Essays on Equality of Opportunity and the Access to Higher Education

by

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ABSTRACT

This dissertation examines the question of how to improve the access to higher education for students from disadvantaged socioeconomic backgrounds, in order to promote equality of opportunity. In order to do so, experimental evaluation methodology is used to address relevant research questions and draw actionable policy lessons in the context of the Chilean higher education system.

The first chapter of this dissertation studies the impact of college peers on academic performance with the help of a natural experiment in Chile, which allows for exogenous classroom composition. In particular, first year students at the Pontificia Universidad Católica de Chile, one of the leading Chilean universities, are randomly assigned to their first semester college class groups. I take advantage of this feature in order to robustly estimate the impact of peer characteristics on undergraduate academic performance. The research hypothesis is that being assigned as a freshman to a group with more or less students from a same school, or from a given socioeconomic background, may result in very different patterns of adaptation, potentially impacting academic performance. Significant evidence is found that suggests that, contrary to the results found in most of the existing literature, the average college admission score of first semester classmates not only has no positive impact on the academic performance of undergraduate students, but may actually be negatively affecting their grades. Also, although there are some differences across degrees and secondary school types, in general undergraduate students are more likely to be dismissed, and have lower grades, when they share their first semester college class with a secondary schoolmate. Moreover, students assigned to first semester college classrooms with a higher concentration of classmates who attended the same secondary school(s) generally have significantly lower grades, and are less likely to graduate. Finally, students sharing their first semester college classroom with students from public or subsidized secondary schools are more likely to be dismissed due to poor academic performance. The fact that these peer effects are persistent in time points to the existence of a path dependence pattern, suggesting that this initial period in college is key for student adaptation. These findings have important implications for the design of policies intended to improve the adaptation of freshman college students and the access to higher education, suggesting that students would benefit from targeted first semester college class group assignment policies, as well as from additional transitional aid tailored to their profiles.

The second chapter addresses the question of how to distinguish "knowledge" from "ability", in the context of improving the access to higher education. In particular, according to the existing evidence some higher education admission tests may be screening out students who, despite a relative lack of specific knowledge, possess as much intellectual ability as their peers. If this is the case, students from disadvantaged socioeconomic backgrounds are likely to be disproportionately affected, since they generally receive a primary and secondary education of worse quality than their better-off peers, often resulting in significant knowledge gaps. Also, although in some cases these formative shortcomings might be too large to be feasibly addressed at the time of enrollment in higher education, it is plausible to think that in some cases they may perhaps be relatively easy to remedy. In view of all this, in this chapter I present a diagnostics experiment, aimed at helping to better understand this issue. In particular, I custom-designed a multiple-choice test, intended to measure an individual's mathematical ability, while minimizing the reliance on previously acquired knowledge. Also, I put together a two page "cheat sheet", which outlined all the necessary concepts to successfully complete the exam, without providing any explicit answers. This test was subsequently used to evaluate the candidates applying for admission into a special access program at one of the leading Chilean universities. A staged randomized control trial was used to measure the difference in academic performance (i.e. number of correctly answered questions) across the three parts of the exam between students who received a "cheat sheet" after the first or second parts of the test, respectively. As expected, "cheat sheets" improved the average performance of candidates on the exam, but their impact varied considerably across individuals. Most importantly, "cheat sheets" proved significantly more beneficial (in terms of improved test performance) to those students who were more likely to have had a secondary education of lower quality. This result has important implications for educational policies in Chile and elsewhere, suggesting that a transition to ability-focused admission tests would facilitate the access to higher education for talented students from disadvantaged backgrounds.

The third and final chapter of this dissertation presents a higher education special access program for students from disadvantaged socioeconomic backgrounds, custom-designed by the author for one of the leading Chilean universities, and implemented as a pilot during the 2013 and 2014 admission periods. A non-experimental comparison of the academic performance of special and ordinary admission students after enrollment finds evidence that, consistent with Arcidiacono et al (2011), although on average special admission students have comparable final grades than their ordinary admission peers, they tend to perform comparatively worse in "hard" subjects (i.e. those with a strong mathematical component). However, although special admission students seem more likely to decide to withdraw earlier, no significant differences in voluntary withdrawal or dismissal rates are observed between the latter and their ordinary admission peers. Moreover, an initial gap in GPA between special and ordinary admission students is closed by the end of the third semester of enrollment. All this suggests that, with some nuances, students from disadvantaged socioeconomic backgrounds can successfully catch up with their peers when provided with adequate support, and that special admission programs can therefore be an effective tool to improve the access to higher education. Nonetheless, the fact that the program was undersubscribed suggests that, apart from potential information diffusion problems, the minimum requirements set forth for special admission may have been too stringent, and/or that the demand for special admission among the targeted student population may not be as large as predicted.

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Para Elena.

Mi amiga.

Mi amor.

Mi vida.

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BIOGRAPHICAL NOTE

"Who am I? If this once I were to rely on a proverb, then perhaps everything would amount to knowing whom I 'haunt'. I must admit that this last word is misleading, tending to establish between certain beings and myself relations that are stranger, more inescapable, more disturbing than I intended. Such a word means much more than it says, makes me, still alive, play a ghostly part, evidently referring to what I must have ceased to be in order to be who I am. Hardly distorted in this sense, the word suggests that what I regard as the objective, more or less deliberate manifestations of my existence are merely the premises, within the limits of this existence, of an activity whose true extent is quite unknown to me. My image of the 'ghost', including everything conventional about its appearance as well as its blind submission to certain contingencies of time and place, is particularly significant for me as the finite representation of a torment that may be eternal. Perhaps my life is nothing but an image of this kind; perhaps I am doomed to retrace my steps under the illusion that I am exploring, doomed to try and learn what I should simply recognize, learning a mere fraction of what I have forgotten."

A. Breton

"I am come of a race noted for vigor of fancy and ardor of passion. Men have called me mad; but the question is not yet settled, whether madness is or is not the loftiest intelligence, whether much that is glorious, whether all that is profound does not spring from disease of thought, from moods of mind exalted at the expense of the general intellect. They who dream by day are cognizant of many things which escape those who dream only by night. In their gray visions they obtain glimpses of eternity, and thrill, in awakening, to find that they have been upon the verge of a great secret. In snatches, they learn something of the wisdom of which is of good, and more of the mere knowledge which is of evil. They penetrate, however, rudderless or compassless into the vast ocean of the "light ineffable," and again, like the adventures of the Nubian geographer, "agressi sunt mare tenebrarum, quid in eo esset exploraturi."

We will say, then, that I am mad."

E. A. Poe

"I am a poet. That is why I am interesting. That is what I write about."

V. Mayakovsky

"There is no such thing as a moral or an immoral book.
Books are well written, or badly written.
That is all."

O. Wilde

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"In my younger and more vulnerable years my father gave me some advice that I've been turning over in my mind ever since. 'Whenever you feel like criticising anyone', he told me, 'just remember that all the people in this world haven't had the advantages that you've had.' "

F. S. Fitzgerald

CHAPTER 1

The Impact of College Peers on Academic Performance: Evidence from a Natural Experiment in Chile

1.1. Introduction

The interaction among peers is a very difficult subject to study, given its complexity and the fact that peer group formation is usually endogenous (e.g. individuals self-select into peer groups, or are assigned to them according to observable characteristics). Therefore, natural experiments in which students have been randomly assigned to their peer groups provide a unique opportunity to exploit exogenous group formation, allowing to robustly estimate peer effects[1]. For example, in his seminal paper Sacerdote (2001) uses random assignment of college roommates to evaluate the impact of room sharing on grades and socialization patterns. This has spurred a series of related papers which also take advantage of natural experiments[2], but these generally focus on non-academic dimensions and non-classroom interactions, so that there is ample scope to improve our understanding of the impact of college peers on undergraduate academic performance.

Chile, albeit a middle-income country and an OECD member, faces substantial gaps in the provision of higher education. For example, while the OECD average net coverage of higher education (i.e. the ratio of students 18-24 years old enrolled in higher education) is 59 %, the net coverage of higher education in Chile is 36.3 %, and the net coverage for the poorest decile of the population is 16.4 % (OECD, 2011). Moreover, poor

[1] For alternative methodologies see for example: Manresa (2013), who discusses in depth the estimation of social interactions using panel data; De Giorgi et al (2010) who discuss the identification of social interactions through partially overlapping peer groups; Bramoullé et al (2009) or Boucher et al (2014), who estimate a linear-in-mean model of secondary school students in the context of recreational services consumption and student achievement, respectively; or Calvo-Armengol et al (2009) and Patacchini et al (2011), who develop and estimate models to study the impact of adolescent friendship networks on school performance and educational attainment, respectively.

[2] See for example: Boisjoly et al (2006), who study the impact of random first year roommate assignment on attitudes towards other ethnic groups; Burns et al (2013), who take advantage of random assignment of peers at one of the leading South African universities to also study racial relations; or Kremer and Levy (2008), who use the same strategy of random assignment of roommates to study the impact of peers on alcohol use among college students.

students usually attend public or subsidized secondary schools, while rich students usually attend private schools of higher quality. Only 10 % of public school graduates attend elite universities, versus 31 % for private schools, resulting in a clear majority of private school students in those institutions. Then, it is not surprising that the access to higher education is currently one of the most important issues for Chilean society (see for example Loofbourow, 2013), and the main reason behind the notorious student protests which have taken place there during the last years. Therefore, there is an ongoing debate both at the government and university levels regarding which is the best way to increase the access to higher education, and to ensure equality of opportunity for all.

In view of all of the above, this chapter takes advantage of a natural experiment in Chile in order to estimate the impact of college peers on academic performance. In particular, it exploits the random assignment of first year students to their first semester college class groups at the Pontificia Universidad Católica de Chile, one of the leading Chilean universities. It relies on anonymous administrative data, collected by the university on a regular basis for academic and administrative purposes. The analysis includes all students who entered the Engineering and Commercial Engineering[3] degrees via ordinary admission between 2000 and 2006. These students are randomly assigned to first semester groups of 40-60 students, with whom they share the classroom when taking "core" non-elective courses (which make up the majority of the first semester curriculum). The research hypothesis is that, ceteris paribus, being assigned as a freshman to a class group with more or less students from the same school(s) or from a given socioeconomic background may result in very different patterns of adaptation (e.g. determining how the student evolves in the new environment, or the size and characteristics of the network of college contacts acquired). This idea is similar to Shue (2013), who taking advantage of the random assignment of students to MBA sections at Harvard Business School, estimates how executive peer networks can affect managerial decision-making and firm policies. However, by focusing on undergraduate degrees instead than on a MBA program, this chapter tries to improve our understanding of college student adaptation in general, and of peer effects on academic performance in particular. This includes exploring whether causal adaptation mechanisms may rely on different socialization patterns triggered by the heterogeneous composition of first semester class groups, in terms of (i) admission score, (ii) number of students from the same secondary school, (iii) concentration of students from the same secondary school type[4], and (iv) secondary school type. All these dimensions have clear implications for the design of policies intended to improve the academic performance and adaptation of college students in general, and of those from disadvantaged socioeconomic backgrounds in particular.

[3]Note that the Commercial Engineering undergraduate degree offered by Chilean universities usually encompasses the Economics and Business undergraduate majors offered by universities in the United States.

[4]It is an stylized fact of Chilean education that there is a very high correlation between secondary school type and socioeconomic status, as well as between tuition rates and the quality of secondary education. The vast majority of students from the top quintile of the income distribution attend private secondary schools, while students from the lowest quintiles usually attend subsidized secondary schools (or if their parents cannot even afford the subsidized tuition, public ones).

It is not trivial to anticipate, *a priori*, what should be the impact on undergraduate academic performance of sharing the classroom with peers who obtained a better admission score. On the one hand, students may be able to benefit from potential positive learning externalities, but on the other hand it is also conceivable to think that peers with a better admission score may be more likely to procrastinate (e.g. if they feel that they can still achieve good grades with reduced effort). However, this chapter not only rules out a positive impact of average college admission score of first semester classmates, but finds evidence of a negative impact on undergraduate grades (both short, medium and long term). This differs from previous findings in most of the literature, suggesting that the above mentioned negative "drag" effect outweighs potential positive learning externalities.

Similarly, it is not trivial to anticipate, *a priori*, what should be the impact on undergraduate academic performance of sharing the same first semester college classroom with secondary schoolmates. On the one hand, being in a classroom with familiar faces may ease the transition from secondary school to college, but on the other hand it is also conceivable to imagine that the presence of secondary schoolmates may increase the temptation to procrastinate, at the expense of academics. This chapter finds that secondary schoolmate presence in the first semester college classroom has a significant negative impact on undergraduate academic performance, both in terms of lower medium and long term grades, and of an increased likelihood of being dismissed due to poor academic performance. This suggests that the negative effect of a familiar face in the classroom outweigh its potentially positive ones.

Also, it is not trivial to anticipate what should be, *a priori*, the impact on academic performance of being assigned to a first semester college classroom with a higher concentration of students from the same secondary school(s). On the one hand, if a large proportion of students already know each other from secondary school, others may be shut off the main social group(s). But on the other hand, new students may find it easier to assimilate into an already structured social group. Moreover, it is not trivial to anticipate how being left out or assimilated should affect academic performance. Similarly to the case of secondary schoolmate presence, already discussed above, on the one hand students may benefit from more academic and social interaction with their college classmates. However, on the other hand this may also increase the opportunities for procrastination and the time devoted to non-academic activities, at the expense of academic performance. This chapter finds a persistent and significant negative impact of secondary school concentration in the first semester college classroom on both short and long term undergraduate grades, as well as on the likelihood of dismissal due to poor academic performance. This suggests that having a large proportion of classmates who attended the same few secondary schools is detrimental to academic performance.

Furthermore, it is again not trivial to anticipate what should be, *a priori*, the impact on academic performance of being randomly assigned to a first semester college classroom in which there is a larger presence of public or subsidized secondary school students. On the one hand, as already mentioned above these students, and particularly the former, usually have had a secondary education of lower quality. They therefore may have significant formative gaps, which may potentially be the cause of negative learning externalities. However, on the other hand these students have obtained admission to very competitive degrees, despite the fact that they often faced considerably more difficulties than their peers. They therefore may have a comparable, or even greater, innate ability than their private school counterparts, and/or be more motivated[5]. This chapter finds evidence that students assigned to a first semester college classroom with a higher percentage of public or subsidized secondary school students are more likely to be dismissed. However, while there is some evidence that an increased presence of public school students may, *ceteris paribus*, result in slightly lower undergraduate grades for their peers, this chapter finds that an increased presence of subsidized school students may have the opposite effect. This suggests that although positive learning externalities may in some cases be overshadowed by other factors, they still matter.

Finally, when looking separately at students admitted to each of the two degrees included in the analysis (Engineering and Commercial Engineering), or when allowing for the coefficients of interest to vary by the type of secondary school of origin, the results are generally consistent with the main findings discussed above. However, although there is evidence of some differences across students from the two degrees, and across students from different secondary school types, the results are noisier and no robust pattern is observed. These results are therefore no presented on this chapter.[6]

It is worth noting that the above presented results are generally time-persistent, pointing to the existence of a path dependence pattern, and suggesting that this initial period in college is key for the student adaptation. These findings have important implications for the design of policies intended to improve the adaptation of freshman college students, and the access to higher education. In particular, they suggest that students would benefit from targeted first semester college class group assignment policies, as well as from additional transitional aid tailored to their profile.

[5]Since students from private secondary schools usually come from the top quintile of the income distribution their outside option may be much higher than that of public or subsidized school students from lower quintiles, potentially reducing motivation and effort.

[6]When making cross-degree comparisons it is worth noting that the assignment to each degree is not random, allowing for self-selection and potentially resulting in very different student profiles in Engineering and Commercial Engineering. Also, note that population size problems may be aggravated when looking at each degree separately. This may be the reason why some significant effects are only found on the Engineering subpopulation, since it is much larger than the Commercial Engineering one. Therefore, this type of differential impacts across degrees should not be viewed as exceedingly robust. Finally, note also that the limited number of students from subsidized and public schools results in limited power to detect differential impacts by school type, and may potentially be causing near-complete determination problems, as well as increased sensibility of point estimates to alternative specifications and estimation methods. However, this is only a concern when looking at the differential impact by school type, and in principle should not affect the general results presented in this chapter, which are applicable to all school types.

The rest of this chapter is organized as follows: Section 1.2 presents the motivation and background for the chapter; Section 1.3 provides a description of the data used in the analysis; Section 1.4 provides a detailed description of the research methodology; Section 1.5 outlines the main findings; Section 1.6 discusses the robustness of the analysis; Section 1.7 concludes.

1.2. Motivation

Chile, albeit a middle-income country and a member of the OECD, faces substantial gaps in the provision of higher education. For example, while the OECD average net coverage of higher education (i.e. the ratio of students 18-24 years old enrolled in higher education) is 59 %, the net coverage of higher education in Chile is 36.3 %, while the net coverage for the poorest decile of the population is 16.4 %. Also, students from low income families usually attend public or subsidized public schools, while students from the top of the income distribution usually attend private schools featuring higher quality. It is then not surprising that only 10 % of public school graduates attend elite universities, versus 31 % for private schools, resulting in a clear majority of private school students in high quality undergraduate institutions. Moreover, lengthy degrees (lasting 13.6 semesters on average) make education comparatively costly, and there is great variance (3:1 to 5:1) in income among graduates with the same degree (for more details about these stylized facts see Comisión de Financiamiento Estudiantil para la Educación Superior, 2012).

The university in which this study was carried out, one of the top in the country, is a good example of the above: 71.7 % of students are from households in the upper quintile of the income distribution, versus 3.4 % from its lower quintile. The pattern is even more pronounced in the most prestigious degrees: for example, ordinary admission into its Commercial Engineering degree usually requires a score of at least 730 points in the "Prueba de Selección Universitaria" (PSU), the standardized admission test administered at the national level. This score corresponds to the 98 % percentile of the distribution, so that the overwhelming majority of the 250 new students admitted each year attended private secondary schools, and belong to households in the two upper quintiles of the income distribution (see DEMRE, 2011, and Dirección de Servicios Financieros Estudiantiles, 2011).

Then, it is not surprising that the access to higher education is currently one of the most pressing issues for Chilean society, and the main reason behind the notorious student protests which have taken place there during the last years (see for example Loofbourow, 2013). Therefore, there is an ongoing debate at both the government and university levels regarding which is the best way to increase the access to higher education, and to ensure equality of opportunity. At its forefront is the role of the PSU, the standardized admissions test, which some argue that may be discriminating against talented students from poor backgrounds. This is both because due to its alleged focus on knowledge instead of ability (talented but poor students who attended public or subsidized secondary schools may have very significant knowledge gaps compared to their private secondary school peers), and to the prevalence of test preparation courses, or "preuniversitarios". The latter are attended by most private school students, but are generally not affordable for poorer students from public and subsidized secondary schools (for a related study on the subject in Chile see Banerjee et al (2012), who provide test preparation courses to students from disadvantaged backgrounds, and experimentally evaluate their impact). Another factor which is generally perceived as an important barrier to access higher education is its cost, which makes it prohibitive for many households. The Chilean government has been expanding public funding, but many times this doesn't cover the full tuition fees, and stipends to cover living expenses are very rare. Moreover, in order to address potential incentive problems, this funding often takes the shape of loans. However, this may have information and risk aversion implications which are not trivial, particularly in a middle- or low- income development country setting, with high uncertainty regarding the returns to education (see Dinkelman and Martinez, 2011, who using an experimental design evaluate the role of information about financial aid in the access to higher education in Chile; or Hoxby and Turner, 2012, who also look at the issue in the United States using a randomized control trial).

In order to bypass the potential admission test bias and/or funding problems, in the last few years many universities have created special admission programs. These are intended to improve the access to undergraduate education for secondary school students from disadvantaged backgrounds, but their impact is not yet clear. Moreover, many students admitted via those programs seem prone to experience adaptation problems, leading to student drop out (anecdotical evidence suggests that similar adaptation problems arise with ordinary admission students from the lower quintiles of the income distribution). [7]. In the United States, Arcidiacono et al (2011) study the on-campus interracial interaction among college students, and find empirical evidence that the probability of interaction between races on a campus is sensitive to the degree of mismatch between racial groups[8]. Therefore, it is plausible that the probability of interaction between students from different socioeconomic backgrounds on a campus or degree may also be sensitive to the degree of mismatch between socioeconomic groups (see for example Rao, 2013, who analyses how mixing students from different socioeconomic backgrounds in Indian schools affects social preferences and behaviors). This could be affecting the socialization patterns of students from disadvantaged backgrounds, which in turn may be affecting their adaptation to college.

However, it seems that ordinary admission students from disadvantaged backgrounds who do not drop out have an academic performance comparable to that of their counterparts, although some may be choosing "softer" courses with a more reduced mathematical component. The latter would be consistent with Arcidiacono

[7]For related research in the U.S. and Canada see, for example, Arcidiacono et al (2011) or Angrist et al (2006).

[8]See also Burns et al (2013) for an analysis of the relationship between social interaction and racial prejudice in South Africa using randomly assigned university peers.

et al (2012), who find that minority students in at Duke University in the United States catch up with their majority counterparts in terms of grades, but that this is at the expense of switching to the above mentioned less quantitative "softer" courses. Also, existing evidence suggests that there is a very high variance, in terms of labor market outcomes, across individuals with the same undergraduate education degree (this is often true even for graduates of the same university). In view of Sacerdote (2001), who using random assignment of college roommates finds an impact of room sharing on grades and socialization patterns, it is plausible that this labor market heterogeneity may at least partly be due not only to peer effects, but also to differential socialization patterns. These may lead to differences in the characteristics of the network of contacts acquired during college, which in many cases may impact not only undergraduate academic performance, but also choice of subjects or labor market outcomes after graduation.

Finally, it is worth noting that the interaction among peers is in general terms a very difficult subject to study. This is due to its complexity, but also because peer group formation is usually endogenous (e.g. students self-select into peer groups, or assigned according to observable characteristics). Therefore, natural experiments in which students have been randomly assigned to their peer groups provide a unique opportunity to estimate peer effects (for alternative methodologies see for example: Manresa (2013), who discusses in depth the estimation of social interactions using panel data; De Giorgi et al (2010) who discuss the identification of social interactions through partially overlapping peer groups; Bramoullé et al (2009) or Boucher et al (2014), who estimate a linear-in-mean model of secondary school students in the context of recreational services consumption and student achievement, respectively; or Calvo-Armengol et al (2009) and Patacchini et al (2011), who develop and estimate models to study the impact of adolescent friendship networks on school performance and educational attainment, respectively). The above mentioned seminal paper by Sacerdote (2001) has spurred a series of related papers using other natural experiments (see for example: Boisjoly et al (2006), who study the impact of random first year roommate assignment on attitudes towards other ethnic groups; Burns et al (2013), who take advantage of random assignment of peers at one of the leading South African universities to also study racial relations; or Kremer and Levy (2008), who use the same strategy of random assignment of roommates to study the impact of peers on alcohol use among college students). However, these generally focus on non-academic dimensions and non-classroom interactions, so that there is ample scope to improve our understanding of the impact of peer effects on academic performance.

In view of all of the above, this chapter takes advantage of a natural experiment in Chile in order to estimate the impact of class composition on academic performance. In particular, it exploits the random assignment of freshmen to their first semester college class groups at the Pontificia Universidad Católica de Chile, one of the leading Chilean universities. The research hypothesis is that being assigned as a freshman to a group with more or less students from the same school(s), or from a given socioeconomic background, may ceteris paribus result in very different patterns of socialization. The latter may determine how the student adapts to the new environment, as well as the size and characteristics of the network of contacts acquired during college. This idea is similar to Shue (2013), who in order to estimate how executive peer networks can affect managerial decision-making and firm policies, exploits the random assignment of students to MBA sections at Harvard Business School. However, this chapter focuses on college education, instead than on MBA students. By doing so, it intends to help to improve our understanding of student adaptation mechanisms, and the relationship between peer characteristics and undergraduate academic performance. In particular, this chapter tries to estimate the impact of being randomly assigned to a first semester classgroup with peers which may differ along several dimensions, i.e. (i) admission score, (ii) presence of secondary schoolmates, (iii) concentration of students from the same secondary school type, and (iv) presence of public or subsidized secondary school students (note that it is an stylized fact of Chilean education that there is a very high correlation between secondary school type and socioeconomic status, and between tuition rates and the quality of secondary education; the vast majority of students from the top quintile of the income distribution attend private secondary schools, while students from the lowest quintiles usually attend subsidized secondary schools, or if their parents cannot afford even the subsidized tuition, public ones). All of the above have clear implications for the design of policies intended to improve the adaptation of all college students in general, and of those from disadvantaged socioeconomic backgrounds in particular.

1.3. Data

This study relies on anonymous administrative data from undergraduate students, collected by the Pontificia Universidad Católica de Chile on a regular basis, for academic and administrative purposes. This includes standard administrative data required for the admission process (such as secondary education details and standardized test scores), but also information about socioeconomic status (necessary to determine benefit eligibility). Moreover, once students are enrolled in the university, their grades, courses taken, class groups and academic status are all recorded each semester, in order to allow for the effective monitoring of their progress during their undergraduate studies.

Data is available for all students enrolled in the university from 2000 to 2012.[9] However, the analysis is limited to students admitted from 2000 to 2006, so that a complete record from admission to graduation exists for all the studied cohorts. Also, the analysis is limited to students enrolled in the Engineering and Commercial Engineering degrees (note that the Commercial Engineering undergraduate degree offered by Chilean

[9]Records exist before the year 2000. However, due to the use of outdated databases and inconsistent data gathering and storage protocols, they were not deemed reliable by the university, and were not made available for the purpose of this analysis. It is also worth noting that, due to the country's location in the Southern hemisphere, the Chilean academic year starts in March and ends in December.

universities usually encompasses the Economics and Business undergraduate majors offered by universities in the United States). This is because these are among the largest degrees in terms of student enrollment, but also because other degrees were affected by curricular changes, making it impossible to reliably compare cohorts across time.[10]

Students seeking admission to the university must take a standardized test, administered at the national levels to all Chilean students interested in accessing higher education[11]. This test consists of two compulsory parts (language and mathematics), and two or more optional ones. Together, they generate a weighted admission score, which is then used to determine admission in a centralized clearing process performed at the national level. First, each university decides whether or not to participate in the centralized admission process (the majority do, and certainly the best regarded ones). If so, it submits the admissions criteria (i.e. weighted admission score formula) to the centralized authority. Then, after taking the standardized admissions tests, students are asked to rank their university-degree preferences. Finally, the system clears in several rounds, by allocating the highest ranked students (in terms of admissions score) to their most preferred choice, and using ranked waiting lists to resolve conflicts (for more details see DEMRE, 2011-2013).

Both the Engineering and the Commercial Engineering degrees at the Pontificia Universidad Católica de Chile are highly competitive. Weighted admission scores are invariably very close to the maximum possible (850 points), with minimum admission scores ranging between 705-710 points, and maximum ones ranging between 825-830 points. The Engineering degree generally takes 6 years to complete, while the Commercial Engineering degree usually takes 5 years to complete. There are several financial aid options available for students who qualify, in terms of both socioeconomic and academic criteria. During their secondary schooling students may have attended a public (fully paid for by the government), subsidized (partly paid for by the government) or private (paid for in full by the student) school. The quality of secondary education in subsidized schools is generally lower than in private ones, while the quality of secondary education in public schools is in turn generally lower than in subsidized ones (note that a few but important exceptions to this stylized fact exist, most notably the "Instituto National" or ***National Institute***, an elite secondary school funded by the government). This, together with the high cost of test preparation courses, results in students from private secondary schools usually obtaining substantially higher scores in the standardized admission

[10]Note that *ceteris paribus* a smaller population size will result in more limited statistical power, i.e. an increase in the minimum effect size which can be inferred to be significantly different from zero. In other words, in the absent of sufficient statistical power, if no impact is observed it is impossible to establish whether it is truly non-existent, or whether its size is simply below the observable threshold. Pooling degrees may alleviate this problem, allowing for increase statistical power, and pushing the minimum detectable effect threshold upwards. However, this would only allow to estimate aggregate peer effects, as opposed to degree-specific. Also, note that even the Engineering and Commercial Engineering degrees have undergone curricular changes during the period of study. However, those changes were sufficiently limited so that it still possible to perform a reliable comparison of cohorts across time.

[11]Note that the standardized admissions test format changed in 2003 from the old PAA ("Prueba de Aptitud Académica" or *Academic Aptitude Test*, to the new PSU ("Prueba de Selección Universitaria" or *University Selection Test*.

test. Therefore, the majority of students admitted to the most demanded degrees at elite universities (including the two studied in this chapter) attended private secondary schools. Moreover, many students who attended the same secondary school then enroll in the same degree, at the same university, sometimes even sharing their first semester college classroom (for example, the database used for this analysis shows that some students shared their first semester college classroom with up to 8 secondary school classmates).

Table I.I provides a summary of the number of students by school type in each degree. As observed there, each year there are usually four first semester class groups in the Commercial Engineering degree, and at least six class groups in the Engineering degree.[12] Each first semester class group usually features 50-60 students in the Commercial Engineering degree, and 40-50 students in the Engineering one. Each year between 200 and 250 students are admitted to the Commercial Engineering degree via ordinary admission, while between 250-300 are admitted to the Engineering school.

1.4. Methodology

This chapter takes advantage of the natural experiment created by the random assignment of incoming undergraduate students to first semester class groups at the Pontificia Universidad Católica de Chile. Freshmen are ranked according to their weighted admission score, and randomly assigned to one of the first semester class groups (the latter are referred to as "secciones", or *sections*). Students in each of these class groups share the classroom when attending their first semester non-elective "core" courses. These are the majority (and many times the only) courses taken by freshmen during their first college semester, and students in the same class group therefore spend most of their first semester together. It is then plausible to think that many newly arrived students form the majority of their college social links during this period, and that assignment to one class group or another will influence the social networks of the student during their undergraduate years (and potentially even after graduation).

Therefore, this random assignment to first semester class groups allows to robustly estimate the impact of peer characteristics on undergraduate academic performance. Linear[13] specifications with fixed effects and clustered standard errors are used (i.e. the analysis takes into account that there may be correlation within each class group, and corrects for this fact by clustering at the class group and year level - class groups are considered distinct across admission years). Academic performance variables of interest include:

[12] Note that the actual group numbers in the Engineering degree are not always correlative. Also, the variation in the number of groups in the Engineering degree seems to be due to a larger intake of new students via ordinary admission in 2000 and 2006.

[13] More sophisticated and non-linear specifications have also been explored, but the structure of the data is such that, given the available population size, the simpler linear specifications already provide limited statistical power. Therefore, more complex specifications run into standard small population size problems.

(1) Graduation (i.e. whether the student graduated); (2) Drop Out (i.e. whether student decided to abandon studies); (3) Dismissal (i.e. whether the student was dismissed due to poor academic performance)[14]; (4) First Semester GPA (Grade Point Average); (5) First Year GPA; (6) Final Undergraduate GPA.

First, this chapter analyzes the impact on the above mentioned outcome variables of secondary schoolmate presence in a student's first semester college class group. For this purpose two linear functional forms are specified: a baseline specification (which includes only the independent variable of interest and the appropriate fixed effects), and a extended specification (which includes six additional control variables for robustness purposes). These two linear regression models are respectively represented as

$$\text{(III.1)} \quad y_{ijkl} = \beta_0 + \delta_1 m_{ijkl} + \gamma_{jl} + \mu_{kl} + e_{ijkl}$$

$$\text{(III.2)} \quad y_{ijkl} = \beta_0 + \delta_1 m_{ijkl} + \sum_{h=1}^{6} \beta_h x_{hijkl} + \gamma_{jl} + \mu_{kl} + e_{ijkl}$$

where y_{ijkl} is one of the six college academic performance outcome variables described above, and m_{ijkl} is an indicator variable equal to one if student i in first semester college class group j shares the classroom with any other students from their same secondary school k who were also admitted to the same degree during academic year l[15]. As mentioned, for robustness purposes six additional student level individual controls $x_{hijkl}h = \{1, ..., 6)\}$ are introduced in the second specification. These are: (i) Gender (1 = Male); (ii) Weighted Admission Score; (iii) Mother's Educational Level; (iv) Father's Educational Level; (v) Housing Status (1 = Student lives with both parents); and (vi) Region (1 = Santiago Metropolitan Region). Two sets of fixed effects are also specified in the functional form: (a) γ_{jl} accounts for any unobservable idiosyncratic characteristics of first semester college class group j in academic year l; (b) μ_{kl} is the number of students from secondary school k admitted in academic year l to the same degree (note that μ_{kl} is included in place of η_{kl} - i.e. secondary school fixed effects - because, although this also guarantees that m_{ijkl} satisfies the standard exogeneity assumption, the number of required fixed effect terms in the specification goes down, increasing the precision of the estimation.). Finally, as already mentioned the analysis takes into account that there might be correlation across class groups, and corrects for this fact by clustering at the class group and year level (class groups are considered distinct across admission years).

