = 1|P_i = 1, MI_i = 1, \mathbf{X}_i^c) &= \Delta\Phi_{\beta_{p1}+\beta_{p1,I}}, \\ \Pr(y_i = 1|P_i = 2/3, MI_i = 1, \mathbf{X}_i^c) - \Pr(y_i = 1|P_i = 2/3, MI_i = 0, \mathbf{X}_i^c) &= \Delta\Phi_{\beta_I+\beta_{p2,I}}, \\ \Pr(y_i = 1|P_i = 1/3, MI_i = 1, \mathbf{X}_i^c) - \Pr(y_i = 1|P_i = 1/3, MI_i = 0, \mathbf{X}_i^c) &= \Delta\Phi_{\beta_I+\beta_{p1,I}}, \\ \Pr(y_i = 1|P_i = 2/3, MI_i = 1, \mathbf{X}_i^c) - \Pr(y_i = 1|P_i = 1, MI_i = 1, \mathbf{X}_i^c) &= \Delta\Phi_{\beta_{p2}+\beta_I+\beta_{p2,I}}, \\ \Pr(y_i = 1|P_i = 1/3, MI_i = 1, \mathbf{X}_i^c) - \Pr(y_i = 1|P_i = 1, MI_i = 1, \mathbf{X}_i^c) &= \Delta\Phi_{\beta_{p1}+\beta_I+\beta_{p1,I}}. \end{aligned}$$

In sum, $\beta_{p2}+\beta_{p2,I}$ and $\beta_{p1}+\beta_{p1,I}$ capture the price sensitivity in the monthly installment treatment, while $\beta_I + \beta_{p2,I}$ and $\beta_I + \beta_{p1,I}$ capture the impact of allowing the monthly installment payment when the price was 2/3 and 1/3, respectively. $\beta_{p2} + \beta_I + \beta_{p2,I}$ and $\beta_{p1} + \beta_I + \beta_{p1,I}$ reflect the combined effect of the price discount and monthly installment payment option. Also note that the test for $\beta_{p2} = \beta_{p1}$ investigated the difference in uptake rate between $P = 1/3$ and $P = 2/3$ in the upfront payment treatment, while the test for $\beta_{p2} + \beta_{p2,I} = \beta_{p1} + \beta_{p1,I}$ examined the analogous difference in the installment payment treatment.

Column (1) of Table 7 demonstrates the estimation result of the base specification (1). The result indicates that the uptake decision was price sensitive. While the 2/3 price offer did not affect the uptake rate significantly, the 1/3 price offer increased the uptake rate by 16.2 percentage points, which is significant at the 5% level. The difference between the 2/3 price offer and 1/3 price offer was not significant. We obtained more nuanced results when we estimated the model with the interaction terms, (2), as shown in column (2). It emerges that students were price-sensitive only in the monthly installment treatment. While neither β_{p2} nor β_{p1} were significant, $\beta_{p2} + \beta_{p2,I}$ and $\beta_{p1} + \beta_{p1,I}$ were positive and statistically significant at the 5% and 1% levels, respectively. However, this price sensitivity result seems to have been driven by the substantially low uptake rate in the group of the installment payment with $P = 1$, which was reflected in the negative value of β_I . There is no rational reason why the option to pay in monthly installments should have reduced the uptake rate. Further, the estimates of $\beta_I + \beta_{p2,I}$ and $\beta_I + \beta_{p1,I}$ indicate no significant impact of this option

when $P = 2/3$ and $P = 1/3$. The estimates of $\beta_{p2} + \beta_I + \beta_{p2,I}$ and $\beta_{p1} + \beta_I + \beta_{p1,I}$ are also insignificant, indicating that the uptake rate in the group of $P = 2/3$ or $P = 1/3$ with the monthly installment payment option was not statistically different from the reference group of $P = 1$ with upfront payment. Hence, it is likely that, for some reason, the uptake rate in the installment payment group with $P = 1$ happened to be low. We avoid concluding whether or not the uptake decision was price sensitive, and rather focus more on the difference in price sensitivity between poor students and better-off students.³⁴