Secondly, this chapter also analyzes the impact on academic performance of the average weighted admission score of any secondary schoolmates in a student's first semester college class group. As before, two linear functional forms are specified: a baseline specification (which includes only the independent variable of

[14] It is worth noting that a student dropping out is likely to be a proxy for lack of adaptation to the new environment, while a student being dismissed is likely to be a proxy for gaps in secondary education, particularly in the case of public and subsidized secondary school students.

[15] As discussed in Section 1.6, the results of the analysis are robust to the substitution of the binomial presence variable for the actual number of secondary schoolmates in the first semester college class group.

interest and the appropriate fixed effects), and a extended specification (which for robustness purposes includes six additional control variables). These two linear regression models are respectively represented as

$$\text{(IV.1)} \quad y_{ijkl} = \beta_0 + \delta_1' m_{ijkl} + \delta_2 s_{ijkl} m_{ijkl} + \gamma_{jl} + \eta_{kl} + e_{ijkl}$$

$$\text{(IV.2)} \quad y_{ijkl} = \beta_0 + \delta_1' m_{ijkl} + \delta_2 s_{ijkl} m_{ijkl} + \sum_{h=1}^{6} \beta_h x_{hijkl} + \gamma_{jl} + \eta_{kl} + e_{ijkl}$$

where as before y_{ijkl} is one of the six college academic performance outcome variables described above, and m_{ijkl} is an indicator variable equal to one if student i in first semester college class group j shares the classroom with any other students from their same secondary school k who were also admitted to the same degree during academic year l. However, in this case the variable of interest is s_{ijkl}, which represents the average weighted admission score of secondary school k mates of student i in their first semester college class group j in academic year l. This is interacted with m_{ijkl} to account for the fact that many students do not share their first semester college class group with any secondary schoolmates. As before, six additional student level individual controls $x_{hijkl} h = \{1, ..., 6)\}$ are introduced in the third specification for robustness purposes. These are: (i) Gender (1 = Male); (ii) Weighted Admission Score; (iii) Mother's Educational Level; (iv) Father's Educational Level; (v) Housing Status (1 = Student lives with both parents); (vi) Region (1 = Santiago Metropolitan Region). However, in this case two slightly different sets of fixed effects are specified in the functional form: (a) γ_{jl} again accounts for any unobservable idiosyncratic characteristics of first semester college class group j in academic year l; (b) η_{kl} accounts for any unobservable idiosyncratic characteristics of students from secondary school k in academic year l (note that in this case it is not possible to substitute η_{kl} with μ_{kl} to increase precision as before, since the latter does not guarantee that s_{ijkl} satisfies the standard exogeneity assumption. Finally, as always the analysis takes into account the potential correlation within class groups, and corrects for this fact by clustering at the class group and year level (class groups are considered distinct across admission years).

Finally, this chapter also analyzes the impact on academic performance of other characteristics of first semester college class group peers, as detailed below. As always, two linear functional forms are specified: a baseline specification (which includes only the independent variables of interest and the appropriate fixed effects), and a extended specification (which includes six additional controls for robustness purpose)s. These two linear regression models are respectively represented as

$$\text{(V.1)} \quad y_{ijkl} = \beta_0 + \delta_1' m_{ijkl} + \delta_2 s_{ijkl} m_{ijkl} + \delta_3 s_{ijl} + \delta_4 H_{ijkl} + \delta_5 p_{1ijl} + \delta_6 p_{2ijl} + \eta_{kl} + e_{ijkl}$$

$$\text{(V.2)} \quad y_{ijkl} = \beta_0 + \delta_1' m_{ijkl} + \delta_2 s_{ijkl} m_{ijkl} + \delta_3 s_{ijl} + \delta_4 H_{ijkl} + \delta_5 p_{1ijl} + \delta_6 p_{2ijl} + \sum_{h=1}^{6} \beta_h x_{hijkl} + \eta_{kl} + e_{ijkl}$$

where as before y_{ijkl} is one of the six college academic performance outcome variables described above, m_{ijkl}

is an indicator variable equal to one if student i in first semester college class group j shares the classroom with any other students from their same secondary school k who were also admitted to the same degree during academic year l, and s_{ijkl} represents the average weighted admission score of secondary school k mates of student i in their first semester college class group j in academic year l. However, in this case the variables of interest are the characteristics of all first semester college class group peers. To begin with, s_{ijl} represents the average weighted admission score of (all) student i's first semester college class group j mates in academic year l (note that s_{ijl} refers to the average weighted admission score of all first semester college classmates, while s_{ijkl} refers only to secondary schoolmates in the first semester class group). Then, H_{ijkl} measures the concentration of secondary schools[16] in class group j in academic year l, excluding student i's secondary school k (once again, as mentioned in Section 1.6, the results of the analysis are robust to the substitution of the Herfindahl index for other secondary school concentration measures). Finally, p_{1ijl} and p_{2ijl} represent the percentage of student i's first semester college class group j mates in academic year l who attended a public or subsidized secondary school, respectively (note that neither s_{ijl}, H_{ijkl}, p_{1ijl} and p_{2ijl} include student i). Also, as always six additional student level individual controls $x_{hijkl}h = \{1, ..., 6)\}$ are introduced in the third specification for robustness purposes. These are: (i) Gender (1 = Male); (ii) Weighted Admission Score; (iii) Mother's Educational Level; (iv) Father's Educational Level; (v) Housing Status (1 = Student lives with both parents); (vi) Region (1 = Santiago Metropolitan Region). However, in this case only one set of fixed effects is specified in the functional form[17]: η_{kl} accounts for any unobservable idiosyncratic characteristics of students from secondary school k in academic year l (note that in this case it is again not possible to substitute η_{kl} with μ_{kl} to increase precision, as the latter does not guarantee that s_{ijl}, H_{ijkl}, p_{1ijl} and p_{2ijl} satisfy the standard exogeneity assumption). Finally, as always the analysis takes into account the potential correlation within class groups, and corrects for this fact by clustering at the class group and year level (class groups are considered distinct across admission years).

It is worth noting that the parameters of interest are the δ coefficients, which identify the impact of independent variables in each specification on the academic performance outcome variables described above (note that $\delta_1 \neq \delta_1'$, and that while in equations III we have that $E(y_{ijkl}|m_{ijkl} = 1) - E(y_{ijkl}|m_{ijkl} = 0) = \delta_1$, in equations IV and V it is the case that $E(y_{ijkl}|m_{ijkl} = 1) - E(y_{ijkl}|m_{ijkl} = 0) = \delta_1' + \delta_2 s_{ijkl}$).

[16] Concentration of secondary schools in the class group is measured as the Herfindahl index of secondary school share, constructed by squaring and adding each secondary school's share in the classroom (i.e. the percentage of students who attended it before being admitted to the university). In particular:

$$H_{ijkl} = \sum_{k} \left\{ \frac{n_{jkl}}{\sum_{k'} n_{jk'l}} \right\}^{2} \text{ for } k \neq k_i \text{ and } k' \neq k_i'$$

where and s_{kj} is the share of students in class group j who attended secondary school k.

[17] Note that in this case γ_{jl} class group fixed effects are not included because although neither s_{ijl}, H_{ijkl}, p_{1ijl} and p_{2ijl} include student i and therefore differ across students within the same class group, the variation at that level is not enough to avoid acute multi-collinearity problems.

Table I.II provides an overview of the balance by first semester class group of the additional control variables listed above, i.e. (i) Gender (1 = Male); (ii) Weighted Admission Score; (iii) Mother's Educational Level; (iv) Father's Educational Level; (v) Housing Status (1 = Student lives with both parents); (6) Region (1 = Santiago Metropolitan Region). Despite the multidimensionality of the data, and the reduced size of each first semester college class group, the balance seems to be reasonably good. In general, the null hypothesis of joint orthogonality across class groups during the same admission year cannot be rejected at the 90 % confidence level or higher. However, this null hypothesis is indeed rejected in a few instances, which means that the balance of the random assignment is not perfect. As discussed in Section 1.6 this may potentially cause some robustness concerns.

1.5. Findings

1.5.1. Impact of Presence of Secondary Schoolmates

It is not trivial to anticipate what should be, *a priori*, the impact on undergraduate academic performance of sharing the same first semester classroom with secondary schoolmates. On the one hand, being in a class group with familiar faces and old acquaintances may ease the adaptation from secondary school to college. Also, this may allow students to better learn from their classmates, allowing them to benefit from potential positive learning externalities. However, on the other hand it is also conceivable to imagine that the presence of secondary schoolmates may increase the temptation to procrastinate, at the expense of academics. Also, secondary schoolmate presence may discourage students to expand their social network (e.g. if they tend to orbit towards known acquaintances at the expense of developing new relationships). This may limit the interaction with other classmates, decreasing the opportunities to benefit from potential positive learning externalities.

This chapter finds that there is a significant negative impact of secondary schoolmate presence in the first semester college classroom, both in terms of lower grades in the medium and long term, and of an increased likelihood of being dismissed due to poor academic performance. This suggests that the potential negative effects of a familiar face in the classroom discussed above outweigh its positive ones. In particular, as in can be observed on Table I.III (1), students who share their first semester college class group with a secondary schoolmate are 2.7 % less likely to graduate (in particular, because they are 1.5 % more likely to be dismissed due to poor academic performance). Also, students who share their first semester college class group with a secondary schoolmate have first year and final undergraduate Grade Point Averages which are respectively 0.39 and 0.5 points lower (in the Chilean educational system grades range from 1 to 7, which are respectively the lowest and highest possible scores, and 4 generally is the lowest passing grade). These coefficients are significant with a 90 % confidence, and as it can be observed on Table I.III (2), the results are qualitatively robust to the inclusion of other student characteristics as additional controls (given the complex nature of the data exact point estimates can be noisy, and the precision of the analysis decreases as new control variables are included, but the sign of coefficients is the same and their magnitudes are roughly comparable when other student characteristics are considered).

Although the fact that no significant impact is observed on the likelihood of a student choosing to drop out may be attributable to limited statistical power, it nonetheless suggests that the negative impact of secondary schoolmate presence on the first semester college class group is mainly attributable to academic adaptation problems, which result in poor academic performance (as opposite to social adaptation problems, which result in the student choosing to abandon the undergraduate studies). Also, the fact that the presence of secondary schoolmates in the first semester college classroom still has a significant impact on grades after many years points to the existence of a path dependence pattern, and suggests that this initial period is key for student adaptation.

1.5.2. Impact of Admission Score of Secondary School Mates

It is again not trivial to anticipate what should be, *a priori*, the impact on undergraduate academic performance of sharing the classroom with secondary schoolmates who have a better weighted admission score. On the one hand, students may be able to benefit from potential positive learning externalities if the peers with whom they are most likely to interact have a better admission score. However, on the other hand it is also conceivable to think that those peers with a higher admission score may be more likely to procrastinate (e.g. if they feel that they can still obtain good grades with reduced effort). In that case, they may "drag" the student with them, negatively affecting academic performance.

This chapter finds a significant negative impact on short, medium and long term grades of average weighted admission score of secondary schoolmates in the classroom. This suggests that the above discussed negative impact of secondary schoolmate presence seems to be aggravated when those secondary schoolmates have better admission scores. In particular, as it can be observed on Table I.IV (1) an additional average weighted admission score[18] point in average for secondary schoolmates in the first semester class group translates into between 0.003 and 0.002 less GPA points in the short and medium/long term, respectively (as already mentioned, in the Chilean educational system grades range from 1 to 7, which are respectively the lowest and highest possible scores). These coefficients are significant with a 95 % confidence in the case of short and

[18] As already mentioned, weighted admission scores for students in both degrees included in the analysis are invariably very close to the maximum of 850 points, with minimum scores ranging between 705-710 points and maximum ones ranging between 825-830 points.

medium term grades, and with a 90 % confidence in the case of long term grades.

This is perhaps a counter-intuitive result, and it contradicts the findings of most of the existing literature. But as already mentioned, the significant negative impact of secondary schoolmates' admission scores may be attributable to secondary schoolmates with better admission scores being more prone to procrastinate (e.g. if they feel more confident about still obtaining good grades with reduced effort), and then "dragging" the student with them. However, it is worth noting that this impact may also be attributable to other factors, such as the use of "curve grading", existence of "teaching to the top" practices, and/or expectational or motivational issues. In any case, the fact that both short and long term grades are affected suggests the existence of a path-dependence pattern, and/or strong persistence of social ties formed during the first college semester. This points towards "teaching to the top" or expectational or motivational factors (which affect the absolute performance of the students in the long term), as opposed to "curve grading" (which would just affect relative performance in the short term).[19] Also, note that this result does not imply that there do not exist positive learning externalities from sharing the classroom with students with a better admission score, but rather, that if they exist, they are more than compensated for by the former (and in fact, there could be other non-learning positive externalities at play, such as research training or familiarity with the university environment).

Finally, note that as it can be observed on Table I.IV (2), in this case the results are not robust to the inclusion of other student characteristics as additional controls (the coefficients of interest become insignificant, and in the case of short term grades even seem to change sign). This is to be expected if those characteristics are very predictive of test scores (something that the existing literature seems to suggest), but it may also be pointing to some potential robustness concerns. These are discussed on Section 1.6.

1.5.3. Impact of Admission Score of Classmates

Analogously to the previous case, it is not trivial to anticipate what should be, *a priori*, the impact on undergraduate academic performance of sharing the classroom with peers who have a better admission score. As before, on the one hand students may be able to benefit from potential positive learning externalities. However, on the other hand it is also conceivable to think that those peers with a better secondary education may be more likely to procrastinate (e.g. if they feel that they can still obtain good grades with reduced effort), "dragging" other students with them and negatively impacting their academic performance. Moreover, it is also not trivial to predict whether the impact of the average admission score of all first semester classmates

[19]Note, however, that if students tend to choose the same electives, and try to continue sharing the classroom with their first semester classmates during the rest of their undergraduate studies, "curve grading" may indeed explain the persistence of lower grades in the medium and long term.

should be larger or smaller than that of just secondary schoolmates. On the one hand, it is plausible to imagine that any impact may be amplified by the larger number of other students, compared to secondary schoolmates. But on the other hand, if a student interacts mostly with the latter, the impact of the admission score of all classmates may be more limited.

This chapter finds evidence of a significant and persistent negative impact on academic performance of the average admission score of first semester college classmates. This suggests that the above discussed negative impact of admission score of secondary schoolmates also holds for other students, irrespective of their secondary school of origin. In particular, as it can be observed on Table I.V (1), an additional average weighted admission score point for classmates in the first semester college class group translates, *ceteris paribus*, into a reduction of between 0.041 and 0.026 GPA points in the short and medium term, and into 0.018 less GPA points in the long term. These coefficients are significant with a 99 % confidence in the case of short and medium term grades, and with a 95 % confidence in the case of long term grades.

As discussed in the previous section, this is again a counter-intuitive result, and it contradicts the findings of most of the exiting literature. But as already mentioned, this significant negative impact may be attributable to secondary schoolmates with better admission scores feeling more confident of still obtaining good grades with reduced effort. If this is the case, it is plausible to think that they are more prone to procrastinate, "dragging" other students with them. However, once again it is worth noting that this impact may also be attributable to other factors, such as the use of "curve grading", existence of "teaching to the top" practices, and/or expectational or motivational issues. Although in this case the negative impact clearly diminishes as time passes, the fact that both short and long term grades are affected again suggests the existence of a (time-attenuated) path-dependence pattern, and/or time persistence of social ties formed during the first college semester. In principle this could again point towards "teaching to the top" or expectational/motivational factors (which affect the absolute performance of the students in the long term), but the clear attenuation and the magnitude of the significant coefficients would be also be consistent with (explicit or implicit) "curve grading". Also, once again it is important to note that this result does not imply that there do not exist positive learning externalities from sharing the classroom with students with a better admission score, but rather that if they exist, they are more than compensated for by the former.

Finally, note that, as it can be observed on Table I.V (2), these results are again not robust to the inclusion of other student characteristics as additional controls (the coefficients of interest become much smaller and insignificant). As before, this is to be expected if those characteristics are very predictive of test scores (as the existing literature seems to suggest), but as already mentioned it may also be pointing to some potential robustness concerns which are discussed on Section 1.6.

1.5.4. Impact of Secondary School Concentration

Similarly to the case of secondary schoolmate presence, it is not trivial to anticipate what should be the impact on undergraduate academic performance of being in a first semester college classroom in which there is a higher concentration of students from the same secondary school(s). On the one hand, having a large proportion of students who already know each other from secondary school may shut others off. But on the other hand, if the main group is already structured, this may facilitate the assimilation of new students into it. Moreover, it is not trivial to anticipate how being left out (or assimilated) will affect academic performance. Once again, on the one hand students may benefit from more interaction with their classmates, but on the other hand that may also increase the opportunities for procrastination and the time devoted to non-academic activities, at the expense of academic performance.

This chapter finds a persistent and significant negative impact of secondary school concentration in the first semester college classroom, on both short and long term grades, and the likelihood of dismissal. This suggests that that having a large proportion of classmates who come from the same few secondary schools is detrimental to academic performance. In particular, as it can be observed on Table I.V (1), an increase of one decimal point in secondary school concentration (as measured by a Herfindahl index)[20] *ceteris paribus* makes a student's likelihood to be dismissed increase 14 percentage points. Also, it results in 0.97 and 0.79 less GPA points in the short and medium term, respectively. These coefficients are significant with a 90 % confidence in the case of dismissal likelihood, and with a 99 % confidence in the case of short and long term grades. Also, as it can be observed on Table I.V (2), the results are qualitatively robust to the inclusion of other student characteristics as additional controls[21].

The above is consistent with the already discussed negative impact of secondary schoolmates in the first semester class group, but suggests that having too many students from a few secondary schools in the first semester class group is detrimental to all students in the group, and not only to their secondary schoolmates. Also, the very large size of the estimated coefficients points to this being a very important issue. Moreover, the fact that secondary school concentration in the first semester class group impacts the likelihood of dismissal, but not the likelihood of drop out, suggests that it causes academic adaptation problems (as opposed to

[20]Constructed by squaring and adding each secondary school's share in the classroom, i.e. the percentage of students who attended it before being admitted to the university. In particular:

$$H_{ijkl} = \sum_{k} \left\{ \frac{n_{jkl}}{\sum_{k'} n_{jk'l}} \right\}^2 \text{ for } k \neq k_i \text{ and } k' \neq k'_i$$

where and s_{kj} is the share of students in class group j who attended secondary school k.

[21]As in the case of secondary schoolmate presence, given the complex nature of the data, exact point estimates can be noisy, and the precision of the analysis decreases as new control variables are included. However, although the size of the estimated coefficient is smaller, the sign of the coefficients of interest is still the same.

social adaptation ones).[22]

1.5.5. Impact of Presence of Public and Subsidized Secondary School Students

As always, it is not trivial to anticipate what should be the impact on academic performance of being randomly assigned to a first semester college classroom in which there is a larger presence of public or subsidized school students. Those students, and particularly the former, usually have had a secondary education of lower quality, and may therefore have significant formative gaps (as already mentioned, it is an stylized fact of Chilean education that there is a very high correlation between secondary school type and socioeconomic status, as well as between tuition rates and the quality of secondary education: the vast majority of students from the top quintile of the income distribution attend private secondary schools, while students from the lowest quintiles usually attend subsidized secondary schools, or public ones if their parents cannot afford even the subsidized tuition). However, at the same time these students have obtained admission to very competitive degrees, while often facing much more difficulties to do so than their counterparts. Therefore, they may have comparable or even greater innate skills than their private school peers, and/or they may be more motivated (since students from private secondary schools usually come from the top quintile of the income distribution, their outside option may be much higher than that of public or subsidized school students from lower quintiles, potentially reducing motivation and effort).

This chapter finds evidence that students assigned to a first semester college classroom with a higher percentage of public or subsidized secondary school students are more likely to be dismissed. However, while there is some evidence that an increased presence of public school students may ***ceteris paribus*** result in slightly lower grades, this chapter finds that an increased presence of subsidized school students may conversely result in slightly higher grades. In particular, as it can be observed on Table I.V (1), an increase of one percentage point in the share of public secondary school students in the first semester classroom ***ceteris paribus*** makes a student's likelihood to graduate and be dismissed decrease 0.29 and increase 0.21 percentage points, respectively.[23] Similarly, an increase of one percentage point in the share of subsidized secondary school students in the first semester classroom ***ceteris paribus*** makes a student's likelihood to be dismissed increase 0.16 percentage points. However, an increase of one percentage point in the share of subsidized secondary school students in the first semester classroom ***ceteris paribus*** results in about 0.009 and 0.007 more GPA points in

[22]It is also worth noting that in this case there is no evidence of any impact on medium term grades, which goes against the monotone time patterns observed for the impact of the other variables of interests discussed so far. This suggests that the relationship between secondary school concentration and academic performance may be more complex, although unfortunately the reduced form analysis in this chapter does not allow to disentangle its exact mechanism.

[23]Although the coefficients are not significant at the 90 % level, as mentioned there is some evidence that an increase of one percentage point in the share of public secondary school students in the first semester classroom ***ceteris paribus*** may result in about 0.005 less GPA points in the short and medium term.

the short and medium term, respectively. These coefficients are significant with a 95 % and 90 % confidence in the case of public and subsidized secondary school presence, respectively, and are qualitatively robust to the inclusion of other student characteristics as additional controls.

The above suggests that although positive learning externalities may in some cases be overshadowed by other factors (as discussed in previous sections), they still matter. The lower average quality of the education of subsidized and public secondary school students, and particularly of the latter, seems to not only affect their performance, but also that of their first semester college classmates. Also, note that although the size of both effects seems to be small, the negative impact of increased public secondary school presence on the dismissal likelihood seems to be larger than that of a higher percentage of subsidized secondary school students. This is consistent with the stylized fact of subsidized secondary schools generally offering a education of higher quality, compared to their public counterparts. Moreover, the fact that a larger presence of subsidized school students in the first semester college class group has a positive impact on grades suggests that, in their case, increased motivation and effort may more than compensate for any gaps in their secondary education [24]. Finally, the fact that this positive impact on grades only lasts until the medium term again suggest that learning externalities may be the main driver behind this impact. However, in any case the fact that there is still some persistence beyond the first semester once more points to the existence of a path-dependence pattern.

1.5.6. Differences by Degree

When looking separately at students admitted to each of the two degrees under study, the results are consistent with the above discussed findings. There is evidence of some differences across students from the two degrees, but the results are noisier and no robust pattern is observable, and they are therefore no presented on this chapter.[25]

[24]Note, however, that the opposite signs of the impact on grades and likelihood of dismissal could also likely be due to students with lower grades being dismissed, therefore increasing the average grades for those who continue their studies.

[25]When making cross-degree comparisons it is worth noting that the assignment to each degree is not random, allowing for self-selection and potentially resulting in very different student profiles in Engineering and Commercial Engineering. Also, note that, as expected, population size problems are aggravated when looking at each degree separately. This may be the reason why some significant effects are only found on the Engineering subpopulation, since it is much larger than the Commercial Engineering one. Therefore, this type of differential impacts across degrees should not be viewed as exceedingly robust.

1.5.7. Differences by Secondary School Type

As in the previous case, when allowing for the coefficients of interest to vary with the type of secondary school of origin, the results are qualitatively comparable to the above discussed findings. There is evidence of some differential impacts across secondary school type, but once again the results are noisier and, no robust pattern is observable. These results are therefore no presented on this chapter.[26].

1.6. Robustness

The main results presented in this chapter are robust to the use of Huber-White heteroskedasticity-consistent estimation, instead of clustered standard errors at the class group level. Also, results regarding the negative impact of secondary school classmate presence on academic performance are robust to alternative specifications (e.g. including school*year*degree fixed effects, or the use of number of secondary school class mates variable, instead of a binomial one simply denoting presence or absence). Moreover, results regarding the negative impact of peer admission score on academic performance are robust to the inclusion of secondary school class mate presence as an independent variable in the specification. Results regarding the negative impact of secondary school concentration on academic performance are also robust to the use of alternative measures of school concentration (e.g. number of schools with more than a 5% or 10% share of students in the classroom, or the share of students in the class group belonging to the top 1, top 2, top 3, top 5 and top 10 most represented schools).

Although the additional controls included in the full specification are not guaranteed to be exogenous in this context (and are therefore not discussed in this chapter), it is worth noting that their estimated coefficients are consistent with the literature findings, as well as with the anecdotical evidence.[27]

However, it is worth noting that, although a population consisting of a few thousand observations is analyzed, given the complexity of the data structure at the end of the day there is limited statistical power, and small

[26]Note that the limited number of students from subsidized and public schools results in limited power to detect differentiated impacts by school type, and may potentially be causing near-complete determination problems and increased sensibility of on point estimates to alternative specifications and estimation methods. This is only a concern when looking at the differentiated impact by school type, and should not affect the general results presented in this chapter, which are applicable to all school types.

[27]For example, the weighted average admission score is the best predictor of academic performance. Also, students from public and subsidized secondary schools are less likely to graduate and have lower grades, while male students have lower grades than female ones. The educational level of parents has a positive impact on academic performance, and students who live with their parents perform better during their undergraduate studies. Finally, students from the Santiago metropolitan region have a better academic performance than their peers from other areas of the country.

size effects may go undetected. Therefore, the discussion of the findings in this chapter focuses on the significant impacts found, rather than on the lack of impact, which could be attributable to low statistical power problems. Also, point estimates should be used with caution for policy purposes, since they are usually more sensitive to the structure of the data than the sign of estimated coefficient.

Similarly to the above, although it would in principle be possible to perform the analysis on other degrees, the reduced number of students enrolled in them (and/or the number of suitable yearly data available) mean that the resulting population size would only allow for a very limited statistical power. Therefore, only very large effects could be detected, unless the information was pooled across degrees (in which case only aggregated peer effects could be estimated with more precision). However, other degrees also experienced curricular changes, which make the comparison across time cohorts very difficult (or outright impossible).

Moreover, as expected non-linear models (such as probit or logit) are very problematic in this setting, due to the large number of fixed effects which need to be included in the specifications (i.e. in order to account for the idiosyncratic differences across secondary schools of origin and class groups). However, note that the linear specifications discussed in this chapter have a better fit (as measured by the adjusted R^2 coefficient) when applied to grades as the dependent variable, instead than to the likelihood of graduation, drop out or dismissal. This is to be expected, given the binomial nature of the latter, and means that *ceteris paribus* it will be easier to detect and measure the impact of peers on grades.

Finally, as already mentioned, note that the results concerning the impact of admission scores of first semester college classmates are not robust to the inclusion of other student characteristics as additional controls (the coefficients of interest become insignificant, and in an instance even seem to change sign). As discussed in the relevant sections above, this is to be expected if those characteristics are very predictive of test scores (something that the existing literature seems to suggest). However, in principle this may also point to balance problems. Or, given that (according to Table II.I) the additional control variables do not seem to be particularly imbalanced across class groups, this may also suggest that the impact of the admission score of first semester college classmates varies with some of the additional control variables included in the extended specification. This would mean that the coefficients for the admission score of first semester college classmates in the regression can no longer be interpreted a simple differential impact, and that interaction terms between the variable of interest and the additional controls must be included.

1.7. Conclusion

This chapter takes advantage of a natural experiment, by which first year college students at one of the leading Chilean universities are randomly assigned to their first semester college class groups, in order to robustly estimate peer effects on undergraduate academic performance. The research hypothesis is that being assigned as a freshman to a group with more or less students from a same school, or from a given socioeconomic background, may result in very different patterns of adaptation and impact academic performance. This chapter finds that, contrary to the evidence in most of the existing literature, the average standardized admission score of first semester college classmates no only seems to have no positive impact on undergraduate grades, but actually may have a negative one. Also, although there are some differences across degrees and secondary school type, college students who share their first semester classroom with a secondary schoolmate are generally more likely to be dismissed due to poor academic performance, and have lower grades. Moreover, students assigned to first semester college classrooms with a higher concentration of classmates who attended the same secondary school(s) have significantly lower grades, and are less likely to graduate. Finally, students who share their first semester college classroom with peers from public or subsidized secondary schools are more likely to be dismissed due to poor academic performance. All these impacts are generally persistent in time, pointing to the existence of a path dependence pattern, and suggesting that this initial period in college is key for student adaptation.

All the above has important implications for educational policy. First of all, the negative impact of secondary schoolmate presence for all types of students suggests that it would be advisable to assign freshmen to college class groups so that, whenever possible, they do not share their first semester classroom with any secondary schoolmates. Moreover, the large negative impact of secondary school concentration suggests that it would be advisable to group freshmen, so that students who attended the same secondary school are as spread as possible across class groups. Similarly, given the observed small but significant negative impact of sharing the classroom with a larger percentage of public or subsidized school students, it seems that it would also be advisable to spread this type of students across class groups. All this would be achievable by implementing targeted, multidimensional first semester classroom assignment policies.[28]

Second of all, the persistence of the observed impacts derived from first semester class group composition suggest that this is a very important period. Therefore, it may be advisable to even more so focus the transitional aid on the first semester, and/or potentially on the summer before starting college. Also, the detected negative impacts on the likelihood of graduation seem to be channeled through an increased probability of being dismissed due to poor academic performance. This suggests that, apart from facilitating the

[28]Note however that as Carrell et al (2013) point out optimal assignment policies may be unsuccessful if students endogenously form sub-groups. Also, the impact of optimal assignment will be weakened if students prefer to interact with a particular set of students even when they are outside their assigned group

social adaptation of students to their new environment, special attention should still continue to be paid to academic training (remedial or otherwise).

Finally, although no clear pattern is observed, and results are therefore not presented on this chapter, there seem to exist some differential impacts by degree and secondary school type. This suggests that one-size-fits-all transitional-aid programs may be less likely to succeed than programs tailored to the specific needs of each student profile in each degree. Also, students from public and subsidized secondary schools seem to be at a disadvantage, and may be negatively impacting their peers. This suggests that it would be advisable to put a special focus on helping this type of students to catch up (ideally with summer courses before starting college, in order to avoid a substitution effect between time devoted to regular subjects and remedial training). However, as the positive impact of subsidized secondary school student presence suggests, it seems that, without the formative shortcomings associated to the lower quality of their secondary education, public and subsidized secondary school students may instead potentially have a positive impact on their peers. Therefore, the first best solution to access to higher education barriers would be to address the quality gap in secondary education (between public and subsidized schools, and their private counterparts).

TABLE I.I

DISTRIBUTION OF FIRST SEMESTER COLLEGE STUDENTS

	Commercial Engineering Degree					Engineering Degree				
		Secondary School Type					Secondary School Type			
Year	Group	Public	Subsidized	Private	Total	Group	Public	Subsidized	Private	Total
2000	1	1	3	51	55	1	3	2	45	50
	2	4	7	41	52	2	3	2	43	48
	3	1	6	45	52	3	4	1	42	47
	4	1	9	43	53	4	3	7	40	50
	...	...	...	...	...	5	7	4	37	48
	...	...	...	...	...	6	1	3	44	48
	...	...	...	...	...	7	2	5	38	45
	...	...	...	...	...	8	1	5	39	45
	All	7	25	180	212	All	24	29	328	381
2001	1	6	3	45	54	1	5	4	41	50
	2	2	1	50	53	2	3	4	39	46
	3	2	3	49	54	3	3	5	38	46
	4	4	2	47	53	4	5	3	35	43
	...	...	...	...	...	5	7	2	41	50
	...	...	...	...	...	6	2	1	45	48
	All	14	9	191	214	All	25	19	239	283
2002	1	6	3	42	51	1	0	4	44	48
	2	2	12	38	52	2	4	6	39	49
	3	5	4	44	53	3	6	5	35	46
	4	3	3	51	57	4	4	5	40	49
	...	...	...	...	...	5	3	3	39	45
	...	...	...	...	...	6	1	2	47	50
	All	16	22	175	213	All	18	25	244	287
2003	1	4	4	43	51	1	4	3	42	49
	2	0	3	48	51	2	3	8	36	47
	3	1	7	45	53	3	5	4	37	46
	4	4	4	41	49	4	5	6	35	46
	...	...	...	...	...	5	6	3	36	45
	...	...	...	...	...	6	1	2	45	48
	All	9	18	177	204	All	24	26	231	281
2004	1	0	2	52	54	1	6	3	39	48
	2	1	6	49	56	2	9	4	32	45
	3	2	5	43	50	3	7	7	35	49
	4	2	3	53	58	4	4	5	39	48
	...	...	...	...	...	5	5	2	40	47
	...	...	...	...	...	6	4	4	41	49
	All	5	16	197	218	All	35	25	226	286
2005	1	3	3	50	56	1	1	8	41	50
	2	0	5	49	54	2	7	3	35	45
	3	3	6	45	54	3	3	5	41	49
	4	1	2	53	56	4	4	4	34	42
	...	...	...	...	...	5	3	4	40	47
	...	...	...	...	...	6	4	5	37	46
	All	7	16	197	220	All	22	29	228	279
2006	1	0	5	51	56	1	6	2	40	48
	2	2	3	47	52	2	4	6	36	46
	3	3	0	47	50	3	3	6	39	48
	4	2	4	48	54	4	8	6	35	49
	...	...	...	...	...	5	4	3	40	47
	...	...	...	...	...	6	7	4	34	45
	...	...	...	...	...	7	2	5	38	45
	...	...	...	...	...	8	7	3	35	45
	All	7	12	193	212	All	41	35	297	373
Total		123	224	2427	2774	Total	317	326	3142	3785

NOTES. Distribution of first semester college students in the Commercial Engineering and Engineering degrees at one of the leading Chilean universities. The data set has been constructed using the administrative data routinely gathered by the university from 2000 to 2012, and it includes all students who entered the Commercial Engineering and Engineering degrees at the university via ordinary admission process between 2000 and 2006.