If poor students are more price sensitive, then requiring cost sharing could exclude poor students from the service, contradicting the original purpose of providing access to higher education for rural poor students. In columns (3) and (4) of Table 7, we estimated the uptake pattern separately for students whose SES scores is below and above the median, respectively. The results indicated that the price responsiveness was similar between these two groups. The differences in the estimated coefficients never became significant.³⁵ This price insensitivity seems reasonable given the substantially large returns to university education and the widespread presence of microfinance institutions in Bangladesh, which provide education loans for the poor.³⁶ The results in columns (5) and (6), where we split the sample into the upfront payment group and installment payment group and included the interaction terms of the discount variables and SES score, confirmed that the price responsiveness did not vary depending on SES score. These results imply that requiring cost sharing would not disproportionately exclude poor students, although we should remember that our sample size

³⁴Even when we split the sample by SES score or gender, we observed a similar pattern, as reported in columns (3) and (4) in Table 7 and columns (1) and (2) in Appendix Table 3, implying that the low uptake rate of this group with installment payment and $P = 1$ was not caused by a specific group. As the SSC exam GPA was not well balanced between the upfront and installment payment groups, we also estimated the model with the squared and cubic terms of the SSC exam GPA to allow for a more flexible form of dependence of the uptake decision on the SSC exam GPA, but the results were quite similar, as reported in Columns (3) and (4) in Appendix Table 3. We also split the sample into low and high SSC exam GPA groups since the imbalance in the SSC exam GPA could affect the price elasticity estimation if the price elasticity was correlated with the SSC exam GPA level. Note that we did not include the interaction terms of the price and installment option since our interest here was to examine whether or not the imbalance in the SSC exam GPA between the upfront and installment payment groups caused the bias in the estimated price elasticity. It emerged that students with low SSC exam GPA were more price sensitive, as reported in Columns (5) and (6) in Appendix Table 3. However, this would not explain the greater estimated price sensitivity in the installment payment group because it was the high (not low) SSC exam GPA students who were more likely to be in the installment payment group.

³⁵ t statistics are easily calculated from the table as the standard error of the difference in coefficients from the different sample, say β^1 and β^2 , is calculated as $SE(\hat{\beta}^1 - \hat{\beta}^2) = \sqrt{[SE(\hat{\beta}^1)]^2 + [SE(\hat{\beta}^2)]^2}$.

³⁶For example, Grameen Bank provides education loans that impose no interest during studies, only 5% interest that is charged after completion of studies, and collects the repayment in small installments after completion of studies. For returns to university education, see Web Appendix and footnote 29.

Table 7: Uptake decision

	(1)	(2)	(3)	(4)	(5)	(6)
	All	All	Low SES	High SES	Up-front payment	Installment
β_{p2} : 2/3 price	0.087 (0.076)	-0.082 (0.093)	-0.041 (0.111)	-0.137 (0.150)	-0.063 (0.102)	0.282** (0.111)
β_{p1} : 1/3 price	0.162** (0.069)	0.017 (0.084)	0.022 (0.093)	0.026 (0.144)	0.018 (0.089)	0.318*** (0.100)
β_I : Installment	0.028 (0.054)	-0.183* (0.094)	-0.193 (0.126)	-0.189 (0.149)		
$\beta_{p2,I}$: 2/3 price × Installment		0.239*** (0.063)	0.236*** (0.072)	0.258*** (0.098)		
$\beta_{p1,I}$: 1/3 price × Installment		0.228*** (0.075)	0.227*** (0.080)	0.217 (0.145)		
2/3 price × SES score					-0.074 (0.080)	-0.109 (0.091)
1/3 price × SES score					0.040 (0.078)	0.017 (0.078)
Other controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	244	244	133	111	137	107
Mean_Control	0.771	0.771	0.783	0.750	0.783	0.750
$\beta_{p2} = \beta_{p1}$	0.218	0.224	0.540	0.199	0.356	0.673
$\beta_{p2} + \beta_{p2,I} = 0$		0.033	0.031	0.316		
$\beta_{p1} + \beta_{p1,I} = 0$		0.000	0.003	0.017		
$\beta_I + \beta_{p2,I} = 0$		0.438	0.641	0.550		
$\beta_I + \beta_{p1,I} = 0$		0.503	0.704	0.786		
$\beta_{p2} + \beta_I + \beta_{p2,I} = 0$		0.829	0.991	0.749		
$\beta_{p1} + \beta_I + \beta_{p1,I} = 0$		0.575	0.681	0.746		
$\beta_{p2} + \beta_{p2,I}$ = $\beta_{p1} +$ $\beta_{p1,I}$		0.206	0.520	0.304		
All β are zero	0.054	0.000	0.001	0.038	0.649	0.006

The dependent variable was an indicator for taking up the DVD program. The control variables included SES score, student's gender, SSC exam GPA, and an indicator of the subject division being commerce. The estimated average marginal effects of the probit models are reported. Robust standard errors are reported in parentheses and asterisks indicate statistical significance: * $p < .10$, ** $p < .05$, *** $p < .01$. The test for $\beta_{p2} = \beta_{p1}$ investigated the difference in uptake rate between the 1/3 price offer and 2/3 price offer, and the corresponding p values were reported. $\beta_{p2} + \beta_{p2,I}$ and $\beta_{p1} + \beta_{p1,I}$ captured the impact of the 2/3 price and 1/3 price offer on the uptake rate in the monthly installment treatment. $\beta_I + \beta_{p2,I}$ and $\beta_I + \beta_{p1,I}$ captured the impact of allowing installment payments when the price was 2/3 and 1/3, respectively. $\beta_{p2} + \beta_I + \beta_{p2,I}$ and $\beta_{p1} + \beta_I + \beta_{p1,I}$ reflected the combined effect of the price discount and installment payment option. The test for $\beta_{p2} + \beta_{p2,I} = \beta_{p1} + \beta_{p1,I}$ examined the difference between the 1/3 price offer and 2/3 price offer in the installment payment treatment. The low SES sample (column (3)) comprised students with SES scores below or equal to the median, while the high SES sample (column (4)) comprised students with SES scores above the median.

was relatively small.

Finally, we investigated whether a lower price attracted more students who were less serious and less likely to pass the exam, and reduced the incentive to study hard owing to smaller sunk costs. Due to the small sample size, we were unable to implement an additional experiment to distinguish the selection effect and incentive effect as in Ashraf et al. (2010). Instead, in Table 8, we investigated the total effect of the selection and incentive effect by examining whether students who took up our program at a higher price recorded a higher attendance rate in the scheduled DVD classes and higher test scores in the two mock exams that were held one and two months after the course initiation.³⁷

Columns (1) and (2) in Table 8 examine the total effect of selection on attendance. We found some evidence that the lower price actually resulted in a lower attendance rate. The coefficient on the $P = 1/3$ treatment was significant at a 5% level and 10% level. The linear combination of β_{p1} and $\beta_{p1,I}$, which captured the difference between $P = 1$ and $P = 1/3$ under monthly installment payment, was not significant ($p = .134$), but $\beta_{p1} + \beta_I + \beta_{p1,I}$, which captured the difference between $P = 1$ with upfront payment and $P = 1/3$ with monthly installment payment, was significant at a 10% level. We also rejected the null hypothesis that the attendance rate was the same between the $P = 2/3$ and $P = 1/3$ treatments at the 5% level in column (1) and 10% level in column (2). For students who attended the DVD program, we additionally collected information on IQ score, grit, the psychological Big Five, and the average study hours at home to prepare for the HSC exam. In columns (3) and (4), we include these variables as well as SES score, SSC exam GPA, and female dummy as regressors to control for these observable characteristics of the students. If the results change substantially from those in columns (1) and (2), and the coefficients decrease, then these characteristics explain the difference in attendance rate, indicating the importance of selection effect. It emerges that the estimated coefficients were similar to those in columns (1) and (2), implying the absence of the selection effect and the existence of the sunk cost effect, which is consistent with Ketel et al. (2016). For the average of the standardized score of the two mock exams, reported in columns (5) to (8), we did not find evidence that the price discount affected exam scores. Note that five students did not take any mock exams,

³⁷The power analysis demonstrated that the effect sizes for the attendance rate were 7.6, 6.9, and 6.4 percentage point changes for the comparison between the 25% and 50% discount groups, between the 25% and 75% discount groups, and between the 50% and 75% discount groups, respectively. For the average mock test scores, the analogous effect sizes were 0.59, 0.54, and 0.50 standard deviation changes.