TABLE I.II

BALANCE BY ADMISSION YEAR AND CLASS GROUP

A. Commercial Engineering Degree										
Year	Group	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	Obs.
2000	1	727.37	0.44	8.24	8.44	0.85	0.84	0.02	0.05	55
	2	726.47	0.58	7.69	8.17	0.77	0.73	0.08	0.13	52
	3	727.61	0.56	8.06	8.44	0.73	0.85	0.02	0.12	52
	4	726.02	0.66	8.19	8.58	0.77	0.83	0.02	0.17	53
	p-value	0.97	0.13	0.23	0.42	047	0.40	0.25	0.31	
2001	1	730.52	0.61	7.94	8.20	0.87	0.85	0.11	0.06	54
	2	731.72	0.62	7.77	8.60	0.87	0.92	0.04	0.02	53
	3	732.07	0.44	7.91	8.24	0.74	0.83	0.04	0.06	54
	4	729.24	0.58	7.96	8.23	0.73	0.85	0.08	0.04	52
	p-value	0.84	0.22	0.91	0.43	0.12	0.53	0.35	0.75	
2002	1	734.08	0.55	7.90	8.00	0.90	0.86	0.12	0.06	51
	2	732.70	0.50	8.04	8.17	0.77	0.73	0.04	0.23	52
	3	730.85	0.49	8.11	8.42	0.83	0.87	0.09	0.08	53
	4	731.82	0.40	8.10	8.33	0.83	0.84	0.05	0.05	58
	p-value	0.78	0.38	0.90	0.54	0.36	0.21	0.39	0.01	
2003	1	732.32	0.69	8.08	8.43	0.86	0.88	0.08	0.08	51
	2	732.57	0.39	8.06	8.49	0.78	0.92	0.00	0.06	51
	3	730.76	0.53	7.60	8.19	0.79	0.83	0.02	0.13	53
	4	730.08	0.57	7.96	8.35	0.84	0.86	0.08	0.08	49
	p-value	0.86	0.03	0.47	0.73	0.70	0.56	0.10	0.60	
2004	1	744.05	0.52	8.07	8.48	0.80	0.87	0.00	0.04	54
	2	744.76	0.52	7.89	8.25	0.73	0.86	0.02	0.11	56
	3	744.92	0.60	7.86	8.54	0.82	0.90	0.04	0.10	50
	4	744.53	0.57	7.76	8.29	0.79	0.84	0.03	0.05	58
	p-value	1.00	0.80	0.78	0.66	0.72	0.86	0.51	0.41	
2005	1	741.34	0.50	8.27	8.63	0.80	0.79	0.05	0.05	56
	2	742.86	0.54	8.17	8.44	0.87	0.80	0.00	0.09	54
	3	742.54	0.52	7.76	8.33	0.85	0.85	0.06	0.11	54
	4	739.62	0.59	8.50	8.64	0.71	0.80	0.02	0.04	56
	p-value	0.92	0.81	0.05	0.46	0.16	0.83	0.27	0.41	
2006	1	747.90	0.55	8.32	8.61	0.82	0.80	0.00	0.09	56
	2	746.31	0.48	7.69	8.48	0.73	0.88	0.04	0.06	52
	3	746.25	0.62	7.98	8.70	0.72	0.84	0.06	0.00	50
	4	746.67	0.54	8.09	8.74	0.81	0.89	0.04	0.07	54
	p-value	0.98	0.57	0.20	0.59	0.46	0.55	0.38	0.22	

NOTES. The data set has been constructed using the administrative data routinely gathered by the university from 2000 to 2012, and it includes all students who entered the Commercial Engineering degree at the university via ordinary admission process between 2000 and 2006. Assignment of students to their first semester college class group was random. Each cell presents the mean of the balance variable (column) in each class group (row). Balance variables are: (1) weighted admission score, (2) gender (1 = male), (3) mother's educational level, (4) father's educational level, (5) housing status (1 = student lives with both parents), (6) region (1 = Santiago Metropolitan Region), (7) secondary school type (1 = public), (8) secondary school type (1 = subsidized). Reported p-values are for joint orthogonality test across class groups during the same admission year for each of the corresponding balance variables..

B. Engineering Degree										
Year	Group	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	Obs.
2000	2	739.56	0.86	8.28	8.32	0.70	0.72	0.06	0.04	50
	3	738.34	0.85	7.85	8.13	0.75	0.75	0.06	0.04	48
	4	740.70	0.83	8.26	8.38	0.74	0.85	0.09	0.02	47
	5	739.35	0.80	7.98	8.18	0.84	0.84	0.06	0.14	50
	6	739.01	0.81	8.17	8.50	0.79	0.81	0.15	0.08	48
	7	739.82	0.79	7.69	8.06	0.85	0.92	0.02	0.06	48
	8	738.85	0.76	7.78	8.11	0.78	0.80	0.04	0.11	45
	9	739.41	0.87	7.73	8.24	0.80	0.80	0.02	0.11	45
	p-value	1.00	0.86	0.40	0.83	0.64	0.32	0.26	0.30	
2001	1	753.33	0.92	7.72	7.82	0.86	0.80	0.10	0.08	50
	2	752.57	0.85	7.43	8.39	0.85	0.85	0.07	0.09	46
	3	751.14	0.83	8.07	8.26	0.78	0.85	0.07	0.11	46
	4	749.02	0.91	7.77	8.40	0.86	0.84	0.12	0.07	43
	5	750.31	0.88	7.52	7.84	0.86	0.86	0.14	0.04	50
	7	749.99	0.83	8.08	8.54	0.85	0.79	0.04	0.02	48
	p-value	0.92	0.67	0.32	0.07	0.90	0.93	0.54	0.57	
2002	1	738.03	0.90	7.63	8.13	0.77	0.73	0.00	0.08	48
	2	738.72	0.92	8.04	8.29	0.82	0.84	0.08	0.12	49
	3	738.20	0.87	7.87	8.24	0.76	0.72	0.13	0.11	46
	4	737.26	0.88	7.71	7.96	0.78	0.84	0.08	0.10	49
	5	740.09	0.80	7.69	8.53	0.73	0.78	0.07	0.07	45
	7	737.96	0.78	8.18	8.34	0.84	0.78	0.02	0.04	50
	p-value	0.99	0.32	0.49	0.51	0.84	0.61	0.11	0.73	
2003	1	738.23	0.88	7.84	8.16	0.76	0.82	0.08	0.06	49
	2	739.12	0.79	7.89	8.00	0.70	0.74	0.06	0.17	47
	3	736.76	0.65	8.00	8.30	0.78	0.80	0.11	0.09	46
	4	738.45	0.89	7.33	7.67	0.70	0.67	0.11	0.13	46
	5	738.15	0.87	7.53	8.36	0.76	0.64	0.13	0.07	45
	7	736.55	0.79	8.38	8.56	0.71	0.73	0.02	0.04	48
	p-value	0.99	0.03	0.08	0.24	0.91	0.35	0.44	0.26	
2004	1	757.16	0.88	8.00	8.52	0.83	0.85	0.13	0.06	48
	2	756.79	0.98	7.31	7.73	0.73	0.80	0.20	0.09	45
	3	757.44	0.80	7.67	8.31	0.80	0.76	0.14	0.14	49
	4	755.68	0.90	8.06	8.06	0.75	0.77	0.08	0.10	48
	5	757.35	0.83	8.06	8.28	0.79	0.77	0.11	0.04	47
	7	756.69	0.84	7.96	8.04	0.71	0.80	0.08	0.08	49
	p-value	1.00	0.14	0.24	0.24	0.76	0.87	0.52	0.61	
2005	1	767.66	0.92	7.92	7.96	0.76	0.84	0.02	0.16	50
	2	768.24	0.96	7.89	8.27	0.69	0.80	0.16	0.07	45
	3	766.14	0.88	7.61	7.82	0.80	0.78	0.06	0.10	49
	4	767.75	0.81	7.93	8.31	0.81	0.76	0.10	0.10	42
	5	765.61	0.74	7.87	8.26	0.91	0.74	0.06	0.09	47
	7	767.03	0.89	7.91	8.17	0.76	0.80	0.09	0.11	46
	p-value	0.99	0.04	0.94	0.64	0.17	0.90	0.26	0.77	
2006	1	774.80	0.85	8.10	8.38	0.67	0.85	0.13	0.04	48
	2	774.96	0.74	8.24	8.35	0.70	0.85	0.09	0.13	46
	3	772.46	0.79	7.88	8.58	0.83	0.77	0.06	0.13	48
	4	774.47	0.86	7.61	8.37	0.80	0.76	0.16	0.12	49
	5	774.14	0.83	8.00	8.17	0.79	0.79	0.09	0.06	47
	6	772.69	0.82	8.00	8.20	0.71	0.73	0.16	0.09	45
	7	773.30	0.84	8.07	8.24	0.73	0.73	0.04	0.11	45
	8	774.16	0.93	8.18	8.38	0.71	0.82	0.16	0.07	45
	p-value	1.00	0.41	0.66	0.89	0.57	0.72	0.43	0.74	

NOTES. The data set has been constructed using the administrative data routinely gathered by the university from 2000 to 2012, and it includes all students who entered the Engineering degree at the university via ordinary admission process between 2000 and 2006. Assignment of students to their first semester college class group was random. Each cell presents the mean of the balance variable (column) in each class group (row). Balance variables are: (1) weighted admission score, (2) gender (1 = male), (3) mother's educational level, (4) father's educational level, (5) housing status (1 = student lives with both parents), (6) region (1 = Santiago Metropolitan Region), (7) secondary school type (1 = public), (8) secondary school type (1 = subsidized). Reported p-values are for joint orthogonality test across class groups during the same admission year for each of the corresponding balance variables..

TABLE I.III

IMPACT ON ACADEMIC PERFORMANCE OF PRESENCE OF SECONDARY SCHOOL MATES IN FIRST SEMESTER COLLEGE CLASS GROUP

		(1) Graduation	(2) Drop Out	(3) Dismissal	(4) 1st Semester GPA	(5) 1st Year GPA	(6) Final GPA
(III.1)	1 = Secondary School Mate(s) in Group	-0.027	0.009	0.015	-0.033	-0.039	-0.050
		(0.015)*	(0.012)	(0.009)*	(0.031)	(0.023)*	(0.021)**
	Other Student Characteristics	No	No	No	No	No	No
	R^2	0.04	0.03	0.04	0.07	0.05	0.05
	Observations	3,634	3,634	3,634	3,660	3,625	3,660
(III.2)	1 = Secondary School Mate(s) in Group	-0.025	0.009	0.014	-0.015	-0.026	-0.037
		(0.015)	(0.012)	(0.009)	(0.026)	(0.019)	(0.019)*
	Other Student Characteristics	Yes	Yes	Yes	Yes	Yes	Yes
	R^2	0.07	0.04	0.07	0.31	0.30	0.23
	Observations	3,634	3,634	3,634	3,660	3,625	3,660

* $p<0.1$; ** $p<0.05$; *** $p<0.01$

NOTES. This table analyzes the impact of the presence of secondary school mates in a student's first semester college class group in the Commercial Engineering and Engineering degrees at one of the leading Chilean universities. The assignment to these first semester college class groups is random, allowing to treat peer characteristics as exogenous. The data set has been constructed using the administrative data routinely gathered by the university from 2000 to 2012, and it includes all students who entered the Commercial Engineering and Engineering degrees at the university via ordinary admission process between 2000 and 2006. The impact of the presence of secondary school mates in the first semester college class group is evaluated on six academic performance measures, presented horizontally, in particular: (1) graduation likelihood, (2) drop out likelihood, (3) dismissal likelihood, (4) 1st semester GPA, (5) 1st year GPA and (6) final GPA. Two sets of specifications are presented stacked over each other, with the one above (III.1) including only the variable of interested and the one below (III.2) including other student characteristics as additional controls, namely: gender (1 = male), weighted admission score, mother's educational level, father's educational level, housing status (1 = student lives with both parents) and region (1 = Santiago Metropolitan Region). Both specifications include two sets of fixed effects: (i) admission year * first semester college class group * degree, (ii) number of same secondary school students admitted the same year to the same degree. The latter allows to increase precision by excluding secondary school fixed effects while still ensuring that the secondary school mate presence variable satisfies the exogeneity condition. Standard errors are clustered by admission year * first semester college class group * degree.

TABLE I.IV

IMPACT ON ACADEMIC PERFORMANCE OF AVERAGE WEIGHTED ADMISSION SCORE OF SECONDARY SCHOOL MATES IN FIRST SEMESTER COLLEGE CLASS GROUP

		(1)	(2)	(3)	(4)	(5)	(6)
		Graduation	Drop Out	Dismissal	1st Semester GPA	1st Year GPA	Final GPA
(IV.1)	Avg. Admission Score of Secondary School Mate(s) in Group (If Any)	0.000	-0.000	0.000	-0.003	-0.002	-0.002
		(0.001)	(0.000)	(0.000)	(0.001)**	(0.001)**	(0.001)*
	1 = Secondary School Mate(s) in Group	-0.210	0.314	-0.114	1.944	1.793	1.383
		(0.419)	(0.371)	(0.264)	(0.954)**	(0.781)**	(0.756)*
	Other Student Characteristics	No	No	No	No	No	No
	R^2	0.59	0.55	0.67	0.56	0.54	0.59
	Observations	3,634	3,634	3,634	3,660	3,625	3,660
(IV.2)	Avg. Admission Score of Secondary School Mate(s) in Group (If Any)	0.001	-0.001	-0.000	0.002	0.001	0.001
		(0.001)	(0.000)	(0.000)	(0.001)*	(0.001)	(0.001)
	1 = Secondary School Mate(s) in Group	-0.691	0.615	0.067	-1.460	-0.961	-0.853
		(0.402)*	(0.371)	(0.251)	(0.781)*	(0.592)	(0.559)
	Other Student Characteristics	Yes	Yes	Yes	Yes	Yes	Yes
	R^2	0.61	0.56	0.67	0.68	0.68	0.68
	Observations	3,634	3,634	3,634	3,660	3,625	3,660

* $p<0.1$; ** $p<0.05$; *** $p<0.01$

NOTES. This table analyzes the impact of the average weighted admission score of secondary school mates in a student's first semester college class group in the Commercial Engineering and Engineering degrees at one of the leading Chilean universities. The assignment to these first semester college class groups is random, allowing to treat peer characteristics as exogenous. The data set has been constructed using the administrative data routinely gathered by the university from 2000 to 2012, and it includes all students who entered the Commercial Engineering and Engineering degrees at the university via ordinary admission process between 2000 and 2006. The impact of the average weighted admission score of secondary school mates in the first semester college class group is evaluated on six academic performance measures, presented horizontally, in particular: (1) graduation likelihood, (2) drop out likelihood, (3) dismissal likelihood, (4) 1st semester GPA, (5) 1st year GPA and (6) final GPA. Two sets of specifications are presented stacked over each other, with the one above (IV.1) including only the variable of interested and the one below (IV.2) including other student characteristics as additional controls, namely: gender (1 = male), weighted admission score, mother's educational level, father's educational level, housing status (1 = student lives with both parents) and region (1 = Santiago Metropolitan Region). Both specifications include two sets of fixed effects: (i) admission year * first semester college class group * degree, (ii) admission year * secondary school * degree. Standard errors are clustered by admission year * first semester college class group * degree.

TABLE I.V

IMPACT ON ACADEMIC PERFORMANCE OF FIRST SEMESTER COLLEGE CLASS GROUP PEER CHARACTERISTICS

		(1)	(2)	(3)	(4)	(5)	(6)
		Graduation	Drop Out	Dismissal	1st Semester GPA	1st Year GPA	Final GPA
(V.1)	Avg. Admission Score of Other Students in Group	-0.003	0.001	0.002	-0.041	-0.026	-0.018
		(0.003)	(0.003)	(0.002)	(0.010)***	(0.008)***	(0.007)**
	Secondary School Concentration in Group (Herfindahl Index)	-1.255	-0.316	1.401	-9.774	-3.890	-7.973
		(1.156)	(1.156)	(0.796)*	(3.677)***	(3.003)	(2.329)***
	% Public School Students in Group	-0.297	0.074	0.218	-0.507	-0.570	-0.337
		(0.137)**	(0.146)	(0.084)**	(0.486)	(0.370)	(0.362)
	% Subsidized School Students in Group	-0.294	0.083	0.160	0.943	0.668	0.017
		(0.205)	(0.184)	(0.089)*	(0.484)*	(0.383)*	(0.341)
	Avg. Admission Score of Secondary School Mate(s) in Group (If Any)	0.000	-0.000	0.000	-0.002	-0.002	-0.001
		(0.000)	(0.000)	(0.000)	(0.001)	(0.001)**	(0.001)
	1 = Secondary School Mate(s) in Group	-0.320	0.355	-0.049	1.239	1.288	0.900
		(0.344)	(0.308)	(0.225)	(0.780)	(0.647)*	(0.624)
	Other Student Characteristics	No	No	No	No	No	No
	R^2	0.33	0.31	0.33	0.37	0.33	0.33
	Observations	2,677	2,677	2,677	2,690	2,671	2,690
(V.2)	Avg. Admission Score of Other Students in Group	0.002	-0.001	-0.000	-0.009	0.000	0.003
		(0.003)	(0.003)	(0.002)	(0.006)	(0.006)	(0.005)
	Secondary School Concentration in Group (Herfindahl Index)	-0.354	-0.843	1.026	-3.922	0.570	-3.972
		(1.232)	(1.220)	(0.791)	(2.440)	(2.211)	(1.834)**
	% Public School Students in Group	-0.274	0.058	0.211	-0.433	-0.501	-0.281
		(0.141)*	(0.152)	(0.078)***	(0.353)	(0.268)*	(0.273)
	% Subsidized School Students in Group	-0.341	0.117	0.173	0.634	0.393	-0.185
		(0.199)*	(0.184)	(0.086)**	(0.354)*	(0.288)	(0.266)
	Avg. Admission Score of Secondary School Mate(s) in Group (If Any)	0.001	-0.001	-0.000	0.002	0.001	0.001
		(0.000)**	(0.000)*	(0.000)	(0.001)**	(0.001)**	(0.001)**
	1 = Secondary School Mate(s) in Group	-0.720	0.593	0.113	-1.625	-1.061	-1.008
		(0.325)**	(0.306)*	(0.213)	(0.638)**	(0.499)**	(0.473)**
	Other Student Characteristics	Yes	Yes	Yes	Yes	Yes	Yes
	R^2	0.35	0.32	0.34	0.54	0.53	0.47
	Observations	2,677	2,677	2,677	2,690	2,671	2,690

* $p<0.1$; ** $p<0.05$; *** $p<0.01$

NOTES. This table analyzes the impact of first semester college class group peer characteristics on students in the Commercial Engineering and Engineering degrees at one of the leading Chilean universities. The assignment to these first semester college class groups is random, allowing to treat peer characteristics as exogenous. The data set has been constructed using the administrative data routinely gathered by the university from 2000 to 2012, and it includes all students who entered the Commercial Engineering and Engineering degrees at the university via ordinary admission process between 2000 and 2006. Four peer characteristics are studied: (a) average weighted admission score of other students in group, (b) secondary school concentration in the class group, measured as the sum of the square of the percentage of students from each secondary school in the class group, (c) percentage of public secondary school students in the class group, and (d) percentage of subsidized secondary school students in the classroom. The impact of these variables is evaluated on six academic performance measures, presented horizontally, in particular: (1) graduation likelihood, (2) drop out likelihood, (3) dismissal likelihood, (4) 1st semester GPA, (5) 1st year GPA and (6) final GPA. Two sets of specifications are presented stacked over each other, with the one above (V.1) including only the variable of interested and the one below (V.2) including other student characteristics as additional controls, namely: gender (1 = male), weighted admission score, mother's educational level, father's educational level, housing status (1 = student lives with both parents) and region (1 = Santiago Metropolitan Region). Both specifications include admission year * secondary school * degree fixed effects. Standard errors are clustered by admission year * first semester college class group * degree.

"Education then, beyond all other devices of human origin, is the great equalizer of the conditions of men, the balance-wheel of the social machinery."

H. Mann

CHAPTER 2

Using "Cheat Sheets" to Distinguish Ability from Knowledge: Evidence from a Randomized Control Trial in Chile

2.1. Introduction

This chapter presents a diagnostics experiment, intended to better understand the role played by admissions tests in the access to higher education (for example, on one hand admissions tests may simply be correctly measuring relevant student characteristics, arising from their education and socioeconomic environment; however, on the other hand admissions tests may be inaccurate, and/or biased towards irrelevant student characteristics). It is motivated by existing evidence which suggests that some higher education admission tests may be screening out students who, despite a relative lack of specific knowledge, possess as much intellectual ability as their peers (or even more). If this is the case, students from disadvantaged socioeconomic backgrounds are likely to be disproportionately affected, since they generally receive a primary and secondary education of worse quality than their better-off peers, often resulting in significant knowledge gaps. Also, although in some cases these formative shortcomings might be too large to be feasibly addressed at the time of enrollment in higher education, it is plausible to think that in some cases they may perhaps be relatively easy to remedy.

In view of all this, I custom-designed a multiple-choice mathematical ability test, intended to measure an individual's ability while minimizing the reliance on previously acquired specific knowledge (as discussed for example in Bransford, 1999, or Pellegrino, 2001, this in itself is obviously far from a trivial task, but I trust that the result is satisfactory). Moreover, I also put together a two page knowledge summary, or "cheat sheet", which outlined all the concepts which I considered necessary to successfully complete the test (copies of both the "cheat sheet" and the full mathematical ability test are included in the relevant appendices). Obviously, this was intended to improve test performance, but it is worth noting that the "cheat sheets" did not provide any explicit answers. This was purposely so, in order to ensure that "cheat sheets" did not just raise the grades for all students, but rather, that they only helped those who were able to successfully apply the general concepts outlined in them to the resolution of the specific exam questions. Given this, and the fact that knowledge summaries should only improve the performance of students who did not previously know the concepts outlined in them, "cheat sheets" were expected to still allow for meaningful variation in grades, while at the same time potentially improving screening. In particular, it was anticipated that talented students from disadvantaged socioeconomic backgrounds who possessed good mathematical reasoning capabilities might be able to overcome their potential knowledge gaps with the help of the "cheat sheets". However, this was far from a trivial conclusion, as the formative shortcomings attributable to a primary and/or secondary education of a lower quality might be too large to allow students from disadvantaged socioeconomic backgrounds to benefit from the knowledge summaries.

This mathematical ability test was subsequently used to screen candidates applying for admission into the Commercial Engineering degree at the Pontificia Universidad Católica de Chile via the "Talento + Inclusión" (*Talent + Integration*) special access program, which targets students from disadvantaged socioeconomic backgrounds (see Chapter 3 for a full description of this access program). The mathematical ability test was divided in three parts, which featured 15 analogous questions each (i.e. the first questions of each part were different but analogous)[29], and candidates were randomly divided into treatment and control groups. All students took the first part of the test without any support materials, but then the "cheat sheet" was distributed to each of the candidates in the treatment group, who had about ten minutes to examine it before the second part of the exam started. Students in the control group simply had a ten minute break after completing the first part of the test, but received the same "cheat sheet" after having completed its second part. Once they received the "cheat sheet" all students could keep it with them until the end of the test, when they had to return it. This staged randomization design allowed to estimate the impact of the "cheat sheet" on student test performance, by looking at the differences in the number of questions answered correctly across the three parts of the test between students in the control and treatment groups.

After performing the above described experiment, this chapter only finds a significant difference in the number of questions answered correctly between students in the treatment and control group in Part II of the test. Since this was precisely the part in which candidates in the control group did not yet have access to the "cheat sheet" (as opposed to students in the treatment group), this suggests that as expected having access to a knowledge summaries improved test performance, *ceteris paribus* resulting in about one additional question answered correctly (out of a total of fifteen). Also, this chapter also finds a significant difference in the improvement (i.e. additional number of questions answered correctly) from Part I to Part II and from part II to Part III between students in the treatment and control groups. In particular, students in the treatment

[29]For comparison purposes, the questions in each part of the test would ideally be the same. However, this would obviously raise some concerns even if the students do not know the answers to the test. Therefore, different but analogous questions were used. This means that the underlying concept of the question was the same, but the precise numbers or examples used differed from one part to another.

group on average answered correctly almost one additional question in Part II than in Part I, compared to students in the control group who did not have access to a "cheat sheet" during the second part of the test. Analogously, students in the control group on average answered correctly more than half an additional question in Part III than in Part II, after receiving a knowledge summary before the third part of the exam, which again suggests that having access to a knowledge summaries increases student performance on the test. Moreover, students who attended a secondary school with a higher average score in the government-administered standardized evaluation test (SIMCE) tended to answer more questions correctly, consistent with stylized fact of positive correlation between secondary school quality and admission test scores.

All the previous makes sense, and corroborates the fact that, as anticipated, students perform better in a test if they have access to a "cheat sheet", and/or if they attended a secondary school of better quality. However, while observing the opposite phenomenon would have raised some concerns, this result is not particularly interesting. Nonetheless, most importantly this chapter also finds robust evidence that "cheat sheets" were significantly more beneficial for those students who were more likely to have had a secondary education of lower quality. In particular, students who attended a secondary school with a lower average score in the government-administered standardized evaluation test (SIMCE) tended to experience a significantly greater differential improvement in the number of questions answered correctly when using a "cheat sheet". Or in other words, there is evidence of a significant negative effect of secondary school government-administered standardized evaluation (SIMCE) on the differential improvement in test performance after students have access to a "cheat sheet". This is observable both in the significantly greater differential improvement from Part I to Part II for students in the treatment group (i.e. after they received the "cheat sheet" at the end of the first part), and in the significantly greater differential improvement from Part II to Part III for students in the control group (i.e. after they received the "cheat sheet" at the end of the second part). Also, no differential impact is observed for the comparisons of Part III vs. Part I, consistent with the fact that all candidates completed both Part I and Part III in the same conditions (no differential impact should be expected in this case, unless having access to the "cheat sheet" for a longer amount of time does matter).

Moreover, although the results are less robust than those presented above, this chapter also finds some evidence of a positive differential impact of having access to a "cheat sheet" on candidates enrolled in the PENTA UC program for talented secondary school students. Since students enrolled in the PENTA UC program come from disadvantaged backgrounds, and were already screened during their secondary education and identified as possessing "exceptional ability", this suggests that *ceteris paribus* the use of "cheat sheets" may be particularly beneficial for talented students. Also, there is some evidence that while students from public schools or the lower quintiles of the income distribution may benefit from "cheat sheets", they may need more time to do so than the amount provided between the parts of the exam in this experiment (e.g. because they may need more time to analyze and comprehend it).[30]

[30]Note that while these results would again point in the same direction of the results discussed above, these relationships are

Finally, a simulation exercise is performed for illustration purposes. It consists of an analysis of which candidates would benefit from (or would be worse off with) the use of cheat sheets, as measured by whether they advanced to or were relegated from the group of top 20 candidates (which is the number of vacancies available each year for admission via the special access program featured in this study). This is performed by comparing the rank of each candidate in Part I (which all students completed without a cheat sheet) and Part III (which all students completed with a cheat sheet), as defined by the number of correct answers relative to the other students who took the exam. The results of this exercise are not robust at the candidate level, since given the reduced number of questions in each part of the test, and the left-skewed distribution of the number of correctly answered questions, there are many ties which are broken randomly. However, they provide an insight of how the introduction of "cheat sheet" may have affected the selection process, if the mathematical ability test was the only criterion used to determine admission. In particular, according to the results of this simulation exercise the use of "cheat sheets" would mainly affect students close to the cut-off, but there are also cases of very large changes in ranking from Part I to Part III of the test. For example, one student only answered correctly to 10 questions (66 %) in Part I, and at that point would not have ranked in the top 100 among all candidates who took the test. However, after receiving the "cheat sheet" s/he answered correctly all 15 questions (100 %) in Part III, and made it to the top 10.[31]

The rest of this chapter is organized as follows: Section 2.2 presents the motivation and background for the chapter; Section 2.3 provides a description of the mathematical ability test custom-designed for the analysis[32]; Section 2.4 provides a description of the randomized control trial design; Section 2.5 outlines the main findings; Section 2.6 discusses the robustness of the analysis; Section 2.7 concludes.

2.2. Motivation

Chile, albeit a middle-income country and an OECD member, faces substantial gaps in the provision of higher education. For example, while the OECD average net coverage of higher education (i.e. the ratio of students 18-24 years old enrolled in higher education) is 59 %, the net coverage of higher education in Chile in is 36.3 %, and the net coverage for the poorest decile of the population is 16.4 % (OECD, 2011). Moreover, poor students usually attend public or subsidized public schools, while better-off students usually attend private

confounded by the fact that the control group also received "cheat sheets" at the end of the second part. Therefore, it is not possible to identify whether these are in fact delayed improvements in the treatment group, or if (although unlikely) the "cheat sheet" instead had a negative impact on the test performance of some students in the control group after they had access to it.

[31]It is worth noting that although s/he was in the treatment group, s/he only answered one additional question correctly in Part I with respect to Part II, with the sharp improvement instead occurring from Part II to Part III. This again suggests that students may benefit from having more time to review the "cheat sheet".

[32]The "cheat sheet" and the full mathematical ability test are included in the relevant appendices.

schools, which generally feature higher quality. Only 10 % of public secondary school graduates attend elite universities, versus 31 % for private schools, resulting in a clear majority of private school students in high quality undergraduate institutions. Also, lengthy degrees (lasting 13.6 semesters on average) make education comparatively costly, and there is great variance (3:1 to 5:1) in income among graduates, even within the same degree (Comisión de Financiamiento Estudiantil para la Educación Superior, 2012). The Pontificia Universidad Católica de Chile, the university in which this study was carried out, and one of the top in the country, is a good example of the above: 71.7 % of students come from households in the upper quintile of the income distribution, versus 3.4 % from its lower quintile. The pattern is even more pronounced in the most prestigious degrees: for example, ordinary admission into its Commercial Engineering degree usually requires a score of 730 or more in the "Prueba de Selección Universitaria", or PSU (the standardized admission test administered at the national level). That score corresponds to the 98 % percentile of the distribution, and not surprisingly, the overwhelming majority of the 250 new students admitted each year attended private secondary schools, and belong to households in the two upper quintiles of the income distribution (DEMRE, 2011, and Dirección de Servicios Financieros Estudiantiles, 2011

Then, it is not surprising that the access to higher education is one of the most pressing issues for Chilean society. Therefore, there is an ongoing debate, both at the government and university levels, regarding which is the best way to increase the access to higher education, and to ensure equality of opportunity for. Of course, the first best solution would be to increase the quality of secondary education in public and subsidized secondary schools, and there currently are may efforts in this direction. However, although necessary, any such reforms will at best improve the access to higher education only in the long term. In view of this, there are also many initiatives aimed at improving the access to higher education in the short and medium term. For example, an important barrier to access is the cost of higher education, which makes it prohibitive for many households. The government has been expanding public funding, but this is many times only partial (it doesn't cover the full tuition fees), and stipends to cover living expenses are very rare (e.g. see Sánchez, 2011, for a pre-2014 reform discussion of the challenges facing the higher education system in Chile; or Williamson and Sánchez, 2009, who discuss the necessary basic features of a potential government-funded public higher education system in Chile). Moreover, in order to address potential incentive problems this funding many times takes the shape of loans. However, this may have information and risk aversion implications which are not clear, particularly in a middle- or low- income development country setting with high uncertainty regarding the returns to education (e.g. see Dinkelman and Martinez, 2011, who using an experimental design evaluate the role of information about financial aid in the access to higher education in Chile; or Hoxby and Turner, 2012, who also look at the issue in the United States using a randomized control trial). However, at the forefront of the debate is the role of the PSU (the current standardized admission test), because of a perceived bias against students from public and subsidized secondary schools, and also because most poor students cannot afford the test preparation courses ("preuniversitarios") which are widespread among their better-off counterparts (for a related study on the subject in Chile see Banerjee et al, 2012). There have been several attempts and proposals to reform the PSU (e.g. see Santelices et al, 2011), and the Chilean Ministry of Education has recently included the school class ranking (i.e. the ranking of students with respect with their secondary school peers) in the weighting formula to determining the final score to be considered for admission purposes. However, this remains an open issue, and it is also worth noting that although the access to higher education is at the forefront of the public debate in Chile at the moment, this is of course an issue which is considered key in almost any other country (including the United States, e.g. see Dickert-Conlin and Rubenstein, 2007). The findings of this chapter are therefore relevant for, and contribute to, the overall academic debate on how to improve the access to higher education.