Table 8: Selection and university admission

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	% attend	% attend	% attend	% attend	Monthly test score	Monthly test score	Monthly test score	Monthly test score
β_{p2} : 2/3 price	-0.001 (0.021)	-0.005 (0.028)	0.002 (0.023)	0.003 (0.033)	0.053 (0.173)	-0.014 (0.237)	0.059 (0.177)	-0.056 (0.235)
β_{p1} : 1/3 price	-0.052** (0.023)	-0.051* (0.031)	-0.049** (0.024)	-0.040 (0.032)	-0.042 (0.160)	-0.015 (0.207)	-0.037 (0.162)	-0.019 (0.211)
β_I : Installment	-0.003 (0.019)	-0.005 (0.033)	-0.010 (0.019)	0.001 (0.038)	-0.087 (0.122)	-0.106 (0.277)	-0.143 (0.125)	-0.210 (0.277)
$\beta_{p2,I}$: 2/3 price × Installment		0.010 (0.042)		-0.003 (0.048)		0.143 (0.351)		0.257 (0.348)
$\beta_{p1,I}$: 1/3 price × Installment		-0.002 (0.047)		-0.020 (0.049)		-0.058 (0.328)		-0.030 (0.328)
Control	No	No	Yes	Yes	No	No	Yes	Yes
Observations	180	180	180	180	175	175	175	175
Mean_Control	0.825	0.825	0.825	0.825	0.043	0.043	0.043	0.043
$\beta_{p2} = \beta_{p1}$	0.015	0.100	0.017	0.130	0.497	0.998	0.509	0.853
$\beta_{p2} + \beta_{p2,I} = 0$		0.891		0.989		0.619		0.451
$\beta_{p1} + \beta_{p1,I} = 0$		0.134		0.101		0.776		0.847
$\beta_I + \beta_{p2,I} = 0$		0.843		0.916		0.861		0.831
$\beta_I + \beta_{p1,I} = 0$		0.842		0.530		0.354		0.187
$\beta_{p2} + \beta_I + \beta_{p2,I} = 0$		0.996		0.999		0.915		0.965
$\beta_{p1} + \beta_I + \beta_{p1,I} = 0$		0.086		0.091		0.405		0.248
$\beta_{p2} + \beta_{p2,I}$ = $\beta_{p1} + \beta_{p1,I}$		0.073		0.057		0.289		0.228
All β are zero	0.028	0.211	0.035	0.230	0.793	0.907	0.804	0.749

The dependent variable was the attendance rate in the DVD classes in columns (1) to (4), and the average of the standardized scores of the two mock exams in columns (5) to (8). The control variables included SES score, student's gender, SSC exam GPA, commerce subject division dummy, IQ score, grit, psychological Big Five, and the average study hours at home for HSC exam preparation. The OLS estimation results are reported, where clustered standard errors are in parentheses and asterisks indicate statistical significance: * $p < .10$, ** $p < .05$, *** $p < .01$. The test for $\beta_{p2} = \beta_{p1}$ was used to investigate the difference between the 1/3 price offer and 2/3 price offer, and the corresponding p values are reported. $\beta_{p2} + \beta_{p2,I}$ and $\beta_{p1} + \beta_{p1,I}$ captures the difference between the 2/3 price and 1/3 price offer in the monthly installment treatment. $\beta_I + \beta_{p2,I}$ and $\beta_I + \beta_{p1,I}$ captures the impact of allowing the installment payment when the price was 2/3 and 1/3, respectively. $\beta_{p2} + \beta_I + \beta_{p2,I}$ and $\beta_{p1} + \beta_I + \beta_{p1,I}$ reflect the combined effect of the price discount and installment payment option. The test for $\beta_{p2} + \beta_{p2,I} = \beta_{p1} + \beta_{p1,I}$ examined the difference between the 1/3 price offer and 2/3 price offer in the installment payment treatment.

and four were in the $P = 1/3$ group (another in the $P = 1$ group). The attendance rates of these four students were among the lowest four, which would explain our finding of some evidence for selection in terms of the attendance rate but lack of evidence in terms of the mock exam score. It also implies that although the lower price might have reduced the incentive to study, this effect was concentrated on a small number of students and will not affect the incentive for most students.

5 Concluding Remarks

We investigated the impact and uptake pattern of a promising education intervention for students applying for university in Bangladesh. Our DVD program may be feasible and expandable, and had a large positive effect on the probability of students passing university entrance exams. More importantly, the results indicate that students suffering from present-bias and lack of self-discipline and grit benefited more from the intervention, highlighting the importance of the scheduling and commitment imposed as part of the program. The price sensitivity of the uptake decision was not found to depend on the socio-economic conditions of the students; hence, cost sharing would not disproportionately exclude poor students from participating in this program. We also found some evidence that the lower price may reduce students' attendance rate, possibly due to the sunk cost effects. This evidence implies that imposing cost sharing might be desirable, although more empirical evidence is required with larger sample sizes.

The DVD-based distance-learning program could contribute to solving the problem of the disparity between rural and urban education. This program helps students to acquire skills, leading to better income opportunities and effective poverty reduction. It may be suitable to implement in many countries, as it only requires that the best teachers are identified to give lectures, with suitable commitment and scheduling devices. While poor infrastructure, such as the lack of electrification and limited access to computer facilities, remains a major obstacle to the widespread adoption of such interventions in poor countries, the combined efforts of governments and aid agencies could prioritize these problems, which may help to achieve better human resources in disadvantaged areas which may lead to future economic growth.

One concern with our current DVD program is its high cost. Because this program

provides a tutoring service and strict monitoring of the students' attendance, the running cost was high. We evaluate, therefore, that the DVD program is still at the prototype stage, and the impact would differ if the project was implemented with a different program design (Bold et al., 2013). For scalability, the DVD program should be provided without additional human resources, which would present two main concerns: lack of direct interaction with lecturers and lack of commitment to attend lectures on schedule. A full-scale DVD program should address these two problems by, for example, incorporating FAQs into the lectures and the implementation of a punishment mechanism if students procrastinate in watching the DVDs. Detailed design of such a project implementation is left for future research.

Another concern is a version of the general equilibrium effect. Since the capacity of the universities is limited, the increased success probability of the treated students will result in the decline of the success probability of other students elsewhere. If the replaced students were from villages with a similar background, then the DVD program, which aims at improving access to tertiary education in rural areas, would only serve to benefit the treated students at the cost of other students in other rural areas. Hence, we should also consider fundamental policy issues such as expansion of the supply-side capacity of universities in accordance with the improvement of learning conditions in rural areas. Otherwise, any intervention that helps students to pass the university entrance exams will only serve to bolster the rat race.

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A Appendix Tables

Appendix Table 1: Number of applicants and seats in major public and national universities in 2014

Name of the University	Number of Applicants	Number of Seats	Applicant-seat Ratio
Dhaka University (DU)	244,937	6,540	37
Chittagong University (CU)	146,295	3,985	37
Rajshahi University (RU)	168,224	3,310	51
Jagannath University (JAU)	186,764	2,760	68
Jahangirnagar University (JU)	219,151	2,110	104
Islamic University (IU)	74,529	1,465	51
SUST †	49,442	1,400	35
Begum Rokeya University (BRU)	71,079	1,260	56
BUET ‡	9,111	1,000	9
Bangladesh Agricultural University (BAU)	9,575	1,000	10
Khulna University (KU)	39,793	979	41
Comilla University (COU)	36,341	700	52
National University (NU)	413,454	172,582	2

Note: Kono, Sawada, and Shonchoy (2016).

† *SUST stands for Shahjalal University of Science and Technology.*

‡ *BUET stands for Bangladesh University of Engineering and Technology.*

Appendix Table 2: Characteristics of Students in Targeted HSC Institutes

Grade 12 students					
	count	mean	sd	min	max
SSC GPA	2157	4.11	0.57	3.00	5.00
SES score	2157	-0.03	0.68	-1.20	1.45
Female	2157	0.52	0.50	0.00	1.00
Commerce	2157	0.53	0.50	0.00	1.00