With the above in mind, this chapter proposes a diagnostics experiment, intended to better understand the role of admissions tests in the access to higher education (for example, on one hand admissions tests may simply be correctly measuring relevant student characteristics, arising from their education and socioeconomic environment; however, on the other hand admissions tests may be inaccurate, and/or biased towards irrelevant student characteristics). It is motivated by existing evidence which suggests that some higher education admission tests may be screening out students who, despite a relative lack of specific knowledge, possess as much intellectual ability as their peers, or even more (it is worth noting that as mentioned for example in Heckman, 1995, in any case latent ability alone cannot explain differences in test scores or wages among individuals, nor is independent of an individual's context). If this is the case, students from disadvantaged socioeconomic backgrounds are likely to be disproportionately affected, since they generally receive a primary and secondary education of worse quality than their better-off peers, often resulting in significant knowledge gaps. Also, although in some cases these formative shortcomings might be too large to be feasibly addressed at the time of enrollment in higher education, it is plausible to think that in some cases they may perhaps be relatively easy to remedy.

All the above is fully compatible with Bloom's seminal "Taxonomy of Educational Objectives", which classifies ***Knowledge*** as the first but lowest of educational goals, followed by ***Comprehension*** and ***Application*** (see Bloom et al, 1956, for a discussion of the original taxonomy; and Krathwohl, 2002, for a proposed modern revision to it). This is, secondary students who do not ***know*** the answers to the questions proposed to them in a test may not necessarily be less talented, or less likely to succeed in higher education. On the contrary, if with the help of a "cheat sheet" they can overcome their knowledge gaps, by quickly ***comprehending*** and ***applying*** the concepts outlined in it, this probably means that they are actually as likely to succeed in higher education (at least when provided with the adequate means to overcome their secondary education shortcomings). Or in other words, "cheat sheets" may help to better distinguish knowledge from ability (as reflected on better comprehension and application of concepts) in admission tests, leveling the playing field for students from disadvantaged socioeconomic backgrounds.

Also, it is worth noting that similar practices to the "cheat sheets" are common in many education contexts. For example, some exams at the university level can be taken "with the book open" (i.e. with any support materials that the student may deem useful), or are "take home" (i.e. the student completes the test on her or his own, without supervision)[33]. Also, it seems that consistent support materials are generally allowed and/or encouraged in those contexts in which pure knowledge is considered as secondary, or even irrelevant (e.g. mathematics or statistics).

2.3. Mathematical Ability Test

In view of all the above, I custom-designed a multiple-choice mathematical ability test, intended to measure an individual's ability, while minimizing the reliance on previously acquired specific knowledge (as discussed for example in Bransford, 1999, or Pellegrino, 2001, this in itself is obviously far from a trivial task, but I trust that the result is satisfactory). The type of questions used in the test were inspired by those featured in the previous national standardized admissions test in use in Chile until 2002, the "Prueba de Aptitud Académica", or *Academic Aptitude Test* (e.g. see Tapia Rojas et al, 1996). Moreover, I also created a two page knowledge summary, or "cheat sheet", which outlined all the concepts which I considered necessary to successfully complete the test (copies of both the "cheat sheet" and the full mathematical ability test are included in the relevant appendices).

Obviously, this was intended to improve test performance, but it is worth noting that the "cheat sheets" did not provide any explicit answers. This was purposely so, in order to ensure that "cheat sheets" did not just raise the grades for all students, but rather, that they only helped those who were able to successfully apply the general concepts outlined in them to the resolution of the specific exam questions. Given this, and the fact that knowledge summaries should only improve the performance of students who did not previously know the concepts outlined in them, "cheat sheets" were expected to still allow for meaningful variation in grades, while at the same time potentially improving screening. In particular, it was anticipated that talented students from disadvantaged socioeconomic backgrounds who possessed good mathematical reasoning capabilities might be able to overcome their potential knowledge gaps with the help of the "cheat sheets". However, this was far from a trivial conclusion, as the formative shortcomings attributable to a primary and/or secondary education of a lower quality might be too large to allow students from disadvantaged socioeconomic backgrounds to benefit from the knowledge summaries.

The mathematical ability test was subsequently used to screen candidates applying for admission into the Commercial Engineering degree at the Pontificia Universidad Católica de Chile via the "Talento + Inclusión"

[33]While "take home" exams will not necessarily allow the of use support materials, many do so.

(*Talent + Integration*) special access program, which targets students from disadvantaged socioeconomic backgrounds (see Chapter 3 for a full description of this access program).The mathematical ability test was divided in three parts, which featured 15 analogous questions each (i.e. the first questions of each part were different but analogous). For comparison purposes, the questions in each part of the test would ideally be the same. However, this would obviously raise some concerns even if the students do not know the answers to the test. Therefore, different but analogous questions are used (this means that the underlying concept of the question is the same, but the precise numbers or examples used differ from part to part). Candidates were randomly divided into treatment and control groups: all students took the first part of the test without any support materials, but then the "cheat sheet" was distributed to each of the candidates in the treatment group, who then had about ten minutes to examine it before the second part started. Students in the control group simply had a ten minute break after completing the first part of the test, but received the same "cheat sheet" after having completed the second part. Once they received the "cheat sheet" all students could keep it with them until the end of the test (when they had to return it). For fairness purposes only the number of correct answers from the third part (which all students took with the aid of the "cheat sheet") was considered for admission via the special access program, together with other criteria. Also, although the tests were strictly monitored to avoid cheating or copying among students, as a further precaution two versions of the tests were distributed, featuring the same questions in a different order.

2.4. Randomized Control Trial

The staged randomization design described above allows to estimate the impact of "cheat sheets" on test performance, by looking at the differences in the number of questions answered correctly across the three parts of the test between students in the control and treatment groups. In particular, it is possible to compare the difference in the number of questions answered correctly between Part I - Part II and Part II - Part III in the treatment and control groups.[34] Also, it is possible to compare how all students performed in the first part compared to the third part of the exam, and see which students would benefit from or be worse off with the use of "cheat sheets". Finally, it is possible to analyze what is the relationship between the observable student characteristics and the improvement in performance when having access to a "cheat sheet", or with the likelihood of benefiting from or be worse off with its use.

A total of 175 candidates took the mathematical ability test, over the 2013 and 2014 academic year application periods. 57 students took it at the end of 2012 and 118 took it at the end of 2013, respectively. They were

[34]Note, however, that the difference in performance between Part I and Part II need not be comparable with the difference in performance between Part II and Part III. For example, if there is non-linear "learning by doing", or simply if students become tired towards the end of the exam

randomly divided into treatment and control groups, which had access to a "cheat sheet" after the first or second parts of the exam, respectively. For the 2013 application period students were assigned to treatment and control using a stratified randomization. The strata used were: (i) the average score obtained by the secondary school of origin in the standardized SIMCE test, administered to all secondary school students by the Chilean government (note that this is an aggregate measure of secondary school quality, not to be confused with the individual score obtained in admission tests); (ii) whether the student attended a secondary school in the Santiago Metropolitan Region; (iii) whether the student attended a public or subsidized secondary school (note that only students from public or subsidized schools are considered); (iv) whether the student attended the PENTA UC program for talented secondary school students; (v) the quintile of the income distribution to which the student belongs (note that fifth quintile students were not eligible to apply for special admission); and (vi) the student's gender (1 = male). Stratification guarantees balance across strata in the treatment and controls groups, and is particularly important in this case (given the reduced population size, which may have caused balance problems if simple random assignment had been used). Due to logistical limitations, for the 2014 application period simple random assignment was used to divide the students into treatment and control groups (i.e. no strata were taken into account). In total, 79 students were assigned to the treatment group, while 96 were assigned to control. The balance across the two groups is presented on Table II.I, but as expected the joint orthogonality hypothesis cannot be rejected for any of the observed student characteristics.[35]

Figure II.II presents the frequency histograms for the number of correct answers in each of the three parts of the mathematical ability test, by treatment and control group. As it can be observed, it seems that the distribution may be skewed to the left and/or truncated at the maximum possible number of correct answers (particularly after the "cheat sheets" were distributed).

2.5. Findings

2.5.1. Do the "Cheat Sheets" Impact the Performance of Students?

Table II.III analyzes the differences in the number of correct answers in each of the three parts of the mathematical ability test between treatment and control groups. The dependent variable in all regressions

[35] Note that three students who took the mathematical ability test but were found to be ineligible to participate in the special access program due to having attended a private school and/or belonging to the top quintile of the income distribution are excluded from the analysis. Also, it is worth noting that although all students took the test in their assigned group, there were a few students who signed up to take the test but did not show up on the day of the exam and were excluded from the special access program and this analysis. However, the number of no-shows was very limited and affected similarly both the treatment and control groups.

(columns) is the number of correct answers in each corresponding part of the test, and independent variables are listed on the left (rows). Apart from the treatment indicator (first row), for robustness purposes several additional controls are included in the extended specifications (1.2, 2.2 and 3.2). In particular, the linear regression models presented in Table II.III are represented as

$$(.1) \quad y_{ik} = \beta_0 + \delta_1 T_i + year + e_i$$

$$(.2) \quad y_{ik} = \beta_0 + \delta_1 T_i + \sum_{h=1}^{6} \beta_h x_{hi} + year + e_i$$

where y_{ik} is the number of questions answered correctly by student i in part $k = 1, 2, 3$ of the test, T_i is an indicator variable denoting whether the student was assigned to the control or treatment group, *year* is an indicator variable denoting whether the student belongs to the 2014 cohort (year fixed effect), and $x_{hi}h = \{1, ..., 6\}$ are the additional student characteristics which are included in the extended specifications (1.2, 2.2 and 3.2) for robustness purposes. These are the same variables used as strata in the random assignment for the 2013 cohort, i.e.: (i) average score obtained by the secondary school of origin in the standardized test administered to all secondary school students by the Chilean government (SIMCE); (ii) whether the student attended a secondary school in the Santiago Metropolitan Region; (iii) whether the student attended a public school, as opposed to a subsidized one (again, private school students were not eligible to apply for special admission); (iv) whether the student attended the PENTA UC program for talented secondary school students; (v) whether the student belongs to the lower three quintiles of the income distribution (as opposed to the fourth quintile, since as mentioned fifth quintile students were not eligible to apply for special admission); and (vi) the student's gender (1 = male). Huber-White heteroskedasticity-consistent standard errors are reported between parentheses.

Analogously to the above, Table II.IV analyzes the differences in the improvement (i.e. additional number of correct answers) across each of the three parts of the mathematical ability test between treatment and control groups. The dependent variable in all regressions (columns) is the number additional correct answers across the corresponding parts of the test, and independent variables are listed on the left (rows) [36]. As before, apart from the treatment indicator (x.0), several additional controls are included in the (x.1) specifications for robustness purposes. The (x.2) specifications further include the interaction terms between the treatment indicator and the additional controls. In particular, the linear regression models presented in Table II.IV are represented as

[36] For example, in columns (1.0, 1.1 and 1.2 the dependent variable is the number of additional correct answers for each students in Part II of the mathematical ability test, compared to Part I.

$$(.0) \quad \mathrm{y}_{ikl} = \beta_0 + \delta_1 T_i + year + e_i$$

$$(.1) \quad \mathrm{y}_{ikl} = \beta_0 + \delta_1 T_i + \sum_{h=1}^{6} \beta_h x_{hi} + year + e_i$$

$$(.2) \quad \mathrm{y}_{ikl} = \beta_0 + \delta_1 T_i + \sum_{h=1}^{6} \beta_h x_{hi} + \sum_{h=1}^{6} \gamma_h T_i x_{hi} + year + e_i$$

where y_{ikl} is the number of additional questions answered correctly by student i in part $k = 1, 2$ compared to part $l = 2, 3$ of the test, T_i is an indicator variable denoting whether the student was assigned to the control or treatment group, *year* is an indicator variable denoting whether the student belongs to the 2014 cohort (year fixed effect), and $x_{hi}h = \{1, ..., 6\}$ are student characteristics which as mentioned are included in the extended specifications (1.2, 2.2 and 3.2) for robustness purposes. Once again these are the same variables used as strata in the random assignment of the 2013 cohort, i.e.: (i) average score obtained by the secondary school of origin in the standardized test administered to all secondary school students by the Chilean government (SIMCE); (ii) whether the student attended a secondary school in the Santiago Metropolitan Region; (iii) whether the student attended a public school (as opposed to a subsidized one); (iv) whether the student attended the PENTA UC program for talented secondary school students; (v) whether the student belongs to the lower three quintiles of the income distribution (as opposed to the fourth one); and (vi) the student's gender (1 = male). As before Huber-White heteroskedasticity-consistent standard errors are reported between parentheses.

As it can be observed on Table II.III, this chapter only finds a significant difference in the number of questions answered correctly between students in the treatment and control group in Part II of the test. Since as described above this is precisely the part in which candidates in the control group did not yet have access to the "cheat sheet" (as opposed to students in the treatment group), this suggests that *ceteris paribus* having access to a knowledge summaries results in about one additional question answered correctly (out of a total of fifteen). Also, as expected it seems that students who attended a secondary school with a higher average score in the government-administered standardized evaluation test (SIMCE) tend to answer more questions correctly. This is consistent consistent with the stylized fact of positive correlation between secondary school quality and admission test performance. All these results are robust to the inclusion of the additional controls.

Moreover, as it can be observed on Table II.IV, this chapter also finds a significant difference in the improvement (i.e. additional number of questions answered correctly) from Part I to Part II and from part II to Part III between students in the treatment and control groups. In particular, students in the treatment group on average answer correctly almost one additional question in Part II than in Part I, compared to students in the control group who did not have access to a "cheat sheet" during the second part of the test. Analogously, students in the control group on average answer correctly more than half an additional question in Part III than in Part II, after receiving a knowledge summary before the third part of the exam. This again suggests that, as anticipated, having access to a knowledge summaries indeed increased student performance on the test. These results are also robust to the inclusion of the additional controls.

2.5.2. Are Some Students Differentially Impacted by the Use of "Cheat Sheets"?

All the above makes sense, and corroborates the fact that, as expected, students perform better in a test if they have access to a "cheat sheet", and/or if they attended better secondary schools. However, while observing the opposite phenomenon would have raised some concerns, this set of results is not particularly interesting). Nonetheless, most importantly this chapter also finds significant evidence that some students were differentially impacted by the "cheat sheets". In particular, *ceteris paribus* "cheat sheets" were significantly more beneficial for those students who were more likely to have had a secondary education of lower quality. This is, students who attended a secondary school with a lower average score in the government-administered standardized evaluation test (SIMCE) experienced a significantly greater differential improvement in the number of questions answered correctly when using a "cheat sheet". Or in other words, there is evidence of a significant negative effect of secondary school government-administered standardized evaluation (SIMCE) on the differential improvement in test performance after students have access to a "cheat sheet". This is observable both in the significantly greater differential improvement from Part I to Part II for students in the treatment group (i.e. after they received the "cheat sheet" at the end of the first part), and in the significantly greater differential improvement from Part II to Part III for students in the control group (i.e. after they received the "cheat sheet" at the end of the second part). Also, no differential impact is observed for the comparisons of Part III vs. Part I. This is consistent with the fact that all candidates completed both Part I and Part III in the same conditions, since no differential impact should be expected in this case (unless having access to the "cheat sheet" for a longer amount of time does matter).

Also, although the results are less robust than those presented above, this chapter also finds some evidence of a positive differential impact of having access to a "cheat sheet" on candidates enrolled in PENTA UC (an extension program for talented secondary school students). Since students enrolled in this program come from disadvantaged backgrounds, and were already screened during their secondary education and identified as possessing "exceptional ability", this suggests that *ceteris paribus* the use of "cheat sheets" may be particularly beneficial for talented students. Also, there is some evidence that while students from public schools or the lower quintiles of the income distribution may benefit from "cheat sheets", they may need more time to do so (or at least more than the amount which was provided in this experiment), for example because they need some time to analyze and comprehend it. These results point in the same direction of the results discussed above, but these relationships are confounded by the fact that the control group also received "cheat sheets" at the end of the second part. Therefore, it is not possible to identify whether these are in fact delayed improvements in the treatment group, or if (although unlikely) the "cheat sheet" instead had a negative impact on the performance of some students in the control group after they received it. Finally, a few other significant relationships can be observed on Table II.IV, but no other robust causal relationships have been detected.

Table II.V further analyzes the relationship between the improvement (i.e. additional number of correct answers) across each of the parts of the mathematical ability test and the student characteristics, by looking separately at the treatment and control groups. Each column corresponds to one regression specification, and independent variables are listed on the left (rows). Two sets of specifications are presented stacked over each other: in the first set of regressions (,1) the dependent variable is the improvement between Part I and Part II of the test for students in the treatment group, who received the cheat sheet before taking the second part of the exam; in the second set of regressions (,2) the dependent variable is the improvement between Part II and Part III of the test for students in the control group, who received the cheat sheet before taking the third part of the exam. All six independent variables are first considered jointly (0.), and then separately (1. -6.). In particular, the linear regression models presented in Table II.V are represented as

$$(0.1) \qquad y_i = \beta_0 + \sum_{h=1}^{6} \beta_h x_{hi} + year + e_i \text{ if } T_i = 1$$

$$(1.1\text{–}6.1) \qquad y_i = \beta_0 + \beta_h x_{hi} + year + e_i \text{ if } T_i = 1$$

$$(0.2) \qquad y_i = \beta_0 + \sum_{h=1}^{6} \beta_h x_{hi} + year + e_i \text{ if } T_i = 0$$

$$(1.2\text{–}6.2) \qquad y_i = \beta_0 + \beta_h x_{hi} + year + e_i \text{ if } T_i = 0$$

where y_i is the number of additional questions answered correctly by student i in Part II compared to Part I (0,1) – (6,1) or in Part III compared to Part II (0,2) – (6,2), $year$ is an indicator variable denoting whether the student belongs to the 2014 cohort (year fixed effect), and $x_{h_i} h = \{1, ..., 6\}$ are once again student characteristics. As before these are the same variables used as strata in the 2013 random assignment, i.e.: (i) average score obtained by the secondary school of origin in the standardized test administered to all secondary school students by the Chilean government (SIMCE); (ii) whether the student attended a secondary school in the Santiago Metropolitan Region; (iii) whether the student attended a public school (as opposed to a subsidized one); (iv) whether the student attended the PENTA UC program for talented secondary school students; (v) whether the student belongs to the lower three quintiles of the income distribution (as opposed to the fourth one); and (vi) the student's gender (1 = male). As usual Huber-White heteroskedasticity-consistent standard errors are reported between parentheses.

As it can be observed on Table II.V, this approach again finds evidence that the performance of students who attended a secondary school with a lower average score in the government-administered standardized evaluation test (SIMCE) improved significantly more than that of their peers when being able to use a "cheat sheet". This supports the above presented results, and again suggests that ***ceteris paribus*** the use of "cheat sheets" was particularly beneficial for students with a secondary education of worse quality. Apart from the above, a few other significant relationships can again be observed on Table II.V, but as in the case of Table II.IV no other robust causal relationships have been detected.

2.5.3. Which Students Benefit From (or Are Worse Off With) the "Cheat Sheets"?

For illustration purposes, let's ignore the rest of the criteria used in the special admission program, and assume that the mathematical ability test would have determined admission to the university on its own. If only 20 slots were available, who would benefit from (or be worse off with) the use of "cheat sheets"?. Or in other words, who would make it to the top 20 in Part I, but be excluded from it on Part III?[37]

Table II.VI presents a roster of all the students who benefit from, or are worse off with, the use of cheat sheets. This is measured by whether they advanced to, or were relegated from, the group of top 20 candidates who would be admitted via the special access program. This is observed by comparing the rank of each candidate in Part I (which all students completed without a cheat sheet) and Part III (which all students completed with a cheat sheet), as defined by the number of correct answers relative to the other students who took the exam. Ties among students with the same number of correct students are resolved randomly, so the results of this exercise are not robust at the candidate level (given the reduced number of questions in each part of the test, and the left-skewed distribution of the number of correctly answered questions, there are many ties which are broken randomly). However, they provide an overview of how the introduction of "cheat sheets" would have affected the admission process. Each row corresponds to one student, for which the rank and number of correct answers in each of the three parts of the mathematical ability test are listed. Finally, the last column indicates whether the student was in the treatment or control group.

As it can be observed on Table II.VI, according to the results of the exercise the use of "cheat sheets" seems to mainly affect students close to the cut-off, but there are also cases of very big changes in ranking. For example, one student only answered correctly to 10 questions (66 %) in Part I, so that at that point would not have ranked in the top 100 among all candidates who took the test. However, with the "cheat sheet" in

[37] Note that in reality 20 special access vacancies were available for each of the 2013 and 2014 admission years, so that 40 vacancies would be available for the two cohorts.

Part III s/he answered correctly to all 15 questions (100 %), and would have subsequently made it to the top 10[38].

Table II.VII then analyzes the relationship between student characteristics and the likelihood of benefiting from (or being worse off with) the use of cheat sheets. This is measured as the likelihood of advancing to (or being relegated from) the group of top 20 candidates who would be admitted via the special access program. As in the case above, this is obtained by comparing the rank of each candidate in Part I (which all students completed without a cheat sheet) and Part III (which all students completed with a cheat sheet), as defined by the number of correct answers relative to the other students who took the exam. Ties among students with the same number of correct students are again resolved randomly, and as before this may affect which particular students make it or not to the top 20, but the results are in any case quantitatively comparable. Each column of the table corresponds to one regression specification, and independent variables are listed on the left (rows). Two sets of specifications are presented stacked over each other: in the first set of regressions (,1) the dependent variable is the binomial indicator of whether the student benefited from the use of a cheat sheet (i.e. whether s/he made it to the top 20 in Part III but not Part I); in the second set of regressions (,2) the dependent variable is the binomial indicator of whether the student was worse off with the use of a cheat sheet (i.e. whether s/he made it to the top 20 in Part I but not Part III). All six independent variables are first considered jointly (0.x), and then separately (1.x-6x). In particular, the linear regression models presented in Table II.VI are represented as

$$(0.1) \qquad y_{1i} = \beta_0 + \sum_{h=1}^{6} \beta_h x_{hi} + year + e_i$$

$$(1.1\text{–}6.1) \quad y_i = \beta_0 + \beta_h x_{hi} + year + e_i$$

$$(0.2) \qquad y_{2i} = \beta_0 + \sum_{h=1}^{6} \beta_h x_{hi} + year + e_i$$

$$(1.2\text{–}6.2) \quad y_i = \beta_0 + \beta_h x_{hi} + year + e_i$$

where y_{1i} is an indicator variable equal to one if the student benefited from the use of a cheat sheet (i.e. whether s/he made it to the top 20 in Part III but not Part I), y_{2i} is an indicator variable equal to one if the student was worse off with the use of a cheat sheet (i.e. whether s/he made it to the top 20 in Part I but not Part III), and *year* is an indicator variable denoting whether the student belongs to the 2014 cohort (year fixed effect). As before, $x_{h_i}h = \{1, ..., 6\}$ are observable student characteristics. As usual these are the same variables used as strata in the random assignment for the 2013 cohort, i.e.: (i) average score

[38]Note that although s/he was in the treatment from Part I to Part II, s/he only answered one additional question correctly, with the sharp improvement occurring from Part II to Part III. This again suggests that students may benefit from having more time to review the "cheat sheet".

obtained by the secondary school of origin in the standardized test administered to all secondary school students by the Chilean government (SIMCE); (ii) whether the student attended a secondary school in the Santiago Metropolitan Region; (iii) whether the student attended a public school (as opposed to a subsidized one); (iv) whether the student attended the PENTA UC program for talented secondary school students; (v) whether the student belongs to the lower three quintiles of the income distribution (as opposed to the fourth one); and (vi) the student's gender (1 = male). As usual Huber-White heteroskedasticity-consistent standard errors are reported between parentheses.

Unfortunately, the estimated coefficients from this specification, presented on Table II.VII, are very sensitive to the above described random tie breaking among students who answered correctly to the same number of questions. This can have a great impact on the characteristics of the candidates who would be "worse-off" and "better-off" with the introduction of "cheat sheets", and therefore these results are presented in this chapter for illustration purposes but not further discussed.

2.6. Robustness

Given the relatively reduced number of students involved in the study, the main robustness concern is precision, i.e. limited statistical power. Although this would not affect the validity of the main results presented, which seem to be very robust, this would reduce the likelihood of observing smaller effect sizes (and therefore the lack of an observed significant effect in this study must be interpreted as lack of evidence, not as proof of non-existence). On a related note, given the limited size of the sample both the Central Limit Theorem and the Law of Large Numbers (on which the standard linear regression models rely) might not hold, potentially threatening the validity of the econometric models used. However, given that the pooled sample for academic years 2013 and 2014 features in excess of 150 observations, this is considered unlikely (and no evidence of it is found).

Also, as already mentioned some students who signed up for the test and were included in the stratified random assignment did not show up. However, the number of individuals who signed up but did not show up was very reduced, and no differential pattern is observable, either among the no-shows, or across the treatment and control groups. Therefore, this is not considered a threat to internal validity.

Moreover, although the random assignment (stratified in 2013, simple in 2014) seems to have been quite successful, and the balance across treatment and control groups seems to be quite robust, the randomized control trial design only guarantees the exogeneity of the treatment (i.e. the use of "cheat sheets" in Part II of the test). All the other student characteristics discussed in this chapter are therefore potentially endogenous, and their relationship with the independent variables in the specifications above should be interpreted with care. That said, given that as mentioned before the pooled sample for academic years 2013 and 2014 features in excess of 150 observations, as that as it can be observed on Table II.I the joint orthogonality hypothesis cannot be rejected for any of the observed student characteristics, this is again not considered a serious threat to internal validity.

Furthermore, note that the most robust comparison of treatment and control is that of the difference in the number of correctly answered questions between Part I and Part II of the exam (i.e. columns (1.x) in Table II.IV). This is because, as already mentioned, the comparison of Part III and Part II is confounded by the fact that the control group also received "cheat sheets" at the end of the second part, so that it is not possible to identify whether the observed impacts are delayed improvements in the treatment group (or if for example the "cheat sheet" instead had a negative impact on the performance of some students in the control group after they received it). Also, note that according to Table II.IV there is some evidence that some students in the treatment group improved significantly more from Part I to Part III, compared to their counterparts in the control group. This may indicate that receiving the "cheat sheet" earlier might have had a positive impact on performance (e.g. because students have more time to examine it). This suggests that "cheat sheets" may be more effective to address knowledge gaps if more time is provided for the students to familiarize themselves with it before taking the test.

Regarding external validity, it is worth noting that all the observations in this analysis correspond to students from disadvantaged backgrounds who believed both that they may not be able to obtain admission in a prestigious undergraduate program in Chile, and that they were nonetheless talented enough to prevail among their peers and obtain admission through an special access program. This means that apart from maybe being more talented, these students may also be more motivated, confident, or risk-averse than their peers. Therefore, the impact of using "cheat sheets" for the general student population may differ from the one observed in this study.

Also, although as noted there were many observable differences among candidates (which were large enough to allow for the detection of some significant effects) the students in this study were relatively similar to each other (e.g. there were no students from elite private schools). This may also pose a threat to external validity, as the impact of "cheat sheets" may be larger when including students with really good secondary education in the analysis. Or, conversely, those students may benefit even more from having a knowledge summary, thus reducing the differential impact with respect to students from disadvantaged backgrounds.

Moreover, the students who took the mathematical ability test were not aware that "cheat sheets" would be provided. It is conceivable to think that if they had known about this fact, they may have prepared for the exam in a different manner. This may also affect the external validity of the results presented in this chapter.

Finally, note also that the distribution of the number of correct answers seems to be skewed to the left and/or truncated on the right. This might point towards the format of the mathematical ability test custom-designed for this study to be too easy, either because the number of questions was too low, and/or because the time allowance was too long.

2.7. Conclusion

This chapter presents a diagnostics experiment, intended to better understand the role played by admissions tests in the access to higher education. In particular, I custom-designed a multiple-choice mathematical ability test, intended to measure an individual's ability while minimizing the reliance on previously acquired specific knowledge. Moreover, I also put together a two page knowledge summary, or "cheat sheet", which outlined all the concepts which I considered necessary to successfully complete the test, without providing explicit answers to exam questions. This mathematical ability test was subsequently used to screen candidates applying for admission into one of the leading Chilean universities via a special access program. It was divided in three parts, which featured 15 analogous questions each (i.e. the first questions of each part were different but analogous), and candidates were randomly divided into treatment and control groups. All students took the first part of the test without any support materials, but students in the treatment group had access to a "cheat sheet" before the second part of the exam, while students in the control group did not have access to a "cheat sheet" until before its third part. This staged randomization design allowed to estimate the impact of the "cheat sheet" on student test performance, by looking at the differences in the number of questions answered correctly across the three parts of the test between students in the control and treatment groups.

This chapter only finds a significant difference in the number of questions answered correctly between students in the treatment and control group in Part II of the test. Since this is precisely the part in which candidates in the control group did not yet have access to the "cheat sheet" (as opposed to students in the treatment group), this suggests that *ceteris paribus* having access to a knowledge summaries results in improved academic performance. Also, this chapter also finds a significant difference in the improvement (i.e. additional number of questions answered correctly) from Part I to Part II and from part II to Part III between students in the treatment and control groups. In particular, students in the treatment group perform significantly better in Part II than in Part I, compared to students in the control group (who did not have access to a "cheat sheet" during the second part of the test). Analogously, students in the control group perform significantly better in Part III than in Part II (i.e. after receiving a knowledge summary before the third part of the exam). This again suggests that having access to a knowledge summaries improves student performance on the test. Moreover, it seems that students who attended a secondary school with a higher average score in the government-administered standardized evaluation test (SIMCE) tend to answer more questions correctly, corroboration the stylized fact of positive correlation between secondary school quality and admission test performance.

While all the above makes sense, and corroborates the fact that as expected students perform better in a test if they have access to a "cheat sheet", it is not a particularly interesting set of results. However, most importantly this chapter also finds significant evidence that "cheat sheets" are significantly more beneficial for those students who were more likely to have had a secondary education of lower quality. In particular, students who attended a secondary school with a lower average score in the government-administered standardized evaluation test (SIMCE) tend to experience a significantly greater differential improvement in the number of questions answered correctly when using a "cheat sheet". Or in other words, there is evidence of a significant negative effect of secondary school government-administered standardized evaluation (SIMCE) on the differential improvement in test performance after students have access to a "cheat sheet". This is observable both in the significantly greater differential improvement from Part I to Part II for students in the treatment group (i.e. after they received the "cheat sheet" at the end of the first part), and in the significantly greater differential improvement from Part II to Part III for students in the control group (i.e. after they received the "cheat sheet" at the end of the second part). Also, no differential impact is observed for the comparisons of Part III vs. Part I, consistent with the fact that all candidates completed both Part I and Part III in the same conditions (no differential impact should be expected in this case, unless having access to the "cheat sheet" for a longer amount of time does matter).