Grade 12 students with intention to study at universities

	count	mean	sd	min	max
SSC GPA	1710	4.14	0.57	3.00	5.00
SES score	1710	-0.01	0.69	-1.20	1.45
Female	1710	0.51	0.50	0.00	1.00
Commerce	1710	0.53	0.50	0.00	1.00

Appendix Table 3: SSC Exam GPA and Uptake Decision

	(1)	(2)	(3)	(4)	(5)	(6)
	Male	Female	Add (SSC GPA) ² (SSC GPA) ³	Add (SSC GPA) ² (SSC GPA) ³	Low GPA	High GPA
β_{p2} : 2/3 price	0.015 (0.128)	-0.188 (0.141)	0.082 (0.076)	-0.092 (0.091)	0.171* (0.103)	0.009 (0.111)
β_{p1} : 1/3 price	0.069 (0.115)	-0.036 (0.122)	0.158** (0.070)	0.008 (0.084)	0.231** (0.098)	0.096 (0.094)
β_I : Installment	-0.198* (0.120)	-0.141 (0.148)	0.035 (0.055)	-0.184* (0.095)	0.051 (0.083)	0.029 (0.074)
$\beta_{p2,I}$: 2/3 price × Installment	0.143 (0.110)	0.335*** (0.070)		0.243*** (0.062)		
$\beta_{p1,I}$: 1/3 price × Installment	0.194** (0.098)	0.244* (0.129)		0.231*** (0.075)		
Other controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	140	104	244	244	124	120
Mean_Control	0.789	0.750	0.750	0.750	0.650	0.933
$\beta_{p2} = \beta_{p1}$	0.599	0.250	0.220	0.227	0.487	0.332
$\beta_{p2} + \beta_{p2,I} = 0$	0.096	0.221		0.037		
$\beta_{p1} + \beta_{p1,I} = 0$	0.002	0.052		0.000		
$\beta_I + \beta_{p2,I} = 0$	0.571	0.112		0.415		
$\beta_I + \beta_{p1,I} = 0$	0.963	0.320		0.484		
$\beta_{p2} + \beta_I + \beta_{p2,I} = 0$	0.788	0.979		0.787		
$\beta_{p1} + \beta_I + \beta_{p1,I} = 0$	0.656	0.671		0.618		
$\beta_{p2} + \beta_{p2,I}$ = $\beta_{p1} + \beta_{p1,I}$	0.240	0.621		0.207		

The dependent variable is an indicator of taking up the DVD program. The control variables include SES score, student's gender, SSC exam GPA, and an indicator of the subject division being commerce. The estimated average marginal effects of the probit models are reported. Robust standard errors are reported in parentheses, and asterisks indicate statistical significance: * $p < .10$, ** $p < .05$, *** $p < .01$. The test for $\beta_{p2} = \beta_{p1}$ investigates the difference in uptake rate between the 1/3 price offer and 2/3 price offer, and the corresponding p values are reported. $\beta_{p2} + \beta_{p2,I}$ and $\beta_{p1} + \beta_{p1,I}$ capture the impact of the 2/3 price and 1/3 price offers on uptake rate in the monthly installment treatment. $\beta_I + \beta_{p2,I}$ and $\beta_I + \beta_{p1,I}$ capture the impact of allowing the installment payment when the price was 2/3 and 1/3, respectively. $\beta_{p2} + \beta_I + \beta_{p2,I}$ and $\beta_{p1} + \beta_I + \beta_{p1,I}$ reflect the combined effect of the price discount and installment payment option. The test for $\beta_{p2} + \beta_{p2,I} = \beta_{p1} + \beta_{p1,I}$ examines the difference between the 1/3 price offer and 2/3 price offer in the installment payment treatment. Columns (3) and (4) reports the results when we add the square and cubic terms of the SSC exam GPA. The low SSC GPA sample (column (5)) comprises those students with SSC exam GPAs lower than or equal to the median, and the high SSC GPA sample (column (6)) comprises students with SSC exam GPA scores of above the median.