Moreover, although the results are less robust than those presented above, this chapter also finds some evidence of a positive differential impact of having access to a "cheat sheet" on candidates enrolled in the PENTA UC program for talented secondary school students. Since students enrolled in the PENTA UC program come from disadvantaged backgrounds, and were already screened during their secondary education and identified as possessing "exceptional ability", this suggests that *ceteris paribus* the use of "cheat sheets" may be particularly beneficial for talented students. Also, there is some evidence that while students from public schools or the lower quintiles of the income distribution may benefit from "cheat sheets", they may need more time to do so than the amount provided between the parts of the exam in this experiment (e.g. because they may need more time to analyze and comprehend it).

Finally, a simulation exercise is performed for illustration purposes. It consists of an analysis of which candidates would benefit from (or would be worse off with) the use of cheat sheets, as measured by whether they advanced to or were relegated from the group of top 20 candidates (which is the number of vacancies available each year for admission via the special access program featured in this study). This is performed by comparing the rank of each candidate in Part I (which all students completed without a cheat sheet) and Part III (which all students completed with a cheat sheet), as defined by the number of correct answers relative to the other students who took the exam. The results of this exercise are not robust at the candidate level, since given the reduced number of questions in each part of the test, and the left-skewed distribution of the number of correctly answered questions, there are many ties which are broken randomly. However, they provide an insight of how the introduction of "cheat sheet" may have affected the selection process, if the mathematical ability test was the only criterion used to determine admission. In particular, according to the results of this simulation exercise the use of "cheat sheets" would mainly affect students close to the cut-off, but there are also cases of very large changes in ranking from Part I to Part III of the test.

All the above has important implications for educational policies in Chile and elsewhere, suggesting that a transition to ability-focused admission tests would facilitate the access to higher education for talented students from disadvantaged backgrounds. In the long term this would likely entail a redesign of current admission tests, but interim remedies such as knowledge summaries or "open book" exams may help to alleviate access to higher education problems in the short and medium term. Also, it is worth noting that this measures would be a complement, but not a substitute to deeper educational reform. In particular, it seems that the first best solution would still involve to improve the quality of secondary education for all, in order to avoid the current formative shortcomings suffered by students from disadvantaged socioeconomic backgrounds.

TABLE II.I

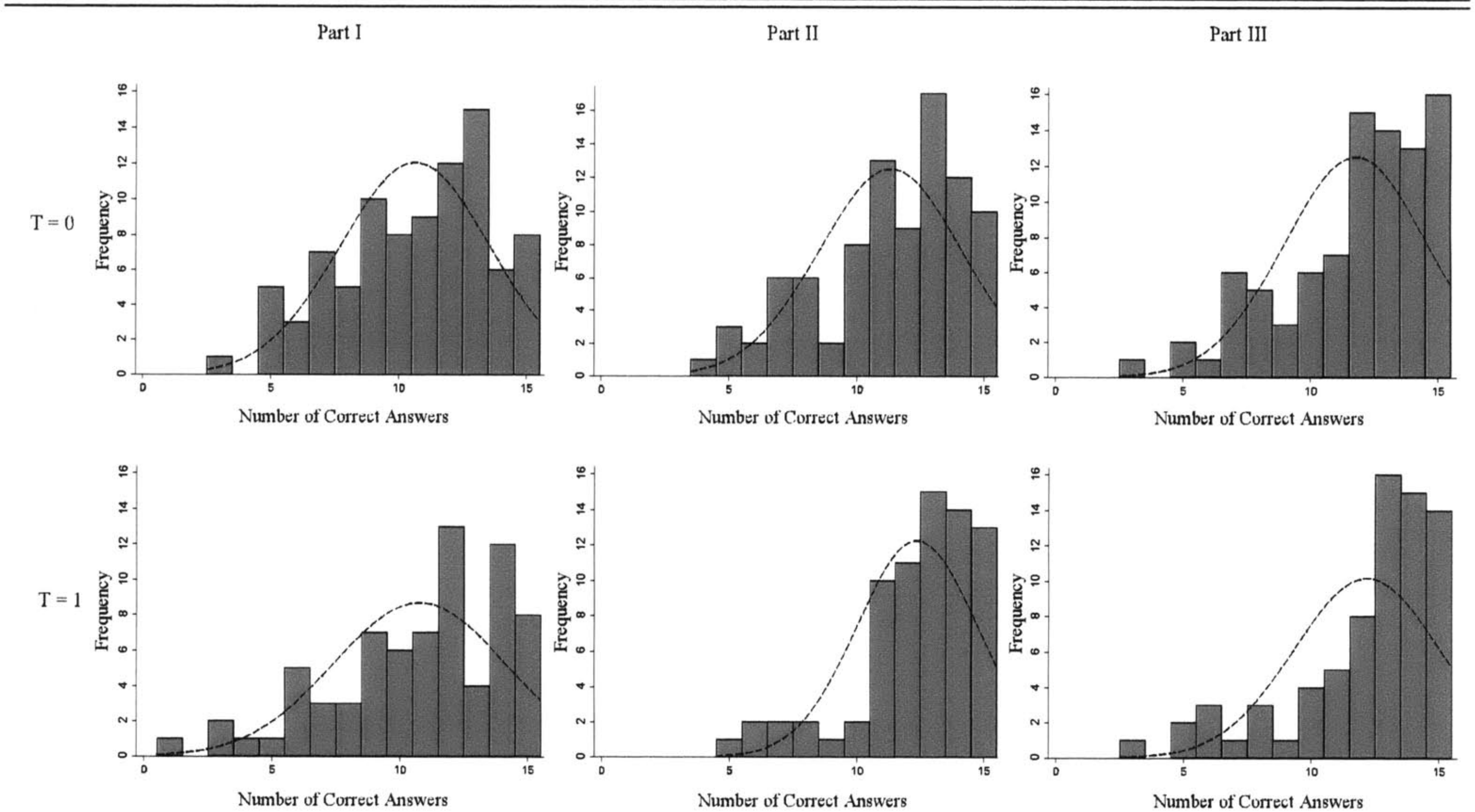
BALANCE ACROSS CONTROL AND TREATMENT GROUPS

	Control (Cheat Sheet in Part III)	Treatment (Cheat Sheet in Part II)	p-value
Secondary School Standardized Math Test Score (SIMCE)	290.52	290.00	0.95
	(5.58)	(4.96)	
Region (1 = Santiago Metropolitan Region)	0.17	0.16	0.94
	(0.04)	(0.04)	
Secondary School Type (1 = Public)	0.36	0.28	0.27
	(0.05)	(0.05)	
PENTA UC Program Fellow (1 = Yes)	0.04	0.07	0.52
	(0.02)	(0.03)	
Income Distribution Quintile (1 = I)	0.24	0.18	0.35
	(0.05)	(0.05)	
Income Distribution Quintile (1 = II)	0.26	0.33	0.35
	(0.05)	(0.06)	
Income Distribution Quintile (1 = III)	0.33	0.27	0.45
	(0.05)	(0.05)	
Gender (1 = Male)	0.42	0.47	0.53
	(0.05)	(0.06)	
Observations	89	73	

NOTES. Candidates seeking to enter the undergraduate degree via the special admission program for students from disadvantaged socioeconomic backgrounds took a multiple-choice mathematical test, which was custom-designed to try to measure the individual's ability while minimizing the reliance on previously acquired knowledge. The objective was to try to identify talented individuals who may have had a secondary education of poor quality, but who would otherwise be able to successfully complete the undergraduate degree. The mathematical test was divided in three parts, which featured 15 analogous questions each (i.e. the first questions of each part were different but analogous), and candidates were randomly divided into stratified treatment and control groups. All students took the first part of the test without any support materials, but then a "cheat sheet" (i.e. knowledge summaries outlining the basic concepts needed to successfully answer the test questions) was distributed to each of the candidates in the treatment group, who then had about ten minutes to examine it before the second part started. Students in the control group simply had a ten minute break after completing the first part of the test, but received the same "cheat sheet" after having completed the second part. Once they received the "cheat sheet" all students could keep it with them until the end of the test, and for fairness purposes only the number of correct answers from the third part (which all students took with the aid of the "cheat sheet") was considered for admission via the special access program, together with several other criteria. However, this staged randomization design allows to analyze the impact of the cheat sheet on the students' performance on the test. The above table provides an overview of the balance between control and treatment groups after the stratified random assignment. Each cell presents the mean of the balance variable (row) in group (column), and standard errors are reported between parentheses. Balance variables are: (i) the math score obtained in the standardized test administered to secondary school students (SIMCE) (ii) whether the student attended a secondary school in the Santiago Metropolitan Region, (iii) whether the student attended a public school, as opposed to a subsidized one (private school students were not eligible to apply for special admission) , (iv) whether the student attended the PENTA UC program for talented secondary school students, (v) whether the student belongs to the lower three quintiles of the income distribution, as opposed to the fourth quintile (fifth quintile students were not eligible to apply for special admission), and (vi) the student's gender (1 = male). Reported p-values are for joint orthogonality test across control and treatment groups each of the corresponding balance variables.

FIGURE II.II

FREQUENCY HISTOGRAM OF NUMBER OF CORRECT ANSWERS IN EACH OF THREE PARTS OF MATHEMATICAL ABILITY TEST BY TREATMENT AND CONTROL GROUP



NOTES. The graphics above are frequency histograms for the number of correct answers in each of the three parts of the mathematical ability test (columns) by control and treatment groups (rows). As already mentioned, the mathematical test was divided in three parts, which featured 15 analogous questions each (i.e. the first questions of each part were different but analogous), and candidates were randomly divided into stratified treatment and control groups. All students took the first part of the test without any support materials, but then a "cheat sheet" (i.e. knowledge summaries outlining the basic concepts needed to successfully answer the test questions) was distributed to each of the candidates in the treatment group, who then had about ten minutes to examine it before the second part started. Students in the control group simply had a ten minute break after completing the first part of the test, but received the same "cheat sheet" after having completed the second part. Once they received the "cheat sheet" all students could keep it with them until the end of the test, and for fairness purposes only the number of correct answers from the third part (which all students took with the aid of the "cheat sheet") was considered for admission via the special access program, together with several other criteria. The vertical axes show the number of observations in each bin (i.e. the number of students who answered correctly the corresponding number of times), and the horizontal axes denote the number of correct answers in each part of the test. T = 0 denotes the control group (first row) and T = 1 denotes the treatment group. The dotted lines depict the fitted normal distributions for each subpopulation.

TABLE II.III

DIFFERENCES IN NUMBER OF CORRECT ANSWERS IN EACH OF THREE PARTS OF MATHEMATICAL ABILITY TEST BETWEEN TREATMENT AND CONTROL GROUPS

	Part I		Part II		Part III	
Number of Correct Answers in Each Part of the Test	(1.1)	(1.2)	(2.1)	(2.2)	(3.1)	(3.2)
Treatment (1 = Cheat Sheet in Part II)	0.164	-0.019	1.075	1.064	0.425	0.261
	(0.502)	(0.443)	(0.410)***	(0.381)***	(0.450)	(0.429)
Secondary School Standardized Math Test Score (SIMCE)		0.031		0.024		0.023
		(0.011)***		(0.008)***		(0.010)**
Region (1 = Santiago Metropolitan Region)		-0.013		-0.421		-0.022
		(0.651)		(0.579)		(0.541)
Secondary School Type (1 = Public)		-0.442		-0.408		-0.607
		(0.480)		(0.407)		(0.484)
PENTA UC Program Fellow (1 = Yes)		0.558		-0.349		-0.034
		(0.589)		(0.605)		(0.574)
Income Distribution Quintile (1 = I)		-1.361		-0.916		-1.173
		(0.720)*		(0.631)		(0.678)*
Income Distribution Quintile (1 = II)		-0.574		-0.214		-0.195
		(0.634)		(0.525)		(0.579)
Income Distribution Quintile (1 = III)		-0.257		-0.044		-0.173
		(0.499)		(0.414)		(0.483)
Gender (1 = Male)		1.753		1.281		1.380
		(0.459)***		(0.394)***		(0.444)***
Admission Year (1 = 2014)	-0.539	-0.091	-0.645	-0.210	-0.453	-0.122
	(0.500)	(0.427)	(0.411)	(0.361)	(0.445)	(0.414)
Constant Term	10.986	1.817	11.750	4.323	12.077	5.104
	(0.433)***	(3.324)	(0.370)***	(2.605)*	(0.390)***	(2.996)*
R^2	0.01	0.35	0.05	0.34	0.01	0.26
Observations	162	152	162	152	162	152

* $p<0.1$; ** $p<0.05$; *** $p<0.01$

NOTES. This table analyzes the differences in the number of correct answers in each of the three parts of the mathematical ability test between the randomly assigned treatment and control groups. As already mentioned, the mathematical test was divided in three parts, which featured 15 analogous questions each (i.e. the first questions of each part were different but analogous), and candidates were randomly divided into stratified treatment and control groups. All students took the first part of the test without any support materials, but then a "cheat sheet" (i.e. knowledge summaries outlining the basic concepts needed to successfully answer the test questions) was distributed to each of the candidates in the treatment group, who then had about ten minutes to examine it before the second part started. Students in the control group simply had a ten minute break after completing the first part of the test, but received the same "cheat sheet" after having completed the second part. Once they received the "cheat sheet" all students could keep it with them until the end of the test, and for fairness purposes only the number of correct answers from the third part (which all students took with the aid of the "cheat sheet") was considered for admission via the special access program, together with several other criteria. The dependent variable in all regressions (columns) is the number of correct answers in each corresponding part of the test, and independent variables are listed on the left (rows). Apart from the treatment indicator (first row), several additional controls are included in the extended specifications (1.2, 2.2 and 3.2) for robustness purposes. These are: (i) the math score obtained in the standardized test administered to secondary school students (SIMCE) (ii) whether the student attended a secondary school in the Santiago Metropolitan Region, (iii) whether the student attended a public school, as opposed to a subsidized one (private school students were not eligible to apply for special admission), (iv) whether the student attended the PENTA UC program for talented secondary school students, (v) whether the student belongs to the lower three quintiles of the income distribution, as opposed to the fourth quintile (fifth quintile students were not eligible to apply for special admission), and (vi) the student's gender (1 = male). A 2014 admission year fixed effect is included (base category is admission year 2013). Huber-White heteroskedasticity-consistent standard errors are reported between parentheses.

TABLE II.IV

DIFFERENCES IN IMPROVEMENT (ADDITIONAL CORRECT ANSWERS) ACROSS PARTS OF MATHEMATICAL ABILITY TEST BETWEEN TREATMENT AND CONTROL GROUPS

	Part II - Part I			Part III - Part II			Part III - Part I		
Improvement (Additional Correct Answers)	(1.0)	(1.1)	(1.2)	(2.0)	(2.1)	(2.2)	(3.0)	(3.1)	(3.2)
Treatment (1 = Cheat Sheet in Part II)	0.911	1.083	10.834	-0.650	-0.804	-11.782	0.261	0.280	-0.948
	(0.274)***	(0.294)***	(3.300)***	(0.273)**	(0.309)**	(3.331)***	(0.276)	(0.281)	(2.330)
Secondary School Standardized Math Score		-0.006	0.002		-0.001	-0.008		-0.007	-0.005
		(0.004)	(0.003)		(0.004)	(0.003)**		(0.003)**	(0.003)*
Region (1 = Santiago Metropolitan Region)		-0.408	0.007		0.398	0.441		-0.009	0.448
		(0.378)	(0.455)		(0.422)	(0.467)		(0.428)	(0.512)
Secondary School Type (1 = Public)		0.034	0.323		-0.198	0.270		-0.165	0.593
		(0.333)	(0.320)		(0.368)	(0.396)		(0.314)	(0.390)
PENTA UC Program Fellow (1 = Yes)		-0.907	-1.446		0.315	0.319		-0.592	-1.126
		(0.424)**	(0.348)***		(0.360)	(0.464)		(0.517)	(0.501)**
Income Distribution Quintile (1 = I)		0.446	0.422		-0.257	-0.999		0.188	-0.577
		(0.391)	(0.423)		(0.461)	(0.566)*		(0.461)	(0.583)
Income Distribution Quintile (1 = II)		0.360	0.575		0.019	-0.712		0.379	-0.137
		(0.376)	(0.464)		(0.364)	(0.523)		(0.401)	(0.545)
Income Distribution Quintile (1 = III)		0.213	0.310		-0.129	-0.273		0.084	0.037
		(0.352)	(0.412)		(0.350)	(0.489)		(0.404)	(0.537)
Gender (1 = Male)		-0.472	-0.353		0.100	0.183		-0.373	-0.170
		(0.260)*	(0.305)		(0.281)	(0.340)		(0.272)	(0.316)
Admission Year (1 = 2014)	-0.106	-0.119	-0.093	0.192	0.088	0.420	0.086	-0.031	0.328
	(0.275)	(0.282)	(0.317)	(0.282)	(0.312)	(0.369)	(0.279)	(0.307)	(0.425)
Secondary School Standardized Math Score			-0.032			0.027			-0.005
* Treatment			(0.007)***			(0.008)***			(0.006)
Region (1 = Santiago Metropolitan Region)			-0.843			-0.302			-1.145
* Treatment			(0.728)			(0.789)			(0.821)
Secondary School Type (1 = Public)			0.222			1.547			1.769
* Treatment			(0.698)			(0.681)**			(0.549)***
PENTA UC Program Fellow (1 = Yes)			1.488			0.155			1.643
* Treatment			(0.667)**			(0.989)			(0.807)**
Income Distribution Quintile (1 = I)			-0.857			2.017			1.160
* Treatment			(0.822)			(0.953)**			(0.930)
Income Distribution Quintile (1 = II)			-0.974			1.730			0.756
* Treatment			(0.793)			(0.717)**			(0.829)
Income Distribution Quintile (1 = II)			-1.007			0.722			-0.285
* Treatment			(0.693)			(0.705)			(0.824)
Gender (1 = Male)			-0.407			-0.165			-0.572
* Treatment			(0.532)			(0.580)			(0.570)
Admission Year (1 = 2014)			0.080			-0.717			-0.637
* Treatment			(0.544)			(0.592)			(0.592)
Constant Term	0.765	2.506	-0.290	0.326	0.781	2.745	1.091	3.287	2.455
	(0.209)***	(1.270)*	(0.836)	(0.228)	(1.166)	(1.136)**	(0.247)***	(0.908)***	(0.995)**
R^2	0.07	0.16	0.33	0.04	0.06	0.18	0.01	0.09	0.20
Observations	162	152	152	162	152	152	162	152	152

* $p<0.1$; ** $p<0.05$; *** $p<0.01$

NOTES. See next page.

TABLE II.IV

DIFFERENCES IN IMPROVEMENT (ADDITIONAL CORRECT ANSWERS) ACROSS PARTS OF MATHEMATICAL ABILITY TEST BETWEEN TREATMENT AND CONTROL GROUPS

NOTES. This table analyzes the differences in the improvement (additional correct answers) across each of the parts of the mathematical ability test between the randomly assigned treatment and control groups. As already mentioned, the mathematical test was divided in three parts, which featured 15 analogous questions each (i.e. the first questions of each part were different but analogous), and candidates were randomly divided into stratified treatment and control groups. All students took the first part of the test without any support materials, but then a "cheat sheet" (i.e. knowledge summaries outlining the basic concepts needed to successfully answer the test questions) was distributed to each of the candidates in the treatment group, who then had about ten minutes to examine it before the second part started. Students in the control group simply had a ten minute break after completing the first part of the test, but received the same "cheat sheet" after having completed the second part. Once they received the "cheat sheet" all students could keep it with them until the end of the test, and for fairness purposes only the number of correct answers from the third part (which all students took with the aid of the "cheat sheet") was considered for admission via the special access program, together with several other criteria. The dependent variable in all regressions (columns) is the number of additional correct answers across corresponding parts of the test, and independent variables are listed on the left (rows). For example, in columns (1.0, 1.1 and 1.2 the dependent variable is the number of additional correct answers for each students in Part II of the mathematical ability test, compared to Part I. Apart from the treatment indicator (x.0), several additional controls are included in the (x.1) specifications for robustness purposes. The (x.3) specifications further include the interaction terms between the treatment indicator and the additional controls. The latter are: (i) the math score obtained in the standardized test administered to secondary school students (SIMCE) (ii) whether the student attended a secondary school in the Santiago Metropolitan Region, (iii) whether the student attended a public school, as opposed to a subsidized one (private school students were not eligible to apply for special admission), (iv) whether the student attended the PENTA UC program for talented secondary school students, (v) whether the student belongs to the lower three quintiles of the income distribution, as opposed to the fourth quintile (fifth quintile students were not eligible to apply for special admission), and (vi) the student's gender (1 = male). A 2014 admission year fixed effect is included (base category is admission year 2013). Huber-White heteroskedasticity-consistent standard errors are reported between parentheses.

TABLE II.V

RELATIONSHIP BETWEEN IMPROVEMENT (ADDITIONAL CORRECT ANSWERS) ACROSS PARTS OF MATHEMATICAL ABILITY TEST AND STUDENT CHARACTERISTICS

Part I – Part II (Treatment = 1, i.e. Cheat Sheet from Part II)	(0.1)	(1.1)	(2.1)	(3.1)	(4.1)	(5.1)	(6.1)
Secondary School Standardized Math Test Score (SIMCE)	-0.029	-0.027					
	(0.007)***	(0.004)***					
Region (1 = Santiago Metropolitan Region)	-0.836		-0.472				
	(0.573)		(0.595)				
Secondary School Type (1 = Public)	0.101			-0.870			
	(0.626)			(0.548)			
PENTA UC Program Fellow (1 = Yes)	0.042				-0.617		
	(0.574)				(0.598)		
Income Distribution Quintile (1 = I)	-0.435					1.118	
	(0.712)					(0.653)*	
Income Distribution Quintile (1 = II)	-0.398					0.667	
	(0.649)					(0.535)	
Income Distribution Quintile (1 = III)	-0.696					0.442	
	(0.563)					(0.598)	
Gender (1 = Male)	-0.760						-0.670
	(0.440)*						(0.427)
Admission Year (1 = 2014)	-0.013	-0.208	-0.179	-0.212	-0.240	-0.331	-0.190
	(0.446)	(0.452)	(0.514)	(0.536)	(0.517)	(0.467)	(0.506)
Constant Term	10.988	9.685	1.803	2.004	1.809	1.290	2.045
	(2.175)***	(1.530)***	(0.442)***	(0.469)***	(0.450)***	(0.440)***	(0.521)***
R^2	0.39	0.33	0.01	0.04	0.01	0.04	0.04
Observations	68	68	73	68	73	73	73
Part III – Part II (Treatment = 0, i.e. Cheat Sheet from Part III)	**(0.2)**	**(1.2)**	**(2.2)**	**(3.2)**	**(4.2)**	**(5.2)**	**(6.2)**
Secondary School Standardized Math Test Score (SIMCE)	-0.008	-0.006					
	(0.003)**	(0.003)**					
Region (1 = Santiago Metropolitan Region)	0.441		0.351				
	(0.464)		(0.474)				
Secondary School Type (1 = Public)	0.270			0.012			
	(0.394)			(0.366)			
PENTA UC Program Fellow (1 = Yes)	0.319				0.071		
	(0.461)				(0.499)		
Income Distribution Quintile (1 = I-III)	-0.999					-0.551	
	(0.562)*					(0.537)	
Income Distribution Quintile (1 = V)	-0.712					-0.435	
	(0.519)					(0.506)	
Income Distribution Quintile (1 = III)	-0.273					-0.224	
	(0.486)					(0.452)	
Gender (1 = Male)	0.183						-0.016
	(0.338)						(0.338)
Admission Year (1 = 2014)	0.420	0.356	0.368	0.437	0.418	0.451	0.408
	(0.367)	(0.322)	(0.354)	(0.356)	(0.355)	(0.347)	(0.336)
Constant Term	2.745	1.965	0.155	0.182	0.179	0.493	0.194
	(1.128)**	(0.898)**	(0.242)	(0.322)	(0.267)	(0.346)	(0.307)
R^2	0.10	0.05	0.02	0.02	0.01	0.03	0.01
Observations	84	86	89	85	89	88	89

* $p<0.1$; ** $p<0.05$; *** $p<0.01$

NOTES. See next page.

TABLE II.V

RELATIONSHIP BETWEEN IMPROVEMENT (ADDITIONAL CORRECT ANSWERS) ACROSS PARTS OF MATHEMATICAL ABILITY TEST AND STUDENT CHARACTERISTICS

NOTES. This table analyzes the relationship between improvement (additional correct answers) across each of the parts of the mathematical ability test and the student characteristics. Each column corresponds to one regression specification, and independent variables are listed on the left (rows). Two sets of specifications are presented stacked over each other. In the first set of regressions (x.1) the dependent variable is the improvement between Part I and Part II of the test for students in the treatment group, who received the cheat sheet before taking the second part of the exam. In the second set of regressions (x.2) the dependent variable is the improvement between Part II and Part III of the test for students in the control group, who received the cheat sheet before taking the third part of the exam. All six independent variables are first considered jointly (0.x) and then separately (1.x-6.x). These are: (i) the math score obtained in the standardized test administered to secondary school students (SIMCE) (ii) whether the student attended a secondary school in the Santiago Metropolitan Region, , (iii) whether the student attended a public school, as opposed to a subsidized one (private school students were not eligible to apply for special admission), (iv) whether the student attended the PENTA UC program for talented secondary school students, (v) whether the student belongs to the lower three quintiles of the income distribution, as opposed to the fourth quintile (fifth quintile students were not eligible to apply for special admission), and (vi) the student's gender (1 = male). A 2014 admission year fixed effect is included (base category is admission year 2013). Huber-White heteroskedasticity-consistent standard errors are reported between parentheses.

TABLE II.VI

ROSTER OF STUDENTS WHO BENEFIT FROM OR ARE WORSE OFF WITH THE USE OF CHEAT SHEETS

	Part I		Part II		Part III		
	Rank	Correct Answers	Rank	Correct Answers	Rank	Correct Answers	Treatment
Students Who Are Better Off With Cheat Sheet	22	14	28	14	8	15	1
(i.e. in Top 20 on Part III but not on Part I)	25	14	17	15	10	15	0
	31	14	7	15	2	15	1
	40	13	52	13	5	15	0
	42	13	74	13	3	15	0
	44	13	14	15	6	15	1
	49	13	78	13	9	15	0
	65	12	118	11	1	15	1
	68	12	61	13	18	15	1
	69	12	38	14	20	15	0
	72	12	93	12	12	15	0
	88	11	71	13	19	15	1
Total: 13	103	10	121	11	4	15	1
Students Who Are Worse Off With Cheat Sheet	1	15	43	14	26	15	0
(i.e. in Top 20 on Part I but not on Part III)	3	15	20	15	25	15	0
	4	15	41	14	57	14	1
	7	15	26	14	79	13	1
	8	15	15	15	78	13	0
	10	15	24	14	53	14	1
	11	15	21	15	24	15	0
	12	15	9	15	33	14	0
	13	15	5	15	32	14	1
	16	15	32	14	36	14	0
	18	14	62	13	85	13	1
	19	14	16	15	49	14	0
Total: 13	20	14	35	14	40	14	1

NOTES. As already mentioned, the mathematical test was divided in three parts, which featured 15 analogous questions each (i.e. the first questions of each part were different but analogous), and candidates were randomly divided into stratified treatment and control groups. All students took the first part of the test without any support materials, but then a "cheat sheet" (i.e. knowledge summaries outlining the basic concepts needed to successfully answer the test questions) was distributed to each of the candidates in the treatment group, who then had about ten minutes to examine it before the second part started. Students in the control group simply had a ten minute break after completing the first part of the test, but received the same "cheat sheet" after having completed the second part. Once they received the "cheat sheet" all students could keep it with them until the end of the test, and for fairness purposes only the number of correct answers from the third part (which all students took with the aid of the "cheat sheet") was considered for admission via the special access program, together with several other criteria. This table presents a roster of all the students who benefit from or are worse off with the use of cheat sheets, as measured by whether they advanced to or were relegated from the group of top 20 candidates who would be admitted via the special access program, respectively. This is observed by comparing the rank of each candidate in Part I (which all students completed without a cheat sheet) and Part III (which all students completed with a cheat sheet), as defined by the number of correct answers relative to the other students who took the exam. Ties among students with the same number of correct students are resolved randomly. Each row corresponds to one student, for which the rank and number of correct answers in each of the three parts of the mathematical ability test are listed. The last column indicates whether the student was in the treatment or control group.

TABLE II.VII

RELATIONSHIP BETWEEN STUDENT CHARACTERISTICS AND THE LIKELIHOOD OF BENEFITING FROM AND BEING WORSE OFF WITH THE USE OF CHEAT SHEETS

1 = Student Better Off With Cheat Sheet	(0.1)	(1.1)	(2.1)	(3.1)	(4.1)	(5.1)	(6.1)
Secondary School Standardized Math Test Score (SIMCE)	0.001	0.001					
	(0.000)*	(0.000)					
Region (1 = Santiago Metropolitan Region)	-0.062		-0.050				
	(0.054)		(0.044)				
Secondary School Type (1 = Public)	-0.048			-0.039			
	(0.045)			(0.044)			
PENTA UC Program Fellow (1 = Yes)	-0.067				-0.090		
	(0.036)*				(0.026)***		
Income Distribution Quintile (1 = I)	-0.008					-0.035	
	(0.058)					(0.058)	
Income Distribution Quintile (1 = II)	0.023					-0.000	
	(0.064)					(0.059)	
Income Distribution Quintile (1 = III)	0.085					0.078	
	(0.072)					(0.067)	
Gender (1 = Male)	0.035						0.033
	(0.053)						(0.044)
Admission Year (1 = 2014)	0.005	-0.007	-0.009	-0.017	-0.021	-0.002	-0.017
	(0.051)	(0.049)	(0.047)	(0.048)	(0.047)	(0.047)	(0.047)
Constant	-0.112	-0.073	0.095	0.109	0.099	0.066	0.077
	(0.117)	(0.116)	(0.040)**	(0.044)**	(0.041)**	(0.045)	(0.044)*
R^2	0.05	0.01	0.01	0.00	0.01	0.03	0.00
N	152	154	162	153	162	161	162
1 = Student Worse Off With Cheat Sheet)	(0.2)	(1.2)	(2.2)	(3.2)	(4.2)	(5.2)	(6.2)
Secondary School Standardized Math Test Score (SIMCE)	0.002	0.002					
	(0.001)**	(0.001)***					
Region (1 = Santiago Metropolitan Region)	-0.030		-0.050				
	(0.047)		(0.050)				
Secondary School Type (1 = Public)	0.106			0.172			
	(0.052)**			(0.063)***			
PENTA UC Program Fellow (1 = Yes)	0.083				0.148		
	(0.124)				(0.146)		
Income Distribution Quintile (1 = I)	-0.094					-0.164	
	(0.086)					(0.086)*	
Income Distribution Quintile (1 = II)	-0.089					-0.160	
	(0.085)					(0.085)*	
Income Distribution Quintile (1 = III)	-0.167					-0.206	
	(0.076)**					(0.079)**	
Gender (1 = Male)	0.000						0.033
	(0.043)						(0.044)
Admission Year (1 = 2014)	0.020	0.011	-0.009	0.010	-0.008	-0.018	-0.017
	(0.054)	(0.047)	(0.051)	(0.052)	(0.050)	(0.048)	(0.047)
Constant	-0.381	-0.550	0.095	0.022	0.077	0.237	0.077
	(0.218)*	(0.205)***	(0.039)**	(0.049)	(0.043)*	(0.083)***	(0.040)*
R^2	0.23	0.13	0.01	0.08	0.02	0.07	0.00
N	152	154	162	153	162	161	162

* $p<0.1$; ** $p<0.05$; *** $p<0.01$

NOTES. See next page.