B Web Appendix. Cost Benefit Analysis of University Education

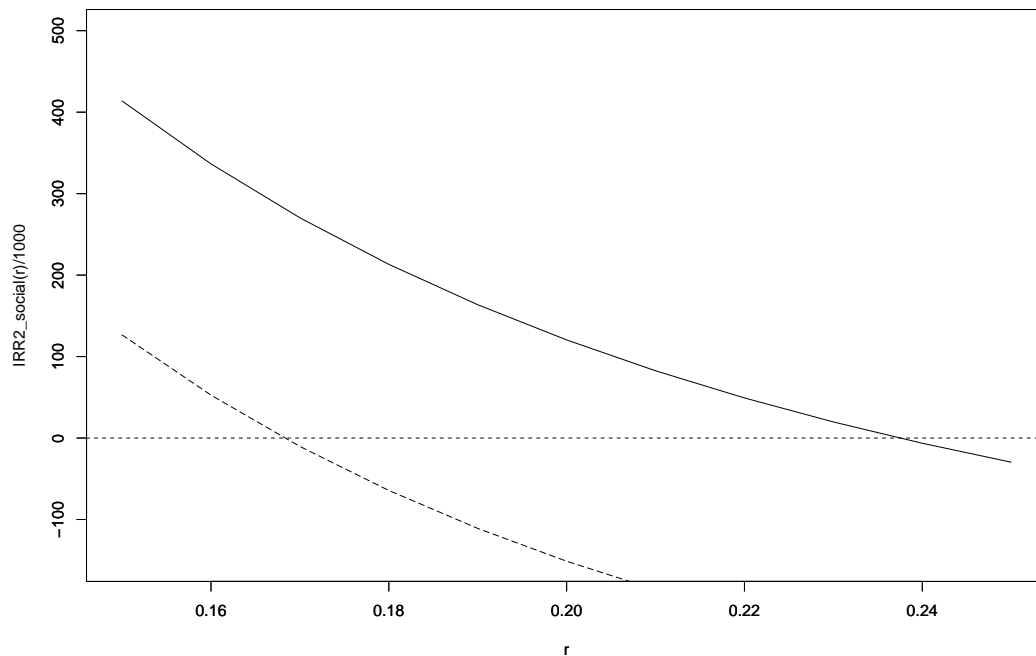
In this Appendix, we provide a rough calculation of the internal rate of return of university education and a cost benefit analysis. For this purpose, we need information on the cost of university education and the career-long wage profiles of university graduates and HSC graduates for a given individual. Because it is rare to have such career-long wage profiles, most existing studies on the internal rate of education return use the wage profile of private firms (Psacharopoulos and Patrinos, 2004). In Bangladesh, the wage profile in private firms is not publicly available, and we instead use the wage profile of civil servants, to which many HSC holders and university graduates apply. The starting monthly salary for university graduates was 22,000 BDT (284 US\$), while that of HSC holders was 10,200 BDT (132 US\$) in 2015. University graduates are typically employed as the cadre candidates with qualification rank 8, and will be promoted at least up to qualification rank 3, at which the monthly salary was 56,500 BDT (728 US\$). HSC holders will not become cadres, and will not be promoted to qualification rank 8 or above. Hence, typically, the wage increase rate is lower for HSC holders, but to make our estimates conservative, we assumed the rate (not amount) of wage increase was the same between university graduates and HSC holders. We also assumed that individuals begin working right after graduation, and work until age 60. The salary increases every year by the same amount, and the salary will reach its maximum level right before the retirement age.

For the cost of university education, we used the education cost at Dhaka University written in the University Grant Commission Report 2014. The per capita annual expenditure of Dhaka University students was 97,441 BDT (1,256 US\$). The average student only paid approximately 10,000 BDT (129 US\$), while the remainder of the cost was financed by government subsidies. We set the annual private cost for university education at 10,000 BDT and the annual social cost at 97,441 BDT.

With these assumptions, the private internal rate of return (IRR) for university education was 23.7 percent, and the social IRR was 16.8. The net benefit of university education crucially depends on the discount rate, as depicted in Figure 1. It amounts to 413,707 BDT (5,334 US\$) if the discount rate is 0.15, and 120,440 BDT (1,553 US\$) if the discount rate

is 0.2.³⁸

Appendix Figure 1: Net Discounted Current Value of University Education



Note: The solid line indicates the private net discounted current value of university education. The dotted line indicates the social net discounted current value, where the social cost includes the private cost and government subsidy.

³⁸The R code for calculating the IRR and net present discount benefit is available upon request.