TABLE II.VII

RELATIONSHIP BETWEEN STUDENT CHARACTERISTICS AND THE LIKELIHOOD OF BENEFITING FROM AND BEING WORSE OFF WITH THE USE OF CHEAT SHEETS

NOTES. This table analyzes the relationship between student characteristics and the likelihood of benefitting from or being worse off with the use of cheat sheets, as measured by the likelihood of advancing to or being relegated from the group of top 20 candidates who would be admitted via the special access program, respectively. This is obtained by comparing the rank of each candidate in Part I (which all students completed without a cheat sheet) and Part III (which all students completed with a cheat sheet), as defined by the number of correct answers relative to the other students who took the exam. Ties among students with the same number of correct students are resolved randomly. Each column corresponds to one regression specification, and independent variables are listed on the left (rows). Two sets of specifications are presented stacked over each other. In the first set of regressions (x.1) the dependent variable is the binomial indicator of whether the student benefited from the use of a cheat sheet, i.e. whether s/he made it to the top 20 in Part III but not Part I. In the second set of regressions (x.2) the dependent variable is the binomial indicator of whether the student was worse off with the use of a cheat sheet, i.e. whether s/he made it to the top 20 in Part I but not Part III. All six independent variables are first considered jointly (0.x) and then separately (1.x-6x). These are: (i) the math score obtained in the standardized test administered to secondary school students (SIMCE) (ii) whether the student attended a secondary school in the Santiago Metropolitan Region, (iii) whether the student attended a public school, as opposed to a subsidized one (private school students were not eligible to apply for special admission), (iv) whether the student attended the PENTA UC program for talented secondary school students, (v) whether the student belongs to the lower three quintiles of the income distribution, as opposed to the fourth quintile (fifth quintile students were not eligible to apply for special admission), and (vi) the student's gender (1 = male). A 2014 admission year fixed effect is included (base category is admission year 2013). Huber-White heteroskedasticity-consistent standard errors are reported between parentheses.

Appendix 2.A: "Cheat Sheet" (Spanish Original)

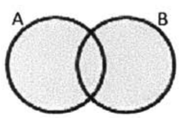
CONSEJOS GENERALES

- Lee cuidadosamente el enunciado de cada pregunta, prestando especial atención a los paréntesis y operadores matemáticos. ¡Es muy importante no malinterpretar el enunciado de la pregunta o las posibles respuestas! Siempre resuelve la operación dentro de los paréntesis primero.

- Por simplicidad en esta prueba la división se representa mediante el símbolo "/", mientras que el operador multiplicativo se omite y se usan paréntesis para separar los múltiplos. Es decir, 3 / 3 =1, y (3)(3) = 9.

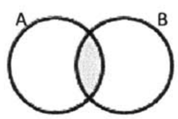
CONJUNTOS

Unión de Conjuntos



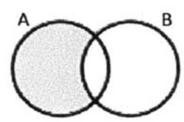
A ∪ B

Intersección de Conjuntos



A ∩ B

Diferencia de Conjuntos



A - B

PORCENTAJES

X% = X/100 → *Por ejemplo, 20% = 20 / 100 = 0,2*

"X% de Y" = (X/100)(Y) → *Por ejemplo, "20% de 50" = (20 / 100) (50) = 10*

"sube un X%" significa (100 + X)% → *Por ejemplo, si 50 aumenta un 20%, tenemos (100 + 20)% de 50 = 60*

"baja un X%" significa (100 - X)% → *Por ejemplo, si 50 baja un 20%, tenemos (100 - 20)% de 50 = 40*

"A es X% más grande que B" significa que [(A-B) / B] (100) = X% → *Por ejemplo, "375 es un 25% más grande que 300", ya que [(375-300) / 300] (100) = 0.25 = 25%, o lo que es lo mismo, 375 = (1,25)(300) = (1 + 0,25) (300), es decir, 375 es un 125% de 300*

"B es X% más pequeño que A" significa que [(A-B) / A] (100) = X% → *Por ejemplo, "150 es un 25% más pequeño que 200", ya que [(200-150) /200] (100) = 0.25 = 25%, o lo que es lo mismo, 150 = (0,75) (200) = (1 – 0,25)(200), es decir, 150 es un 75% de 200*

RAZONES

"razón de X a Y" es X:Y=X/Y → *Por ejemplo, razón de 8 a 4 es 8:4=8/4=2/1=2:1*

[(X)(Y)]/[(X)(Z)]=Y/Z → *Por ejemplo, 8/6=[(2)(4)] /[(2)(3)]=4/3*

[X/Y]/[Z/W]= [(X)(W)]/[(Y)(Z)] → *Por ejemplo, [10/5]/[6/3]= [(10)(3)]/[(5)(6)]=30/30=1*

"X/Y = Z/W" implica que X=(Z)(Y) /W → *Por ejemplo, si X/2=4/6, esto implica que X=(4)(2) /6=8/6=4/3*

"X/Y = Z/W" puede ser leído como "X es a Y como Z es a W" → *Por ejemplo, X/2=4/6 puede ser leído como "X es a 2 como 4 es a 6"*

"X en Y horas" implica "(1/Y)X por hora", o "[(1/Y)X] / hora" → *Por ejemplo, "10 en 5 horas" implica "2 por hora", o "2/hora"*

EXPONENTES

$X^{(-a)} = 1/X^a$ $(X^a)(X^b) = X^{(a+b)}$ $(X^a)^b = X^{(a)(b)}$

$X^a/X^b = (X^a)(X^{(-b)}) = X^{(a-b)}$ $(X^a)(Y^a) = [(X)(Y)]^a$ $X^a/Y^a = (X^a)(Y^{(-a)}) = [X/Y]^a$

ÁLGEBRA

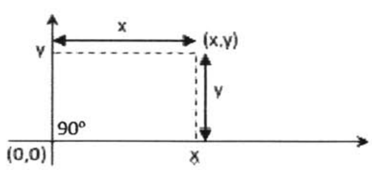
$A=a \rightarrow X^A = X^a$ $aX + b = cX + d \leftrightarrow aX - cX = (a-c)X = d - b$ $aX = b \leftrightarrow X = b/a$

$aX + b > cX + d \leftrightarrow aX - cX = (a-c)X > d - b$ → *Por ejemplo,* $2X + 1 > X + 2 \leftrightarrow 2X - X = (2-1)X = X > 2 - 1 = 1$

Si $a > 0$, entonces $aX > b \leftrightarrow X > b/a$, → *Por ejemplo,* $2X > 4 \leftrightarrow X > 4/2 = 2$, *pero* $-2X > 4 \leftrightarrow X < 4/(-2) = (-2)$

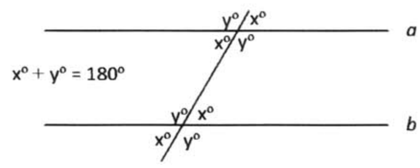
GEOMETRÍA

Eje de Coordenadas (x,y)

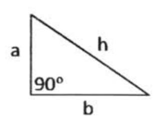


Ángulos

NOTA: Las líneas a y b son paralelas

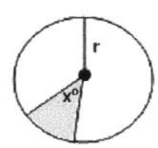


Teorema de Pitágoras



$h^2 = a^2 + b^2$

Área de un círculo y volumen de un cilindro



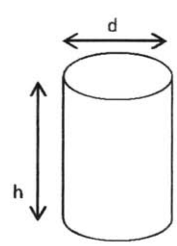
r = radio

d = diámetro

h = altura

Área de una sección de un círculo (sombreada)

área sección determinada por el ángulo $x° = (x/360)(\pi r^2)$



$d = 2r$

área círculo = πr^2

volumen cilindro = $h\ \pi r^2$

Medida de ángulos interiores de un polígono

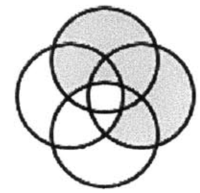
La suma de los ángulos interiores de un polígono de n lados es $(n-2)(180°)$

→ *Por ejemplo, los ángulos interiores de un triángulo suman 180°, los de un cuadrado suman 360°, etc.*

Appendix 2.B: Mathematical Ability Test Part I (Spanish Original)

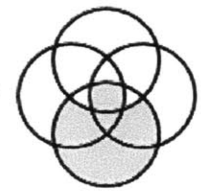
1. En la figura de la derecha A, B, C y D son círculos de igual tamaño.
   El área sombreada representa:

   A. (A ∪ D) – (B ∩ C)
   B. (A ∪ B) – (C ∩ D)
   C. (A ∩ B) – (C ∪ D)
   D. (B ∪ C) – (A ∩ D)
   E. (A ∩ B) – (C ∩ D)



2. En la figura de la derecha A, B, C y D son círculos de igual tamaño.
   El área sombreada representa:

   A. (B – D) ∪ [(A ∩ C) ∩ (B ∪ D)]
   B. (D – B) ∪ [(A ∩ B) ∩ (C ∩ D)]
   C. (C – D) ∪ [(A ∩ B) ∪ (C ∩ D)]
   D. (C – B) ∪ [(A ∩ B) ∪ (C ∩ D)]
   E. (A – D) ∪ [(A ∩ B) ∩ (C ∩ D)]



3. El precio inicial de un auto era de seis millones de pesos. El precio del auto subió un 20% con respecto a su precio inicial, pero después bajó un 20% con respecto a su precio máximo. ¿Cuál es la diferencia entre el precio inicial y el precio actual del auto?

   A. $ 120.000
   B. $ 150.000
   C. $ 0
   D. $ 300.000
   E. $ 240.000

4. Se considera que el precio de una mercancía es "estable" si la diferencia entre su precio mínimo y su precio máximo no es mayor que un 10% de su precio medio. Según la información de la tabla, ¿qué mercancías tienen precios "estables"?

   A. B y C
   B. B y D
   C. A y B
   D. A y C
   E. Ninguna

Mercancía	Pr. Mínimo	Pr. Medio	Pr. Máximo
A	$ 114	$ 120	$ 125
B	$ 47	$ 50	$ 51
C	$ 9	$ 10	$ 11
D	$ 77	$ 70	$ 85

5. Si la razón de mujeres a hombres en un comité de 30 miembros es de 3:2, y el 50% por ciento de las mujeres son chilenas y el 25% de los hombres son extranjeros, ¿cuántos miembros del comité son chilenos?

   A. 16
   B. 22
   C. 24
   D. 18
   E. 20

6. Diez obreros realizan una obra en siete días. ¿En cuántos días se hubiese realizado una obra un 30% más grande si se hubiesen ocupado cinco obreros?

   A. 12,6 días
   B. 14,8 días
   C. 20,6 días
   D. 16,4 días
   E. 18,2 días

7. Una llave de agua llena la piscina A en seis horas, y otra llave de agua llena la piscina B, que es un 50% más grande que la piscina A, en la mitad de tiempo. ¿Cuánto tardarían en llenar la piscina A las dos llaves de agua al mismo tiempo?

   A. 1,5 horas
   B. 3 horas
   C. 2 horas
   D. 1 hora
   E. 2,5 horas

8. ¿Cuál es el valor de $[(X^{A})(X^{(-B)})]^{B}$ cuando X=4, A=3, B=2?

   A. 9
   B. 16
   C. 36
   D. 25
   E. 4

9. $[(X^{10})\,(Y^{(-1)})]\,/\,[(Y^{5})(X^{5})]$ es igual a:

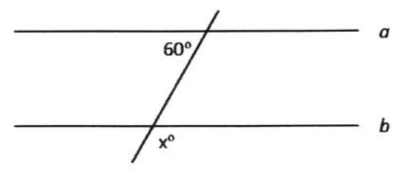
   A. X^{15} / Y^{4}
   B. X^{5} / Y^{4}
   C. X^{5} / Y^{6}
   D. X^{15} / Y^{6}
   E. X^{10} / Y^{4}

10. Si $4X-5X + 8 > 3X + 20$, entonces:

   A. $X < 5$
   B. $X < -1$
   C. $X < 2$
   D. $X < 1$
   E. $X < -3$

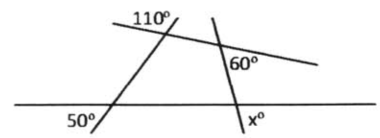
11. En la figura de la derecha las líneas *a* y *b* son paralelas.
¿Cuántos grados mide el ángulo x°?

A. x° = 130°
B. x° = 120°
C. x° = 140°
D. x° = 135°
E. x° = 125°



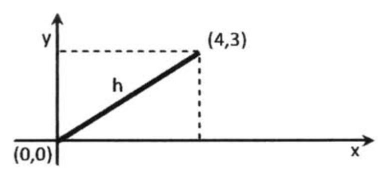
12. ¿En la figura de la derecha, cuántos grados mide el ángulo x°?

A. x° = 85°
B. x° = 70°
C. x° = 80°
D. x° = 75°
E. x° = 65°



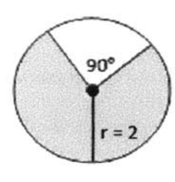
13. En el eje de coordenadas (x,y) a la derecha,
¿cuál es la longitud de la línea h entre los puntos (0,0) y (4,3)?

A. h=5
B. h=6
C. h=4
D. h=3
E. h=7



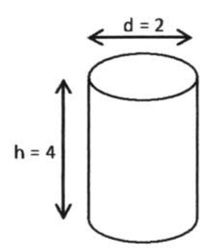
14. El círculo de la derecha tiene un radio r = 2.
¿Cuál es el área de la zona sombreada?

A. 4π
B. 16π
C. 9π
D. 3π
E. 2π



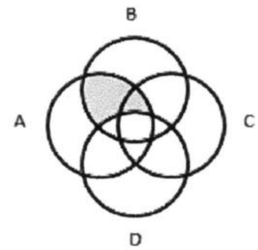
15. El cilindro de la derecha tiene una base circular de diámetro d = 2,
y una altura h = 4. ¿Cuál es su volumen?

A. 4π
B. 16π
C. 9π
D. 3π
E. 2π



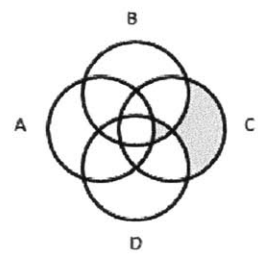
Appendix 2.C: Mathematical Ability Test Part II (Spanish Original)

16. En la figura de la derecha A, B, C y D son círculos de igual tamaño.
El área sombreada representa:



A. (A ∪ C) – D
B. (B ∩ D) – A
C. (C ∪ D) – B
D. (B ∩ C) – A
E. (A ∩ B) – D

17. En la figura de la derecha A, B, C y D son círculos de igual tamaño.
El área sombreada representa:



A. [D – (B ∩ C)] ∪ [(A ∪ D) - C]
B. [B – (A ∪ C)] ∩ [(B ∪ C) - D]
C. [C – (B ∪ D)] ∪ [(B ∩ D) - A]
D. [B – (C ∩ D)] ∩ [(A ∩ B) - C]
E. [C – (A ∪ B)] ∪ [(B ∪ D) - A]

18. El precio inicial de un auto era de ocho millones de pesos. El precio del auto subió un 10% con respecto a su precio inicial, pero después bajó un 20% con respecto a su precio máximo. ¿Cuál es la diferencia entre el precio inicial y el precio actual del auto?

A. $ 720.000
B. $ 960.000
C. $ 540.000
D. $ 380.000
E. $ 800.000

19. Se considera que el precio de una mercancía es "estable" si la diferencia entre su precio mínimo y su precio máximo no es mayor que un 30% de su precio medio. Según la información de la tabla, ¿qué mercancías tienen precios "estables"?

A. A y B
B. B y C
C. A y C
D. C y D
E. Ninguna

Mercancía	Pr. Mínimo	Pr. Medio	Pr. Máximo
A	$ 69	$ 80	$ 94
B	$ 44	$ 40	$ 57
C	$ 9	$ 10	$ 11
D	$ 95	$ 110	$ 126

20. Si la razón de mujeres a hombres en un comité de 70 miembros es de 4:3, y el 20% por ciento de las mujeres son extranjeras y el 60% de los hombres son chilenos, ¿cuántos miembros del comité son extranjeros?

A. 18
B. 16
C. 14
D. 22
E. 20

21. Cinco obreros realizan una obra en diez días. ¿En cuántos días se hubiese realizado una obra un 20% más pequeña si se hubiesen ocupado veinte obreros?

A. 2 días
B. 8 días
C. 5 días
D. 6 días
E. 4 días

22. Una llave de agua llena la piscina A en ocho horas, y otra llave de agua llena la piscina B, que es un 25% más pequeña que la piscina A, en un 50% más de tiempo. ¿Cuánto tardarían en llenar la piscina B las dos llaves de agua al mismo tiempo?

A. 2 horas
B. 3 horas
C. 2,5 horas
D. 4 horas
E. 3,5 horas

23. ¿Cuál es el valor de $[(X^{(-A)}) / (X^{B})]^{A}$ cuando X=3, A=2, B=(-4)?

A. 121
B. 144
C. 100
D. 81
E. 64

24. $[(Y^{(-6)}) / (X^{(-2)})]\ [(X^{3}) / (Y^{2})]$ es igual a:

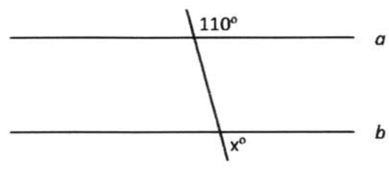
A. X^{5} / Y^{8}
B. X / Y^{4}
C. X^{5} / Y^{4}
D. Y^{8} / X^{5}
E. $X / Y^{(-4)}$

25. Si 6X-4X + 5 < X + 10, entonces:

A. X > 4
B. X < 3
C. X < 4
D. X > 5
E. X < 5

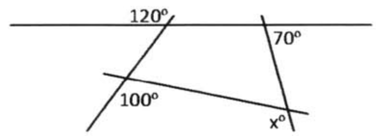
26. En la figura de la derecha las líneas *a* y *b* son paralelas.
¿Cuántos grados mide el ángulo x° ?

A. x° = 60 °
B. x° = 80 °
C. x° = 70 °
D. x° = 50 °
E. x° = 40 °



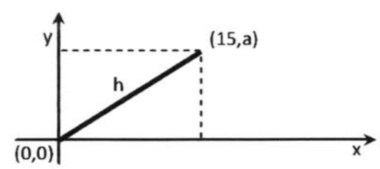
27. ¿En la figura de la derecha, cuántos grados mide el ángulo x° ?

A. x° = 125 °
B. x° = 130 °
C. x° = 115 °
D. x° = 110 °
E. x° = 120 °



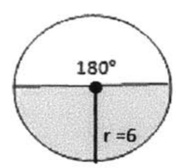
28. En el eje de coordenadas (x,y) a la derecha, si la línea entre los puntos (0,0) y (15,a) tiene una longitud h= 17, ¿cuál es el valor de a?

A. a=9
B. a=10
C. a=8
D. a=11
E. a=7



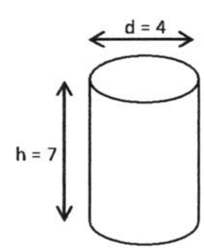
29. El círculo de la derecha tiene un radio r = 6.
¿Cuál es el área de la zona sombreada?

A. 18π
B. 16π
C. 20π
D. 12π
E. 14π



30. El cilindro de la derecha tiene una base circular de diámetro d = 4, y una altura h = 7. ¿Cuál es su volumen?

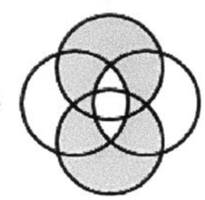
A. 24π
B. 28π
C. 32π
D. 36π
E. 20π



Appendix 2.D: Mathematical Ability Test Part III (Spanish Original)

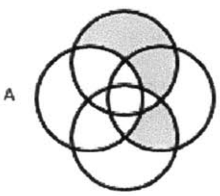
31. En la figura de la derecha A, B, C y D son círculos de igual tamaño. El área sombreada representa:

    A. [A ∩ C] – [D ∪ B]
    B. [B ∪ D] – [A ∩ C]
    C. [C ∪ D] – [A ∩ B]
    D. [B ∪ C] – [A ∪ D]
    E. [A ∪ B] – [C ∩ D]



32. En la figura de la derecha A, B, C y D son círculos de igual tamaño. El área sombreada representa:

    A. [(A ∪ C) – (B ∪ D)] ∪ [A - (B ∪ D)]
    B. [(B ∩ C) – (A ∩ D)] ∪ [C - (B ∪ C)]
    C. [(A ∪ B) – (C ∪ D)] ∪ [A - (C ∩ D)]
    D. [(C ∩ D) – (A ∪ B)] ∪ [B - (A ∪ D)]
    E. [(A ∩ D) – (C ∩ D)] ∪ [A - (C ∩ D)]



33. El precio inicial de un auto era de diez millones de pesos. El precio del auto bajó un 25% con respecto a su precio inicial, pero después subió un 35% con respecto a su precio mínimo. ¿Cuál es la diferencia entre el precio inicial y el precio actual del auto?

    A. $ 125.000
    B. $ 115.000
    C. $ 135.000
    D. $ 155.000
    E. $ 145.000

34. Se considera que el precio de una mercancía es "estable" si la diferencia entre su precio mínimo y su precio máximo no es mayor que un 25% de su precio medio. Según la información de la tabla, ¿qué mercancías tienen precios "estables"?

    A. B y C
    B. C y D
    C. A y D
    D. B y D
    E. Ninguna

Mercancía	Pr. Mínimo	Pr. Medio	Pr. Máximo
A	$ 18	$ 20	$ 22
B	$ 52	$ 60	$ 68
C	$ 61	$ 70	$ 79
D	$ 113	$ 130	$ 145

35. Si la razón de mujeres a hombres en un comité de 45 miembros es de 4:5, y el 20% por ciento de las mujeres son chilenas y el 60% de los hombres son extranjeros, ¿cuántos miembros del comité son chilenos?

    A. 12
    B. 14
    C. 10
    D. 16
    E. 18

36. Seis obreros realizan una obra en veinte días. ¿En cuántos días se hubiese realizado una obra un 40% más pequeña si se hubiesen ocupado ocho obreros?

A. 10 días
B. 8,5 días
C. 10,5 días
D. 9,5 días
E. 9 días

37. Una llave de agua llena la piscina A en 12 horas, y otra llave de agua llena la piscina B, que es un 75% más pequeña que la piscina A, en la mitad de tiempo. ¿Cuánto tardarían en llenar la piscina A las dos llaves de agua al mismo tiempo?

A. 8 horas
B. 2 horas
C. 4 horas
D. 10 horas
E. 6 horas

38. ¿Cuál es el valor de $[(X^{A})(X^{B})]^{B}$ cuando X=2, A=1, B=(-3)?

A. 16
B. 32
C. 64
D. 4
E. 2

39. $[(Y^{4})(X^{(-3)})] / [(Y^{5}) / (X^{4})]$ es igual a:

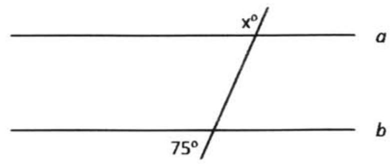
A. Y^{9} / X^{7}
B. X / Y
C. X^{7} / Y^{9}
D. Y / X
E. X^{7} / Y

40. Si $5X - 7X - 6 > 16 - 4X$, entonces:

A. $X < 21$
B. $X > 7$
C. $X < 3$
D. $X > 11$
E. $X < 9$

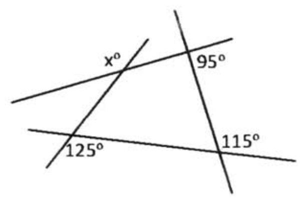
41. En la figura de la derecha las líneas *a* y *b* son paralelas.
¿Cuántos grados mide el ángulo x°?

A. x° = 115°
B. x° = 100°
C. x° = 110°
D. x° = 120°
E. x° = 105°



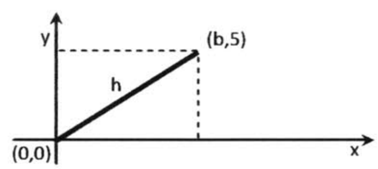
42. ¿En la figura de la derecha, cuántos grados mide el ángulo x°?

A. x° = 150°
B. x° = 145°
C. x° = 160°
D. x° = 140°
E. x° = 155°



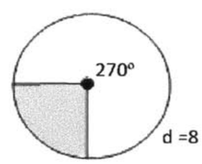
43. En el eje de coordenadas (x,y) a la derecha, si la línea entre los puntos (0,0) y (b,5) tiene una longitud h= 13, ¿cuál es el valor de b?

A. b=12
B. b=7
C. b=10
D. b=8
E. b=9



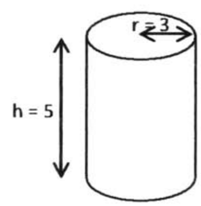
44. El círculo de la derecha tiene un diámetro d = 8.
¿Cuál es el área de la zona sombreada?

A. 16π
B. 8π
C. 2π
D. 4π
E. π



45. El cilindro de la derecha tiene una base circular de radio r = 3, y una altura h = 5. ¿Cuál es su volumen?

A. 30π
B. 40π
C. 45π
D. 35π
E. 50π



"A human being is not attaining his full heights until he is educated."

H. Mann

CHAPTER 3

Improving the Access to Higher Education for the Poor: Lessons from a Special Admission Program in Chile

3.1. Introduction

In the case of Chile, although there have been numerous advances with respect to the access to higher education, the consensus is that there is still a lot of room for improvement in many dimensions. In particular, the economic development experienced by the country calls for a comparison with countries with a similar per-capita income, which have much more resources devoted to higher education (see for example Comisión de Financiamiento Estudiantil para la Educación Superior, 2012; OECD, 2011; or Sánchez, 2011). Also, many of the students from disadvantaged socioeconomic backgrounds, for which the net coverage[39] of higher education has increased more noticeably, have very likely not being admitted on "quality" universities. This means that their education may not have necessarily have translated into a higher income, even if they still have incurred a considerable cost to fund it. Taking all this into account, it is not surprising that the access to higher education is currently one of the most pressing issues for Chilean society, and the main reason behind the notorious student protests which have taken place there during the last years (see for example Loofbourow, 2013).

In view of the above, the Faculty of Economic and Administrative Sciences ("Facultad de Ciencias Económicas y Administrativas") of the Pontificia Universidad Católica de Chile decided to contribute to the national effort to improve the access to higher education, devoting additional resources to run a two-year pilot of a special admission program, with the goal of facilitating the access to its Commercial Engineering degree to students from disadvantaged backgrounds. This program, called "Talento + Inclusión" (*Talent + Integration*), aimed to identify and attract talented students from public and subsidized secondary schools who could succeed in higher education if provided with adequate support, but who may be screened out in the ordinary admission

[39] The net coverage of higher education is defined as the percentage of the population between 18 and 24 years old enrolled in higher education.

process. In order to do this, alternative admission criteria better tailored to the context of this type of students were set.

A non-experimental comparison of the academic performance of special and ordinary admission students finds that, although special admission students on average have comparable final grades to their ordinary admission peers, they tend to perform comparatively worse in "hard" subjects (i.e. those with a stronger mathematical component). This is consistent with the information provided by the School of Engineering about the performance of students admitted to the Engineering degree via their own special access program, and with the findings of Arcidiacono et al (2011) in their study of the time path of racial differences in GPA and major choice at Duke University. Also, no significant differences in voluntary withdrawal or dismissal are observed between special and ordinary admission students, although special admission students seem more likely to decide to withdraw earlier in the program (suggesting potential non-academic adaptation problems). Finally, an initial gap in GPA between special and ordinary admission students is closed by the end of the third semester of enrollment, and no special admission student was dismissed during the period of study.[40]

All the above suggests that, at the time of enrollment, the special admission students featured in this study had a disadvantage in academic performance terms (relative to their ordinary admission peers). Also, it seems that they may be more likely to decide to abandon their studies early. However, it seems that special admission students are in any case very unlikely to be dismissed due to poor academic performance, and that they actually catch up with their ordinary admission peers in terms of GPA as early as after three semesters of enrollment in the degree. This suggests that, with some nuances, students from disadvantaged socioeconomic backgrounds can successfully catch up with their peers when provided with adequate support, and that special admission programs can therefore be an effective tool to improve the access to higher education. However, it also seems that it would be advisable to further increase the additional support provided to special admission students (of course, this support could also be expanded to ordinary admission students, in order to also reduce their withdrawal and dismissal rates). This would mean both addressing adaptation problems to reduce the likelihood of withdrawal, as well as reducing the academic gap with more remedial and tutoring resources (particularly regarding mathematical ability).

Finally, the fact that the program was undersubscribed suggests that, apart from potential information diffusion problems, the minimum requirements set forth for special admission may have been too stringent, and/or that the demand for special admission among the targeted student population may not be as large as predicted.

The rest of this paper is organized as follows: Section 3.2 presents its motivation and background; Section 3.3

[40]Note that catch-up in terms of GPA may be due to pure academic improvement, but also due to differences in subject choice, as observed by Arcidiacono et al (2011).

describes the special access program in detail; Section 3.4 presents the main findings; Section 3.5 concludes.[41]

3.2. Background

Facilitating the access to higher education for talented students from disadvantaged socioeconomic backgrounds is a challenge for any educational system. This is attributable to financial market imperfections which difficult the access to funding for higher education, but also to other non-financial barriers. Also, it is worth noting that this challenge is similar to that of improving the access to primary and secondary education, but that there are some differences which aggravate the problem in the case of higher education. For example, the cost of higher education is generally much higher than that of primary and secondary education, therefore highlighting access to funding problems. Also, the fact that the access to higher education is generally not universal means that admission tests are used. These may constitute a barrier to access for students from disadvantaged socioeconomic backgrounds, who many times receive a primary/secondary education of lower quality, and therefore may have significant knowledge gaps and/or may not be able to afford test preparation courses. Finally, both the higher degree of specialization in higher education, as well as its stricter academic requirements, tend to highlight vocational and adaptation problems which cause students to drop out or be dismissed.

In the case of Chile, although there have been numerous advances in recent years, it seems that there is still a lot of room to improve the access to higher education along many dimensions. This is particularly evident when taking into account the economic development experienced by Chile, which calls for a comparison with countries with a similar per-capita income, which generally devote much more resources to facilitate the access to higher education (see Sánchez, 2011, for a pre-2014 reform discussion of the challenges facing the higher education system in Chile). For example, although the net coverage[42] of higher education has increased substantially in the last two decades, in 2012 it was still only 36.3 % on average. That is already substantially below the OECD average of 59 % (Chile joined the Organisation for Economic Co-operation and Development in 2010), but for the lowest decile of the income distribution the figure goes down to 16.4 % (OECD, 2011; Comisión de Financiamiento Estudiantil para la Educación Superior, 2012). Also, primary and secondary students from the lower end of the income distribution usually attend public or subsidized secondary schools, which generally offer a lower educational quality than their private counterparts (which are attended by the majority of students from the top of the income distribution). Only 10 % and 13 % of

[41] As mentioned above, Appendix 3.A discusses the original experimental design of the special admission program, while Appendix 3.B presents the results of the experimental comparison of information dissemination methods during the program awareness campaign.

[42] The net coverage of higher education is defined as the percentage of the population between 18 and 24 years old enrolled in higher education.

graduates from public and subsidized secondary schools are respectively admitted to "traditional" universities (i.e. those which are members of the the "Consejo de Rectores de las Universidades Chilenas" - CRUCH, or *Council of Rectors of Chilean Universities*-, generally considered to offer an education of higher quality). However, that figure goes up to 31 % in the case of graduates from private secondary schools, which means that there is a very high correlation between socioeconomic status and the likelihood of attending a higher education institution of high quality. Moreover, the percentage of students who complete their studies is very low: 51 % for university students, 48 % for technical education students, and 37 % for professional education students. [43] Furthermore, higher education degrees on average last more than 13 semesters (i.e. 6.5 years), compared to a mean degree duration of about 8 semesters (i.e. 4 years) in the OECD. Finally, there is a large variance in the income distribution of students, even among those graduating from the same degree (the ratio of the highest to the lowest income can usually be 3:1, or in some cases even reach 4:1).

All the above suggests that many of the students from disadvantaged socioeconomic backgrounds, for which the net coverage of higher education has increased more pronouncedly in recent years, have very likely not being admitted to high quality universities. Therefore, their education may not have necessarily translated into a higher income, even if they have still incurred large expenses to fund it. Therefore, it seems that the net coverage of higher education may be a misleading measure of the success of the Chilean higher education system, since it ignores the quality dimension and other nuances of the funding and admission system. However, it is also worth noting that the higher net coverage of higher education in other OECD countries is not necessarily efficient, either, as it might be the result of indiscriminate higher education subsidies which do not take into account income or aptitude criteria (e.g. although the system is currently being reformed, in 2012 public higher education in Spain was 85 % subsidized for all students, irrespective of their academic performance or income level.. Taking all this into account, it is not surprising that the access to higher education is one of the most pressing issues for Chilean society, and the main reason behind the notorious student protests which have taken place there during the last years (see for example Loofbourow, 2013). However, it is worth noting that this is an issue which is considered key in almost any other country, including the United States (see for example Dickert-Conlin and Rubenstein, 2007). Therefore, the findings of this paper are relevant for the overall academic debate on how to improve the access to higher education.

From an academic point of view, there are several possible explanations (which are not necessarily mutually exclusive) for the current state of education in Chile in general, and in the Pontificia Universidad Católica de Chile and its Commercial Engineering degree in particular. For example, the financing model of public schools (which are administered by the municipalities, and depend on their resources) might not be appropriate,

[43]Note that "technical educations students" are defined as those attending a "Centro de Formación Técnica" (*Technical Education Center*), while "professional education students" are defined as those enrolled in a "Instituto Profesional" (*Professional Institute*). Also, it is worth noting that the figures provided constitute an upper bound for the degree completion percentage, as they include those students who are still enrolled but have not graduated.

and may be causing widespread underfunding and quality problems in this type of secondary education institutions (which for many are the only free primary and secondary schooling options available). While subsidized schools also receive government funds to help them operate, they charge fees to students, and the quality of education provided can differ considerably from one institution to another.[44] Also, there might be motivational and incentive issues at play, which may be impacting the performance of both teachers and students (see for example: Duflo et al, 2012, who experimentally evaluate the impact of an incentive scheme intended to reduce teacher absenteeism in India; Glewwe et al, 2010, who analyze the randomized trial of a program which rewarded Kenyan primary school teachers based on student test scores; or Garibaldi et al, 2007, who using quasi-experimental methodology study the relationship between tuition paid and the time required to complete a degree at Bocconi University in Italy). Moreover, there may be incomplete information problems, or other structural issues which might be affecting the educational decision-making of parents, students and teachers (see for example: Dinkelman and Martínez, 2011, who experimentally evaluate the impact of providing information about financial aid to secondary school students on higher education enrollment; Hoxby and Turner, 2012, who also look at the same issue in the United States using a randomized control trial; or Pallais (2013), who finds that a small change in the cost of sending standardized test scores to colleges in the U.S. resulted in low-income test takers attending more selective colleges). Furthermore, the availability and characteristics of financial aid may be preventing the access to higher education for some students, and/or impacting their academic performance (see for example: Rothstein, 2003, who studies the impact of employment during high school on grade point averages; or Williamson and Sánchez, 2009, who discuss the necessary basic features of a potential government-funded public higher education system in Chile). Also, the characteristics of the higher education admission tests in use may be biasing against students from disadvantaged backgrounds (see for example Banerjee et al, 2012, who experimentally evaluate the impact of providing access to higher education admission test preparation courses for secondary school students). Finally, even those students who surmount all the above mentioned potential barriers may be subject to adaptation problems once they enroll in higher education (see for example: Arcidiacono et al, 2011, who analyze the time path of racial differences in GPA and major choice at Duke University in the United States, finding that African-American students have a comparable GPA to their peers, but self-select into "soft" elective courses with a smaller mathematical component; or Angrist et al, 2006, who using a randomized experiment evaluate the impact on student academic performance of offering peer advise and organized study groups, and/or offering merit-based scholarships according to first year grades). However, although there are some studies which explore the above mentioned issues in the context of higher education, the majority of the existing research focuses on primary and secondary schooling. Therefore, there is ample scope to improve our understanding of which policies are more effective to facilitate the access to higher

[44]Note that one of the measures announced by President Bachelet after assuming her office in early 2014 has been the prospective implementation of policies intended to break the link between municipal resources and public school funding. Also, another of her proposed reforms proposed would eliminate fees for students attending subsidized schools.

education for students from disadvantaged socioeconomic backgrounds.

In the particular case of the Pontificia Universidad Católica de Chile, in 2011 71.7 % of students admitted to the university belonged to the top quintile of the income distribution, while only 3.4 % belonged to the lowest quintile. This could be simply a reflection of intrinsic student characteristics, but it could potentially also be due to a bias in the admission process (e.g. if the standardized admission test used in the centralized admission process in Chile puts more emphasis on knowledge than on skills, this may be holding back talented students from public and secondary schools, who may present significant training gaps attributable to the lower quality of their education). However, with the right support some students might be able to catch up with (and perhaps even surpass) the academic performance of their private secondary schools peers.[45] To leave this talented students out just because they happened to be born in a less favorable environment does not only go against the equality of opportunity principle, but constitutes a potentially very large economic inefficiency by not fully realizing the human capital potential the country.

In any case, the Pontificia Universidad Católica de Chile has demonstrated a keen interest in improving the current situation, and there are already some initiatives in place in several areas. For example, Preuniversitario UC is experimentally evaluating the impact of providing preparation aid for the standardized university admission test (the PSU -"Prueba de Selección Universitaria", or *University Selection Test*-) to students from disadvantaged socioeconomic backgrounds who could otherwise not afford it (see Banerjee et al, 2012). Also, the School of Engineering has implemented the "Talento + Inclusión" (Talent + Integration) special access program. This focuses on exploring new admission criteria which might be less biased against students from disadvantaged socioeconomic backgrounds, but it also incorporates features intended to address potential adaptation, motivation and expectation problems of this type of students. In particular, it consists of a separate special application process for students ranked in the top 5 % of their secondary school (although the special application process is also open to students enrolled in the Penta UC program -which targets talented secondary school students from disadvantaged backgrounds-, who have their own special quota). This process is in addition to the ordinary admission process, and provides more information about the students, including another standardized test score (this corresponds to the TEDIB -"Test Estandarizado de Destrezas Intelectuales de Berlín", or *Berlin Standardized Test of Intellectual Skills*-, a test based on the *Berlin Model of Intelligence Structure*, or *BIS*; for further information see Rosas, 1990, and Jäger, 1984). All the information gathered is used to compute the predicted undergraduate GPA of each student, according to a purpose-fitted statistical model. This is the criterion to determine admission via the special program, and all admitted students receive additional support prior to enrolling on a summer camp, as well as support

[45]It is worth noting that, *a priori*, it cannot neither be ruled out that some students from public and subsidized secondary schools may have had such an incomplete primary and secondary education that, while they are comparably talented, their knowledge and formative gaps are so important that they will not be able to overcome them in a reasonable time frame (even with additional support resources).

courses during the academic year (for illustration purposes, in 2010 there were 126 candidates who satisfied all the special access program prerequisites, of whom 44 were admitted to the Engineering degree).

According to the School of Engineering, some students admitted via its special access program attended public and subsidized secondary schools with a very limited (or altogether non-existent) admission record to the Pontificia Universidad Católica de Chile. Also, in general the grades of special admission students were found to be comparable to that of students admitted via the ordinary application process. However, according to the School there seems to be a more noticeable grade gap in "hard" subjects (i.e. those with a larger mathematical component), than in "soft" ones.[46] This would be consistent with the findings of Arcidiacono et al (2011), who in their above mentioned analysis of the time path of racial differences in GPA and major choice at Duke University find a substitution effect between "soft" and "hard" subjects among students with a primary and secondary education of lower quality. In any case, it is worth noting that the above described facts were obtained ex-post through an in-house evaluation of the program performed by the School of Engineering, since the design of this special access program did not incorporate ex-ante evaluation features (experimental or otherwise). This raises some robustness concerns, and leaves room to try to better understand the causal mechanisms involved in this type of programs. For example, according to the documentation provided by the School, the ex-post fit of the statistical model used to generate the predicted undergraduate GPA of candidates (which is used ex-ante as the criterion to determine admission into the program) does not seem to be particularly good. Therefore, it is plausible to think that other characteristics of the program (different from the admission criterion), may be driving the above described results.

3.3. Special Admission Program

In view of all the above, the Faculty of Economic and Administrative Sciences ("Facultad de Ciencias Económicas y Administrativas") of the Pontificia Universidad Católica de Chile decided to contribute to the national effort to improve the access to higher education. In order to do so, it devoted additional resources to run a two-year pilot of a special admission program, which was intended to facilitate the access to its Commercial Engineering degree for students from disadvantaged backgrounds.[47] In particular, the two-year pilot had as its ultimate goal to identify and attract talented students from public and subsidized secondary schools who could successfully complete the degree, but who may be left out by the system in use in the ordinary admission process. In order to do this, alternative admission criteria, which were judged to be better tailored to the context of this type of students, were set. Also, additional resources were devoted to publicize

[46]Note that the School of Engineering provided this information for policy analysis purposes, but did not actually disclose the detailed data; therefore, these claims could not be independently verified.

[47]After a preliminary analysis (see Díez-Amigo, 2011, and Díez-Amigo, 2012), a final proposal was drafted and subsequently implemented during the 2013 and 2014 admission periods (see Díez-Amigo, 2012).

the existence of the program and the availability of financial aid, and existing support programs were reviewed to identify potential opportunities for improvement. The program thus featured three distinct phases: (a) an awareness campaign, intended to disseminate information about the program among target secondary schools; (b) a new special admission process for the Commercial Engineering degree at the university, intended to bypass some of the perceived barriers to the access of students from disadvantaged backgrounds; and (c) additional support provided after enrollment to the students admitted via the program.

In particular, the new special admission process entailed the opening of twenty additional vacancies in each of the 2013 and 2014 academic years. In order to be eligible to apply via the program, students must: (i) have attended a public or subsidized secondary school; (ii) rank in the top 5 % among their secondary school peers; and (iii) belong to the lowest four quintiles of the income distribution (it is worth noting that these requirements might be considered to be quite restrictive, but the Faculty was concerned with reducing the negative implications arising from the admission of students who would not be able to keep up with the demanding academic standards at the institution; also, students in the top 10 % of their secondary school class qualified to receive a government scholarship ("Beca de Excelencia Académica", or *Academic Excellence Scholarship*), so that the second criterion described above also helped to ease the financial burden of the program; similarly, students from the lowest three quintiles of the income distribution with a PSU score greater than 550 points qualified to receive a university partial scholarship, so that the third criterion again helped to ease the funding of the program). Moreover, after the initial application all candidates needed to satisfy two additional minimum eligibility criteria: (iv) pass the special admission tests; and (v) obtain more than 650 points in the ordinary admission test (note that this can be either the average score in the standardized admission test (PSU), or the weighted ordinary admission score).[48] Therefore, special admission students only needed to obtain the above mentioned minimum score in the standardized admission test, while for ordinary admission candidates this was the criterion determining admission into the program (i.e. ordinary vacancies were filled by descending score in the standardized admission test).

It is worth noting that once enrolled these special admission students had additional academic support (and access to full financial aid resources), but they were nonetheless subsequently subject to the same academic criteria as their ordinary admission peers. This was so on purpose, so that the meritocratic principles of the university and the Faculty were upheld, and to avoid the possibility that special admission students were stigmatized. Also, additional vacancies were created for the special admission program, by expanding the number of students admitted to the degree, and keeping the number of ordinary admission vacancies constant. Therefore, no ordinary admission student was left out by the implementation of the special admission program (in principle it could be argued that ordinary admission students may be worse off because of the increased

[48] A personal interview was initially included as a sixth criterion, but it was later discarded due to time and resource limitations. However, it would likely have been very informative, and provided very detailed data about the candidates. This is particularly important given the very small sample size available in the experiment.

enrollment in the degree, but resources were also expanded accordingly, and in any case the number of special admission vacancies created corresponds to less than 10 % of total vacancies).

Also, it is worth noting that, while this was not the first program of its kind in the country (or even in the university), it was the first to try to incorporate experimental evaluation methodology in its design (which was conceived by the author of this study). In particular, whenever feasible, experimental features were included in the original design, using random assignment to address non-experimental robustness concerns (e.g. self-selection). This was intended to facilitate the impact evaluation of the program, in order to not only ensure the efficient use of resources, but to also inform the decision-making processes and the policy debate at both the university and national levels. Unfortunately, as discussed on Appendix 3.A, the majority of the intended experiments could unfortunately not be carried out, either due to the lack of excess demand for admission to the program, or because it was not considered ethical to offer differential additional academic support to admitted students. In the end, the only randomized control trial which could be carried out was the experimental comparison of information dissemination methods during the program awareness campaign. However, since its results are not directly related to student performance, they are presented separately on Appendix 3.B.

3.4. Findings

3.4.1. Admissions

When the application period for special admission for academic year 2013 closed in mid-November 2012, a total of 240 secondary school students had initiated an application. However, only 103 had completed it, and after further screening 56 students were found eligible for the program. These subsequently took the special admission tests, in addition to the standard admission ones. A total of 48 students passed the special admission tests, but after taking into account the minimum standard admission test score criterion[49] only 25 students satisfied all the minimum requirements set forth for the special access program. In the end, 10 students enrolled in the Commercial Engineering degree in the 2013 academic year via the special access program, filling 50 % of the 20 available vacancies. The figures for the 2014 are proportional to the above, although the overall interest in the special access program increased. In particular, 118 students took the special admission test, and 18 enrolled in the Commercial Engineering degree through the special access program, filling 90 % of the 20 available vacancies (note that one student delayed enrollment because of *force*

[49]Note that, as already mentioned, special admission students only needed to obtain a 650 minimum score in the standardized admission test, while for ordinary admission candidates this was the criterion determining admission into the program, i.e. ordinary vacancies were filled by descending score in the standardized admission test.

majeure.

In view of the above, it first of all seems that the information diffusion and program awareness campaign for admission year 2013 was not successful, since it did not generate enough demand to have enough candidates fill all the vacancies created for the program, nor to allow for the use experimental evaluation methodology. Therefore, it seems that in the future it may be advisable to implement a larger and earlier information diffusion campaign to disseminate information about the special access program. In particular, given that the large majority of applicants to the program originated from the Santiago Metropolitan Region, it seems that in the future it would be advisable to extend the program awareness campaign efforts to other areas of the country.

However, it also seems that the minimum requirements set forth for special admission may perhaps have been too stringent, and/or that the demand for special admission among the targeted student population may not be as large as predicted. In particular, for the 2013 academic year the minimum standard admission score requirement of 650 points resulted in the disqualification of 23 candidates out of the 48 who have passed the special admission test (i.e. a 48% disqualification rate). This seems to be too high, particularly taking into account that it resulted on half of the special admission vacancies not being filled, suggesting that the standard admission score required may have been too high. Therefore, it seems that in the future it may be advisable to rely more on the results of the additional tests required for special admission, further relaxing the requirement of obtaining a minimum score in the ordinary admission test (see Chapter 2 for a detailed discussion of the characteristics and impact of the mathematical ability test used as one of the additional criterion for special admission).

3.4.2. Academic Performance

As it can be observed on Figure III.I.A, the performance of students admitted to the Commercial Engineering degree at the Pontificia Universidad Católica de Chile via the special access program in 2013 varied across subjects. In particular, it seems that on average special admission students had comparable grades to their ordinary admission peers in "soft" first semester compulsory subjects (i.e. "Accounting I" and "Horizons and Challenges in Business Management").[50] However, they fell behind in first semester compulsory "hard"

[50]Note that "special admission student" means a student who applied and was admitted via the special admission program "Talento + Inclusión" (Talent + Integration), irrespective of whether ex-post s/he may have been entitled to be admitted via ordinary admission, e.g. because of having obtained a standard admission test score higher than the cut-off required for that academic year. Also, it is worth noting that for robustness purposes only first semester compulsory courses are included in the comparison, because students who fail the first course will not be eligible to take further courses in the sequence (e.g. students who fail Calculus I in the first semester are not eligible to take Calculus II in the second one), nor do all students take the same elective courses.

courses, which featured a greater mathematical component (i.e. "Algebra", "Calculus I" and "Introductory Microeconomics"). This is consistent with the the evidence found by Arcidiacono et al (2011) in their study of the time path of racial differences in GPA and major choice at Duke University, and also with the information provided by the School of Engineering about the performance of students admitted to the Engineering degree via their own special access program. However, note that according to II, these differences are not statistically significant for any of the first semester compulsory courses in 2013. Once again, this is likely due to the reduced number of special admission students not providing enough statistical power to observe differences of this magnitude (the number of special admission students entering the degree in the 2013 and 2014 academic years is 10 and 17, respectively, and the number of ordinary admission students is about 260 in both years; however, some students did not take certain courses, for example because the corresponding credits were recognized by the university, or because of early withdrawal).

As it can be observed on Figure III.I.B, the above described differences in average first semester final grades are accentuated in the case of students entering the Commercial Engineering degree in academic year 2014. In particular, on average special admission students had comparable final grades to their ordinary admission peers in only one of the two "soft" first semester compulsory subjects ("Horizons and Challenges in Business Management"), but fell behind in the other ("Accounting I"). The latter was also the case on all the "hard" courses, featuring a greater mathematical component (i.e. "Algebra", "Calculus I" and "Introductory Microeconomics"). As before, this is consistent with with the findings of Arcidiacono et al (2011) and the information provided by the School of Engineering about the performance of students admitted via their own special access program. However, note that according to Table III.II, in this case the observed differences are indeed statistically significant in the case of "Algebra", "Calculus I" and "Introductory Microeconomics". This suggests that, although there may be some differences across cohorts, the lack of a significant difference in average final grades in 2013 is indeed very likely attributable to the more reduced number of special admission students that academic year, and its associated limited statistical power. In particular, given the available sample size, power calculations suggest that the minimum detectable effect sizes for "Algebra", "Calculus I", "Accounting I", "Horizons and Challenges in Business Management" and "Introductory Microcoenomics" are around 0.3, 0.4, 0.34, 0.16 and 0.29, respectively (fixing the confidence and power levels at 90% and 80%, as is standard). This is, given the sample size in this experiment, and fixing the probability of a false positive at 10%, differences in average final grades smaller than the above would not be observed with a probability of 20% or less. Since this paper finds that any observed differences larger that the above mentioned minimum detectable effect sizes are significant, this suggests that many of the larger differences which are found not to be significant are likely to be so, but just cannot be detected with the available sample size (this is particularly true for the large differences in average final grades observed in "hard" courses).

Note, however, that the above notwithstanding the "true" coefficients for the 2013 and 2014 cohorts need not necessarily be equal, for example because of differences in cohort characteristics between 2013 and 2014. Also, it is worth noting that in the Chilean education system grades range from 1 (lowest) to 7 (highest), with 4 usually being the lowest passing grade. According to Figure III.I.A, this means that in 2013 ordinary admission students on average passed all first semester compulsory subjects, while special admission students on average failed "Calculus I" with an average final grade of 3.8. Also, it means that according to Figure III.I.B, in 2014 ordinary admission students on average passed all first semester compulsory subjects, while special admission students on average failed "Algebra", "Calculus I" and "Accounting I", with average final grades of 3.90, 3.81 and 3.93, respectively. Also, in both 2013 and 2014 it seems that the variance of average final grades in "hard" courses may generally be higher for special admission students than for their ordinary admission peers.

With respect to academic situation, as it can be observed on Figure III.III, at the end of the first semester (March-July) of academic year 2014 (i.e. after three semesters enrolled in the Commercial Engineering degree) only one special admission student admitted in 2013 had withdrawn (10 %). This stands in stark contrast to the total of eighteen ordinary admission students admitted in 2013 who had abandoned their studies by that date (6.9 %). Also, by that date two ordinary admission students admitted in 2013 had been dismissed due to poor academic performance (0.75 %), and another two were not enrolled for other miscellaneous reasons (0.75 %), while all nine special admission students who had not withdrawn from the program were still enrolled in it. As for students admitted in 2014, at the end of the first semester (March-July) of academic year 2014 (i.e. after one semester enrolled in the Commercial Engineering degree) two special admission students (11.8 %) and three ordinary admission (1.2 %) ones had withdrawn, while all other students were still enrolled in the degree (note that in the Commercial Engineering degree it is generally not possible to be dismissed due to poor academic performance until the second semester of the first academic year, so that the number of students admitted in 2014 and dismissed at the end of the first semester of academic year 2014 is zero by definition). However, as it can be observed on Table III.IV, none of the above mentioned differences is statistically significant. As in previous cases, this may be due to the reduced number of special admission students not allowing for enough statistical power to observe differences of the appropriate magnitude. In particular, given the available sample size, power calculations suggest that the minimum detectable effect sizes for GPA, enrollment likelihood, withdrawal likelihood, dismissal likelihood and other non-enrollment likelihood in 2013 are around 0.25, 3.3 %, 2.8 %, and 0.3 %, respectively (with confidence and power levels fixed at 90 % and 80 %, as usual). For 2014 the corresponding minimum detectable effect sizes for GPA, enrollment likelihood, withdrawal likelihood, and dismissal likelihood sizes are 0.25, 0.5 % and 0.5 %, respectively (note that in 2014 it is not possible to compare dismissal and non-enrollment for other reasons, since its incidence is exactly the same in both the special and ordinary admission student subpopulations). This is, given the sample size in this experiment, and fixing the probability of a false positive at 10 %, differences in average final grades smaller than the above would not be observed with a probability of 20 % or less. Since in the case of the likelihood of enrollment/withdrawal/dismissal the thresholds are quite low, it seems that either there indeed are no significant differences with respect to those outcomes of interest between special and ordinary admission students, or that if they exist they are very small (i.e. smaller than the respective thresholds mentioned above). With respect to GPA, as it can be observed on Table III.IV, as of July 2014 (after one semester enrolled in the degree) special admission students admitted in 2014 had significantly lower grades than their ordinary admission peers, while special admission students admitted in 2013 had no statistically significantly different grades from their ordinary admission peers (after three semesters enrolled in the degree).

As it can be observed above, student withdrawal is not a rare event, either in the special admission and ordinary admission subpopulations. However, it seems that special admission students may be more likely to decide to withdraw earlier in the program than ordinary admission students, suggesting potential non-academic adaptation problems. Also, although once again these figures need to be taken with a grain of salt due to the relatively small sample size (note that percentage figures can be particularly misleading given the very large difference of size between the ordinary and special admission subpopulations), it seems that special admission students are very unlikely to be dismissed, and have caught up with their ordinary admission peers by the end of their third semester enrolled in the degree[51]. However, they may decide to abandon their studies earlier, and may have lower grades than their peers to start with.

All the above suggests that, while special admission students in this study start with a disadvantage in academic performance terms, they are very unlikely to be dismissed due to poor academic performance. Also, they catch up with their ordinary admission peers in terms of GPA rather soon (after three semesters). This seems to support the case for this and other special admission programs, but also suggests that improvements could be made. In particular, it seems that it would be advisable to increase the additional support provided to special admission students (of course, this support could also be expanded to ordinary admission students to reduced their withdrawal and dismissal rates). This would mean both addressing adaptation problems to reduce the likelihood of withdrawal, and reducing the academic gap with more remedial and tutoring resources (particularly regarding mathematical ability).

3.5. Conclusion

This paper presents a higher education special access program for students from disadvantaged socioeconomic backgrounds, custom-designed by the author for one of the leading Chilean universities, and implemented as

[51] Note that catch-up in terms of GPA may be due to pure academic improvement, but also due to differences in elective selection, as found by Arcidiacono et al (2011).

a pilot during the 2013 and 2014 admission periods. Although this was not the first program of its kind in the country (or even in the university), it was the first which tried to incorporate experimental evaluation methodology to its design. Unfortunately, as discussed on Appendix 3.A, only one of the planned experiments could actually be implemented. Since its results are not directly related to student performance, but rather to the effectiveness of dissemination information methods tested during the program awareness campaign, they are presented separately on Appendix 3.B.

In any case, although the original experimental design of the special admission process could not be implemented, a non-experimental comparison of the academic performance of special and ordinary admission students was carried out in its place. Evidence is found suggesting that, although special admission students on average have comparable final grades to their ordinary admission peers, they tend to perform comparatively worse in "hard" subjects (i.e. those with a stronger mathematical component). This is consistent with the information provided by the School of Engineering about the performance of students admitted to the Engineering degree via their own special access program, and with the findings of Arcidiacono et al (2011) in their study of the time path of racial differences in GPA and major choice at Duke University. Also, no significant differences in voluntary withdrawal or dismissal are observed between special and ordinary admission students, although special admission students seem more likely to decide to withdraw earlier in the program (suggesting potential non-academic adaptation problems). Finally, an initial gap in GPA between special and ordinary admission students is closed by the end of the third semester of enrollment, and no special admission student was dismissed during the period of study.

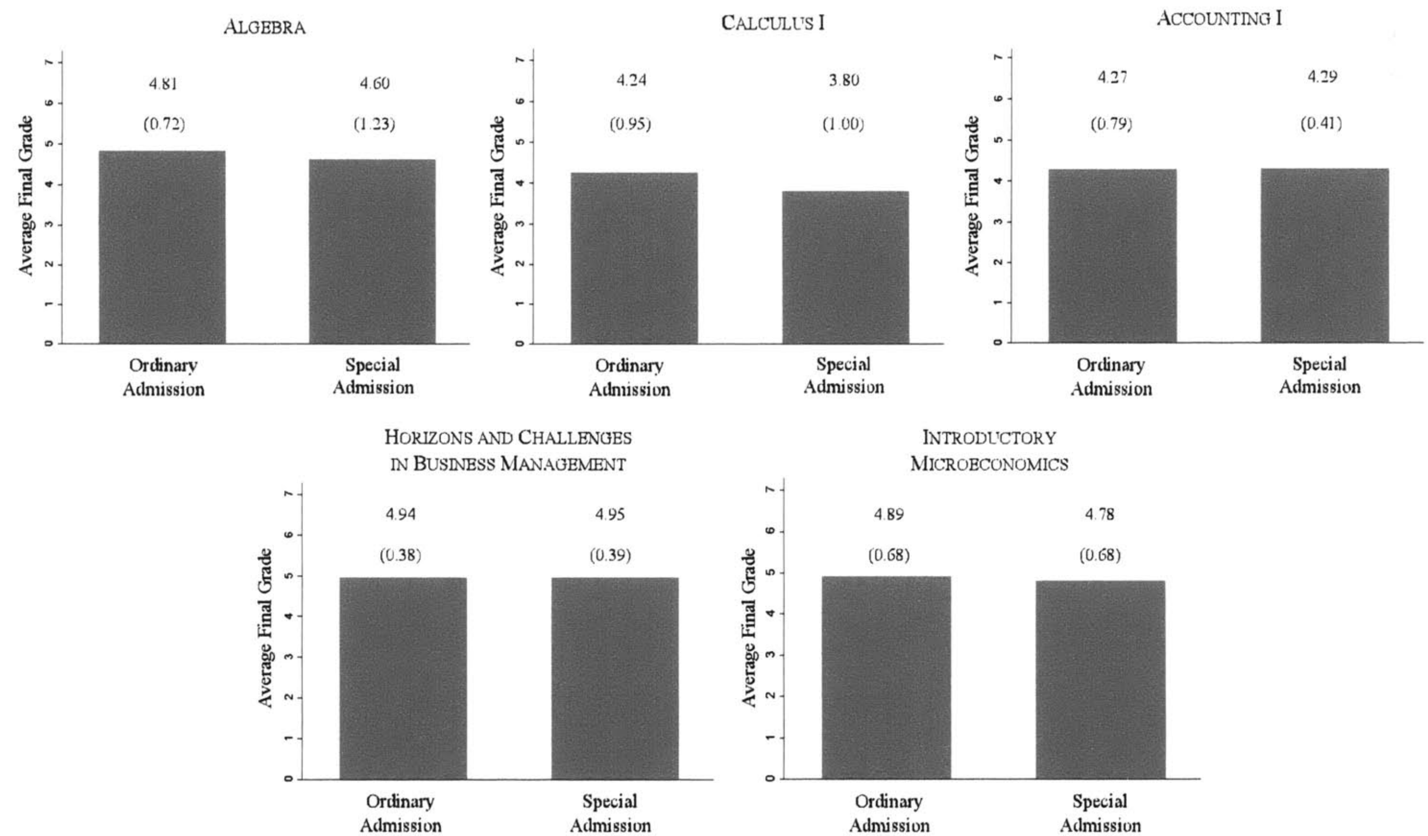
All the above suggests that, at the time of enrollment, the special admission students featured in this study had a disadvantage in academic performance terms (relative to their ordinary admission peers). Also, it seems that they may be more likely to decide to abandon their studies early. However, it seems that special admission students are in any case very unlikely to be dismissed due to poor academic performance, and that they actually catch up with their ordinary admission peers in terms of GPA as early as after three semesters of enrollment in the degree. This suggests that, with some nuances, students from disadvantaged socioeconomic backgrounds can successfully catch up with their peers when provided with adequate support, and that special admission programs can therefore be an effective tool to improve the access to higher education. However, it also seems that it would be advisable to further increase the additional support provided to special admission students (of course, this support could also be expanded to ordinary admission students, in order to also reduce their withdrawal and dismissal rates). This would mean both addressing adaptation problems to reduce the likelihood of withdrawal, as well as reducing the academic gap with more remedial and tutoring resources (particularly regarding mathematical ability).

Finally, the fact that the program was undersubscribed suggests that, apart from potential information diffusion problems, the minimum requirements set forth for special admission may have been too stringent, and/or that the demand for special admission among the targeted student population may not be as large as predicted.

In any case, it is worth noting that all the proposed measures would be a complement, but not a substitute, to deeper educational reform in the medium and long term (e.g. improvement of the quality of secondary education for all, and/or review of the ordinary admission process).

FIGURE III.I.A

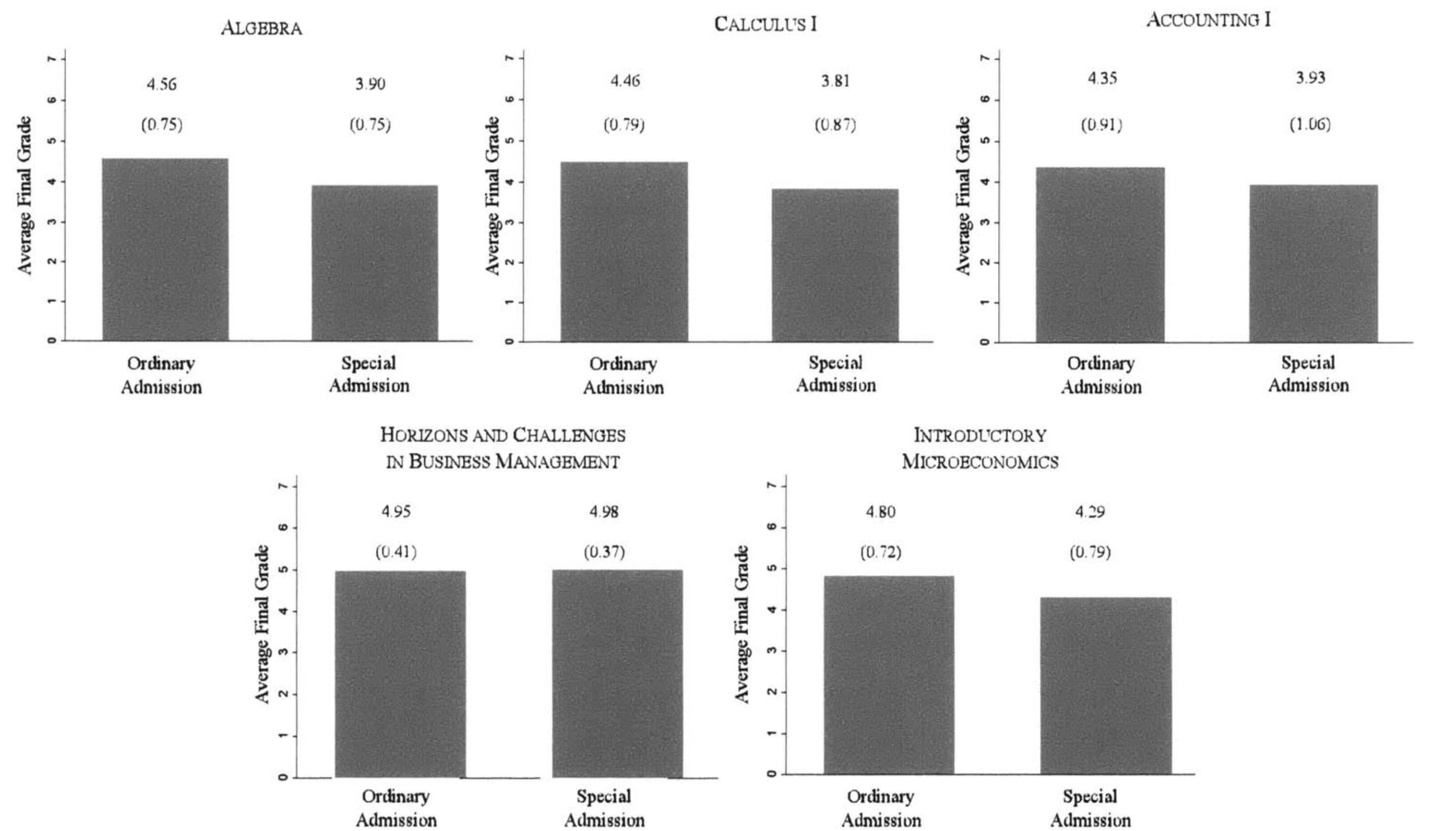
AVERAGE FINAL GRADE FOR ORDINARY AND SPECIAL ADMISSION STUDENTS BY FIRST SEMESTER COMPULSORY COURSE (2013)



NOTES. The figures above depict the average final grade for ordinary and special admission students admitted to the Commercial Engineering degree at the Pontificia Universidad Católica de Chile in the academic year 2013 in each of the first semester (March-July 2013) compulsory courses (i.e. Algebra, Calculus I, Accounting I, Horizons and Challenges in BusinessManagement, and Introductory Microeconomics). The average final grade determines the height of each bar, and is also written over it, with standard deviations reported between parentheses. Grades range from 1 (lowest) to 7 (highest), and 4 is the lowest passing grade. The number of special admission students entering the degree in the 2013 and 2014 academic years is 10 and 17, respectively, and the number of ordinary admission students is about 260 in both years (note that some students did not take some courses, for example because the corresponding credits were recognized by the university, or because of early withdrawal). Note that "special admission student" means a student who applied and was admitted via the special admission program "Talento + Inclusión" (*Talent + Integration*), irrespective of whether ex-post s/he may have been entitled to be admitted via ordinary admission because of having obtained a standard admission test score higher than the cut-off required for that academic year.

FIGURE III.1.B

AVERAGE FINAL GRADE FOR ORDINARY AND SPECIAL ADMISSION STUDENTS BY FIRST SEMESTER COMPULSORY COURSE (2014)



NOTES. The figures above depict the average final grade for ordinary and special admission students admitted to the Commercial Engineering degree at the Pontificia Universidad Católica de Chile in the academic year 2014 in each of the first semester (March-July 2013) compulsory courses (i.e. Algebra, Calculus I, Accounting I, Horizons and Challenges in BusinessManagement, and Introductory Microeconomics). The average final grade determines the height of each bar, and is also written over it, with standard deviations reported between parentheses. Grades range from 1 (lowest) to 7 (highest), and 4 is the lowest passing grade. The number of special admission students entering the degree in the 2013 and 2014 academic years is 10 and 17, respectively, and the number of ordinary admission students is about 260 in both years (note that some students did not take some courses, for example because the corresponding credits were recognized by the university, or because of early withdrawal). Note that "special admission student" means a student who applied and was admitted via the special admission program "Talento + Inclusión" (*Talent + Integration*), irrespective of whether ex-post s/he may have been entitled to be admitted via ordinary admission because of having obtained a standard admission test score higher than the cut-off required for that academic year.

TABLE III.II

DIFFERENCES IN FIRST SEMESTER COMPULSORY COURSES FINAL GRADES BETWEEN ORDINARY AND SPECIAL ADMISSION STUDENTS

	Student's First Semester Final Grades	(1) Algebra	(2) Calculus I	(3) Accounting I	(4) Horizons and Challenges in Business Mgmt.	(5) Introductory Microeconomics
Admitted 2013	1 = Special Admission Student	-0.208	-0.438	0.020	0.014	-0.112
		(0.372)	(0.309)	(0.134)	(0.119)	(0.208)
	Constant Term	4.808	4.238	4.270	4.936	4.892
		(0.045)***	(0.060)***	(0.049)***	(0.024)***	(0.042)***
	R^2	0.00	0.01	0.00	0.00	0.00
	Observations	269	262	266	251	270
Admitted 2014	1 = Special Admission Student	-0.656	-0.646	-0.424	0.033	-0.518
		(0.194)***	(0.223)***	(0.272)	(0.097)	(0.203)**
	Constant Term	4.563	4.460	4.351	4.947	4.805
		(0.048)***	(0.050)***	(0.058)***	(0.026)***	(0.046)***
	R^2	0.04	0.04	0.01	0.00	0.03
	Observations	261	260	265	262	263

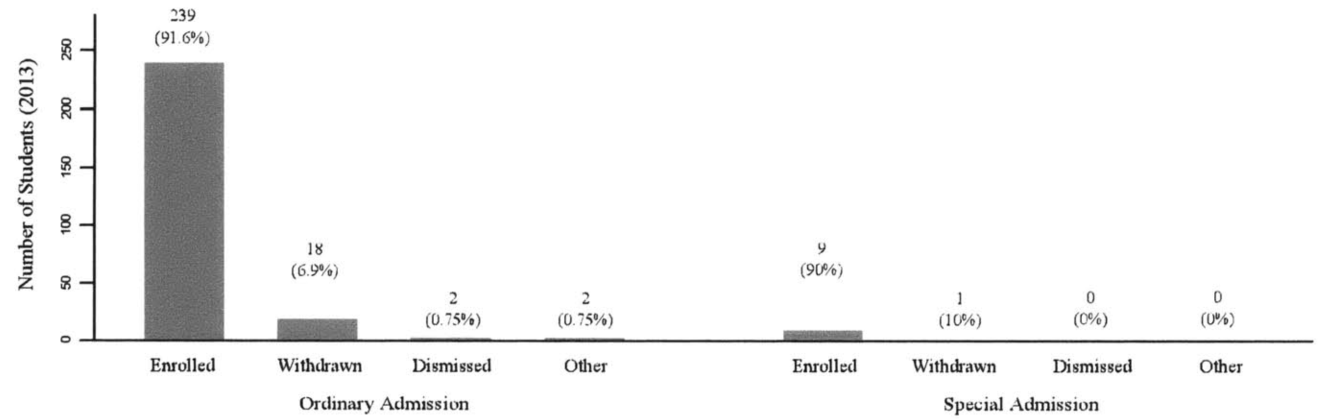
* $p<0.1$; ** $p<0.05$; *** $p<0.01$

NOTES. This table analyzes the differences in first semester final grades between ordinary and special admission students admitted to the Commercial Engineering degree at the Pontificia Universidad Católica de Chile during academic years 2013 (above) and 2014 (below). The dependent variable in all regressions is the student's final grade for each the subject in the corresponding column, i.e. (1) Algebra, (2) Calculus I, (3) Accounting I, (4) Horizons and Challenges in Business Management, and (5) Introductory Microeconomics. The independent variable "1 = Special Admission Student" denotes the indicator variable which takes a value of 1 if the student enrolled via the special admission program "Talento + Inclusión" (*Talent + Integration*) and 0 otherwise (i.e. if the student enrolled via ordinary admission). Grades range from 1 (lowest) to 7 (highest), and 4 is the lowest passing grade. The number of special admission students entering the degree in the 2013 and 2014 academic years is 10 and 17, respectively, and the number of ordinary admission students is about 260 in both years (note that some students did not take some courses, for example because the corresponding credits were recognized by the university, or because of early withdrawal). Note that "special admission student" means a student who applied and was admitted via the special admission program "Talento + Inclusión" (*Talent + Integration*), irrespective of whether ex-post s/he may have been entitled to be admitted via ordinary admission because of having obtained a standard admission test score higher than the cut-off required for that academic year. Huber-White heteroskedasticity-consistent standard errors are reported between parentheses.

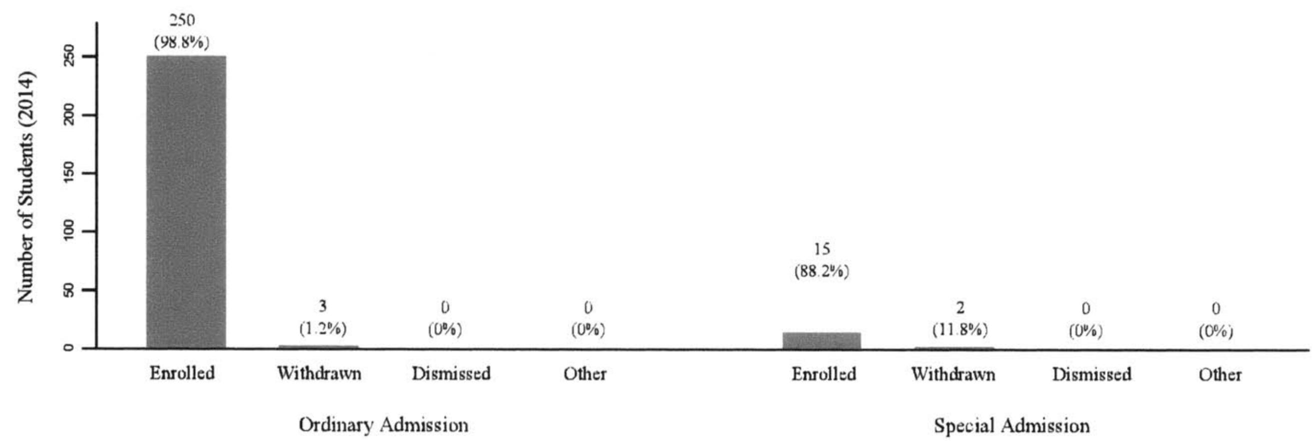
FIGURE III.III

ACADEMIC SITUATION OF STUDENTS BY ADMISSION YEAR AND TYPE AS OF JULY 2014

ACADEMIC SITUATION OF STUDENTS ENTERING THE COMMERCIAL ENGINEERING DEGREE IN 2013 (AFTER THREE SEMESTERS)



ACADEMIC SITUATION OF STUDENTS ENTERING THE COMMERCIAL ENGINEERING DEGREE IN 2014 (AFTER ONE SEMESTER)



NOTES. The figures above depict the academic situation by admission year and type of students entering the Commercial Engineering degree at the Pontificia Universidad Católica de Chile. The upper figure depicts the academic situation as of July 2014 of students entering the degree in the 2013 academic year, i.e. after three semesters of undergraduate studies. The lower figure depicts the academic situation as of July 2014 of students entering the degree in the 2014 academic year, i.e. after one semester of undergraduate studies. The situation of students entering via the ordinary admission process is depicted on the left, while that of students entering via the special admission program "Talento + Inclusión" (*Talent + Integration*). Students may either be still enrolled in the degree (first bar), have decided to withdraw (second bar), have been dismissed because of poor academic performance (third bar), or not be enrolled for any other reason, such as *force majeure* (fourth bar). The total number of students in each category is noted over each bar, and the percentage with respect to the total is provided between parentheses. The number of special admission students entering the degree in the 2013 and 2014 academic years is 10 and 17, respectively, and the number of ordinary admission students is about 260 in both years (note that some students did not take some courses, for example because the corresponding credits were recognized by the university, or because of early withdrawal). Note that "special admission student" means a student who applied and was admitted via the special admission program "Talento + Inclusión" (*Talent + Integration*), irrespective of whether ex-post s/he may have been entitled to be admitted via ordinary admission because of having obtained a standard admission test score higher than the cut-off required for that academic year.

TABLE III.IV

DIFFERENCES IN ACADEMIC SITUATION BETWEEN ORDINARY AND SPECIAL ADMISSION STUDENTS AS OF JULY 2014

	Academic Situation as of July 2014	(1) GPA	(2) Enrollment	(3) Withdrawal	(4) Dismissal	(5) Other
Admitted 2013	1 = Special Admission Student	-0.054	-0.016	0.031	-0.008	-0.008
		(0.207)	(0.097)	(0.097)	(0.005)	(0.005)
	Constant Term	4.776	0.916	0.069	0.008	0.008
		(0.038)***	(0.017)***	(0.016)***	(0.005)	(0.005)
	R^2	0.00	0.00	0.00	0.00	0.00
	Observations	269	271	271	271	271
Admitted 2014	1 = Special Admission Student	-0.476	-0.106	0.106	0.000	0.000
		(0.162)***	(0.079)	(0.079)	(0.000)	(0.000)
	Constant Term	4.658	0.988	0.012	0.000	0.000
		(0.036)***	(0.007)***	(0.007)*	(0.000)	(0.000)
	R^2	0.04	0.04	0.04	.	.
	Observations	265	270	270	270	270

* $p<0.1$; ** $p<0.05$; *** $p<0.01$

NOTES. This table analyzes the differences in academic situation (as of July 2014) between ordinary and special admission students admitted to the Commercial Engineering degree at the Pontificia Universidad Católica de Chile during academic years 2013 (above) and 2014 (below). The dependent variables in each regression (column) are (1) GPA as of July 2014, (2) an indicator variable which takes a value of 1 if the student is still enrolled in the degree, (3) an indicator variable which takes a value of 1 if the student decided to withdraw from the degree, (4) an indicator variable which takes a value of 1 if the student was dismissed due to poor academic performance, and (5) an indicator variable which takes a value of 1 if the student is not enrolled for any other reason, such as *force majeure*. Note that for students entering the degree during the 2013 academic year this table analyzes their academic situation after three semesters of undergraduate studies, while for students entering the degree during the 2014 academic year this table analyzes their academic situation after one semester of undergraduate studies. The independent variable "1 = Special Admission Student" denotes the indicator variable which takes a value of 1 if the student enrolled via the special admission program "Talento + Inclusión" (*Talent + Integration*) and 0 otherwise (i.e. if the student enrolled via ordinary admission). The number of special admission students entering the degree in the 2013 and 2014 academic years is 10 and 17, respectively, and the number of ordinary admission students is about 260 in both years (note that some students did not take some courses, for example because the corresponding credits were recognized by the university, or because of early withdrawal). Note that "special admission student" means a student who applied and was admitted via the special admission program "Talento + Inclusión" (*Talent + Integration*), irrespective of whether ex-post s/he may have been entitled to be admitted via ordinary admission because of having obtained a standard admission test score higher than the cut-off required for that academic year. Huber-White heteroskedasticity-consistent standard errors are reported between parentheses.

Appendix 3.A: Original Experimental Design

As mentioned, the "Talento + Inclusión" (*Talent + Integration*) special access program featured three distinct phases: (a) an awareness campaign, intended to disseminate information about the program among target secondary schools; (b) a new special admission process for the Commercial Engineering degree at the university, intended to bypass some of the perceived barriers to the access of students from disadvantaged backgrounds; and (c) additional support provided after enrollment to the students admitted via the program.

The first phase of the program (i.e. the awareness campaign) featured a randomized control trial, intended to compare the impact of using email or phone to communicate information about the program to secondary schools. This experiment was implemented, and is presented more in detail on Appendix 3.B.

Similarly, the original design of the second phase of the program (i.e. the special admission process) also envisioned an experimental evaluation. It was intended to take advantage of the excess demand generated by the awareness campaign in the first phase, in order to evaluate the impact on eligible applicants of being admitted to the Commercial Engineering degree via the special access program. It would have consisted of a random allocation of the 20 available vacancies among all candidates who met the minimum admission requirements, in a similar manner to, for example, the lottery allocation system used by the state of Tennessee in the United States to award financial aid for higher education (see Pallais, 2009, for a detailed description of the Tennessee lottery system, and an analysis of its impact). This would have created two comparable groups differing only along the treatment dimension (i.e. being admitted), thus allowing for a robust estimation of the impact of the program.

In particular, this experimental design consisted of two steps: (i) First, all applicants were screened to verify that they satisfied the eligibility criteria set forth for the special access program (see previous section). (ii) Then, the special access vacancies were to be randomly assigned among all eligible applicants who in the first step were identified as satisfying all the minimum admission criteria. All the admission criteria were purposely "binomial" (i.e. once a candidate satisfies a criterion no further distinction is made), so that a comparable pool of admitted and non-admitted candidates is generated. This has obvious methodological advantages, but it was also considered the "fairest" selection method, since the main concern (and the very *raison d'être* of the special access program) was to avoid existing selection methods which may be biased against talented students from disadvantaged backgrounds.[52]

[52] It is worth noting that quasi-experimental methodologies, such as a regression discontinuity design, could also be used to study the differences between students who applied via the special admission program, but ended up being admitted via ordinary admission. Also, the comparison of special admission students with ordinary admission ones with the lowest scores in the standardized admission test might allow for a better understanding of the test's performance. Moreover, the correlation between the different admission criteria used in the special access program and academic performance (or any other outcomes

Unfortunately, as already mentioned in the end this second experiment could not be implemented, due to the lack of excess demand for admission via the special access program (i.e. admission was offered to all candidates who met the minimum special admission requirements). In view of this, it seems that, as discussed above, in the future it may be advisable to implement a larger and earlier information diffusion campaign, in order to better publicize the special access program and generate enough demand for it. In particular, given that the large majority of applicants to the program originated from the Santiago Metropolitan Region, it seems that it may be advisable to extend the program awareness campaign efforts to other areas of the country. However, it also appears that the demand for special admission among the targeted student population may not be as large as predicted, and/or that the minimum requirements set forth for special admission might have been too stringent. In particular, it seems that in the future it may be advisable to rely more on the results of the additional tests required for special admission, further relaxing the requirement of obtaining a minimum standard admission score (see Chapter 2 for a detailed discussion of the characteristics and impact of the mathematical ability test used as one of the additional criterion for special admission).

Finally, the third and last phase of the access program consisted on providing additional support to students admitted via it. This was both so that they could overcome any formative or knowledge gaps, as well as in order to ease their adaptation to the new environment. Therefore, this meant providing remedial courses and academic training, but also supporting the integration of the special admission students along non-academic dimensions. Also, it was deemed important to provide this additional support in a way which avoided any potential "stigmatization" of special admission students, or a potential substitution effect between the effort devoted to additional support activities and regular academics. In view of this it was decided that the most appropriate would be to organize a two week intensive summer camp, before the start of the regular academic year.

It is worth noting that, in principle, an experimental design would also have been feasible in this phase (for example, by providing additional support only to a randomly selected subset of admitted students, or using an encouragement-to-treat approach).[53] However, since it was reasonable to think that the additional support would likely have a positive impact on students (while being unlikely to have a negative one), it was decided to provide it to all students admitted via the special access program. Therefore, all students

of interest) may also be informative. Finally, it is also worth noting that, if successful, this design would have also allowed to experimentally measure the economic impact of being admitted via the special access program on income, thus allowing us to better understand the value of education.

[53]Note that another experimental methodology suitable to evaluate the impact of the additional support in this context would be to use an "encouragement to treat" approach, e.g. by allowing ordinary admission students to enroll in additional support activities, and encouraging a randomly selected subset of them to apply to do so. Also, a regression discontinuity design may potentially be used to compare candidates admitted via special admission with their peers who applied via the special admission program, but were finally admitted via ordinary admission (or, in general, with ordinary admission students with the lowest admission scores).

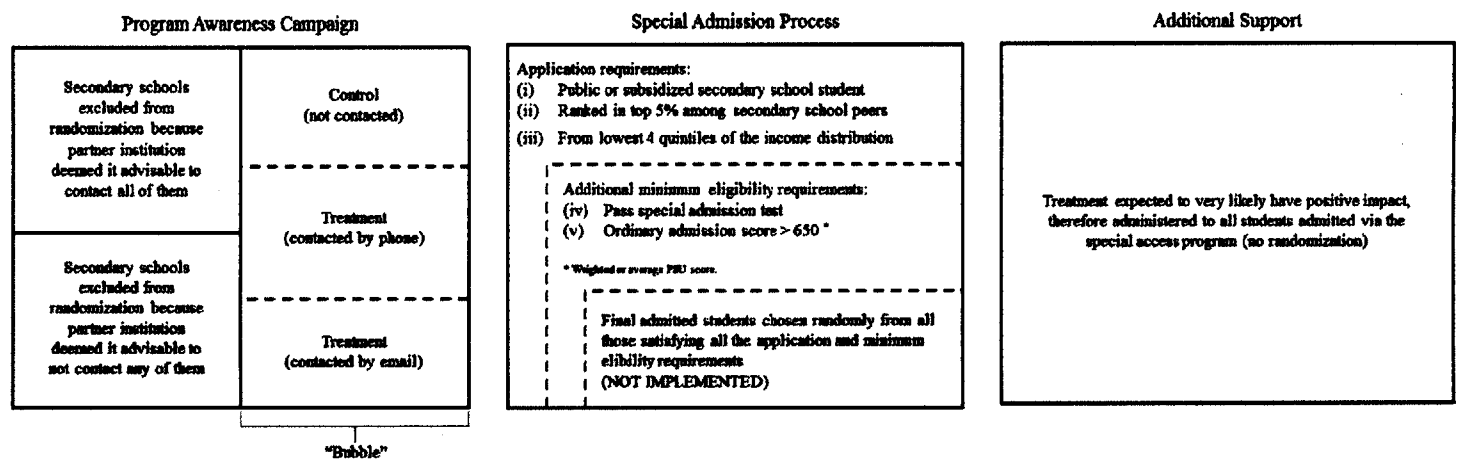
admitted via the special access program underwent the two week intensive summer camp before the start of the regular academic year. Student feedback provided at the end of the camp was very positive, and suggests that in the future it would be advisable to keep this additional support feature (and potentially increase its length).[54]

For illustration purposes the above is summarized in Figure III.V.

[54]In general, a negative impact may indeed be a concern (e.g. if there is a substitution effect between the effort devoted to support activities and regular coursework). However, given the characteristics of the additional support for special admission students, this was not considered a concern in this particular context.

APPENDIX 3.A: FIGURE III.V

TREATMENTS AND ASSIGNMENT IN ORIGINAL EXPERIMENTAL DESIGN



NOTES. This paper analyzes a special access program, custom-designed for one of the leading Chilean universities, and implemented as a pilot during the 2013 and 2014 admission periods. Its two main features were a program awareness campaign targeting secondary schools, and a special admission process for students from disadvantaged backgrounds (although it also included additional support for all students admitted via the special access program). While this was not the first program of its kind in the country (or even in the university), it was the first to try to incorporate experimental evaluation methodology in its design (which was conceived by the author of this study). This was intended to facilitate the evaluation of the impact of the program, in order to help to not only ensure the efficient use of resources, but to also inform the decision-making processes and the policy debate at the university and national levels. The awareness campaign included a randomized control trial, allowing for a robust comparison of the impact of using email or phone to communicate information about the program to secondary schools. The original design of the special admission process also included another randomized control trial, intended to estimate the differential impact of being admitted into the program. However, it unfortunately could not be implemented due to the lack of excess demand for admission into the program. Additional support was expected to very likely have a positive impact on academic performance, and was therefore provided to all students admitted via the special access program.

Appendix 3.B: Experimental Comparison of Communication Methods

As already mentioned above, the first phase of the program (i.e. the awareness campaign) featured a randomized control trial, intended to compare the impact of using email or phone to communicate information about the program to secondary schools. This experiment was carried out, and is discussed in detail below.[55]

In particular, all the potential secondary schools of interest were divided in three subpopulations. The first subpopulation consisted of schools which the Faculty considered essential, and the awareness campaign was to be rolled out in all of them. The second subpopulation consisted of schools in which the Faculty did not think that it would be efficient to spend resources publicizing the program, and the awareness campaign was therefore not to be rolled out in any of them. The third subpopulation consisted of all other schools, and it was randomly divided in one control and two treatment groups. No further action was taken with respect to the latter, while one of the treatment groups was contacted by phone, and the other by email. In the end, emails were sent out to 93 schools, and a first round of calls was made to 96 schools, while 188 schools were not contacted (it is worth noting that some secondary schools which were successfully contacted by phone asked for a follow-up email with more details about the special access program, which was subsequently provided to them). Information was then gathered for all schools in the evaluation, in order determine which information diffusion method had a greater impact (this is achieved by comparing the average number of complete applications received from secondary schools in each of the treatment groups with those received from secondary schools in the control group).

It is worth noting that out of the 96 schools in the phone call treatment group, only 25 could be successfully contacted in the first round of calls over three days (a successful contact means that the person responsible for career advice at the school, or alternatively its principal or other person of responsibility, could be reached and had time to go through the established informational protocol). Therefore, the rate of success for phone contact was 26 %. Also, as already mentioned it is also worth noting that some secondary schools which were successfully contacted by phone asked for a follow-up email with more details about the special access

[55]Note that due to a last-minute re-organization, all information diffusion efforts of the several special access programs offered at the different schools and faculties were centralized at the university level. This meant that the planned awareness campaign at the Faculty level, featuring the experimental evaluation of communication methods, had to be implemented in addition to any diffusion efforts at the university level. The latter did not focus on any degree on particular, but anecdotical evidence and application volumes suggest that most of the demand was channeled to the degrees which already had an established access program (such as the above mentioned Engineering degree). This reorganization also resulted in reduced resources, and a delay of several months in the implementation of diffusion efforts at the Faculty level. Therefore, a reduced size experimental awareness campaign was implemented several months later than intended. However, in any case target schools were identified, and subsequently divided in one control and two treatment groups (email and phone contact, respectively) as originally designed.

program, which was later provided to them. And, out of those 25 schools successfully contacted by phone it was observed that 9 (about a third) had already heard about the special access program.

Figure III.VI presents the average number of complete applications received from students attending secondary school in each of the control and treatment groups. Only complete applications are reported (i.e. applications which were initiated in the system but never fully completed are not included in this analysis). The total number of initiated applications was 240, with 107 completed before the application period ended, of which 76 corresponded to schools included in the special admission program awareness campaign.[56]

The average number of complete applications received from secondary schools contacted by email was two times the average number received from control secondary schools, which were not contacted (0.30 versus 0.15, respectively). However, as it can be observed on Table III.VII, this difference is not statistically significant. In any case, it is worth noting that given the relatively small sample size, it cannot be robustly concluded that email contact at the secondary school level does not significantly increase the likelihood of students from those schools applying to the special access program, i.e. the impact may not be sufficiently large to be observed in this experimental context. In particular, given the sample size in this experiment, power calculations suggest that the minimum detectable (non-standardized) effect size would be about 0.34 (fixing confidence and power levels at 90 % and 80 %, respectively). This is, given the sample size in this experiment, and fixing the probability of a false positive at 10 %, a difference of 0.34 (or less) between treatment and control groups in the average number of completed applications received would go undetected with a probability of 20 % (or more). Since the observed difference falls below this threshold, it cannot be concluded that it is not significant, but rather that it might not be observable with the available sample size.

Similarly, the average number of complete applications received from secondary schools contacted by phone was also larger than the average number received from control secondary schools (0.21 versus 0.15, respectively). This difference is smaller than for email contact, but in any case as it can be observed on Table III.VII it is again not statistically significant. Also, as before given the limited sample size, it cannot be concluded that the different is not significant, but rather that the experiment may not be powered enough to observed.

Finally, despite the fact that no significant differential impact was observed in this experiment, the results

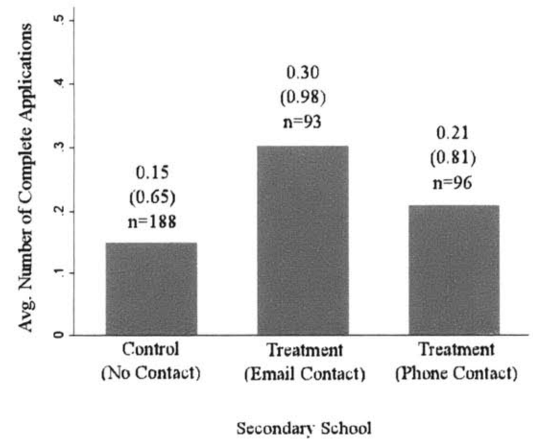
[56]It is worth noting that only applications from schools targeted in the awareness campaign are included, i.e. there were additional applications from students attending other secondary schools which are not reported. Also, note that "email contact" and "phone contact" refers only to targeted contact within the scope of the special admission program awareness campaign carried out by the Faculty of Economic and Administrative Sciences of the Pontificia Universidad Católica de Chile. Moreover, the university organized an earlier awareness campaign of special admission programs at the university level among some secondary schools. For the purpose of this analysis, this earlier contact at the university level in the context of this other campaign was included as a stratum at the time of random assignment. Finally, it is worth noting that that this is an "Intention-to-Treat" approach, i.e. there was no verification that schools had actually read or acted upon the emails sent or calls made, and as already mentioned it was not possible to successfully contact all schools by phone.

of the experiment suggest that email contact is likely the best method of communication (i.e. sending emails is less time-consuming and less expensive than making phone calls, but there is no evidence suggesting that the latter is more effective than the former, and some of the schools initially contacted by phone even asked for follow up emails). Therefore, it seems that in the future it would probably be advisable to just focus on email communication for this type of campaigns.

Also, it seems clear that in general terms the awareness campaign was not successful, in view of the subsequent undersubscription of the program. Therefore, it appears that in the future it would be necessary to start the awareness campaign earlier. Also, it seems that it may be advisable to make it both more extensive and intensive, increasing the intensity of contact, but also the number and type of schools contacted (in particular, given that the large majority of applicants to the program originated from the Santiago Metropolitan Region, it seems that in the future it would be advisable to extend the program awareness campaign efforts to other areas of the country).

APPENDIX 3.B: FIGURE III.VI

AVERAGE NUMBER OF COMPLETE APPLICATIONS RECEIVED FROM SECONDARY SCHOOLS INCLUDED IN THE SPECIAL ACCESS PROGRAM AWARENESS CAMPAIGN



NOTES. The figure above depicts the average number of complete applications received to the special access program "Talento + Inclusión" (*Talent + Integration*) at the Commercial Engineering degree of the Pontificia Universidad Católica de Chile for the academic year 2013 from students attending secondary schools included in the awareness campaign for the program. Each bar represents one of the three groups in which targeted schools were randomly divided, i.e. control (not contacted), treatment (contacted by email), and treatment (contacted by phone). The height of each bar represents the average number of complete applications received from each group, and is also written over it, with standard deviations reported between parentheses over the total number of schools in each group. It is worth noting that only applications from schools targeted in the awareness campaign are included, i.e. there were additional applications from students attending other secondary schools which are not reported. Also, only complete applications are reported, i.e. applications which were initiated in the system but never fully completed are not included above. The total number of initiated applications was 240, with 107 completed before the application period ended, of which 76 corresponded to schools included in the special admission program awareness campaign. Note that "email contact" and "phone contact" refers only to targeted contact within the scope of the special admission program awareness campaign carried out by the Faculty of Economic and Administrative Sciences of the Pontificia Universidad Católica de Chile, in charge of the Commercial Engineering Degree. Some secondary schools which were successfully contacted by phone asked for a follow-up email with more details about the special access program, which was later provided to them. Also, the university organized an earlier awareness campaign of special admission programs at the university level among some secondary schools. Earlier contact at the university level in the context of this other campaign was included as a stratum at the time of random assignment of secondary schools to control and treatment groups for the purpose of this analysis. Note also that this is an "Intention-to-Treat" approach, i.e. there was no verification that schools had actually read or acted upon the emails sent or calls made, and it was not possible to successfully contact all schools to which a call was made by phone. In particular, out of the 96 schools in the phone call treatment group only 25 could be successfully contacted in the round of calls performed over three days, i.e. the rate of success for phone contact was 26% (a successful contact means that the person responsible for career advice at the school or its principal or other person of responsibility could be reached and had time to go through the established informational protocol).

APPENDIX 3.B: TABLE III.VII

DIFFERENCES IN NUMBER OF COMPLETE APPLICATIONS RECEIVED FROM SECONDARY SCHOOLS INCLUDED IN THE SPECIAL ACCESS PROGRAM AWARENESS CAMPAIGN

Complete Applications Received from Secondary School	(1.1) Linear	(1.2) Logit	(2) Linear
1 = Treatment (Email Contact)	0.039	0.399	0.152
	(0.041)	(0.401)	(0.111)
1 = Treatment (Phone Contact)	0.035	0.363	0.059
	(0.040)	(0.400)	(0.095)
Constant Term	0.090	-2.308	0.149
	(0.021)***	(0.255)***	(0.047)***
R^2	0.00		0.01
Observations	377	377	377

* $p<0.1$; ** $p<0.05$; *** $p<0.01$

NOTES. The figure above depicts the differences in the number of complete applications received to the special access program "Talento + Inclusión" (*Talent + Integration*) at the Commercial Engineering degree of the Pontificia Universidad Católica de Chile for the academic year 2013 from students attending secondary schools included in the awareness campaign for the program. Columns (1.1.) and (1.2) report the fitted coefficients from the linear and logit regression analysis of the probability that a student from one of the secondary schools included in the program awareness campaign completed an application to the special access program, i.e. the independent variable is an indicator variable which takes a value of 1 if at least one student from that secondary school completed an application to the special access program. Column (2) reports the fitted coefficient from the linear regression analysis of the number of students who applied to the special access program from each secondary school included in the program awareness campaign, i.e. the independent variable is the number of complete applications to the special access program received from students from that secondary school. The independent variable "1 = Treatment (Email Contact)" denotes the indicator variable which takes a value of 1 if the secondary school was randomly assigned to the treatment group which was contacted by email. Analogously, the independent variable "1 = Treatment (Phone Contact)" denotes the indicator variable which takes a value of 1 if the secondary school was randomly assigned to the treatment group which was contacted by phone, so that the base category therefore corresponds to schools randomly assigned to the control group, which were not contacted during the program awareness campaign. It is worth noting that only applications from schools targeted in the awareness campaign are included, i.e. there were additional applications from students attending other secondary schools which are not reported. Also, only complete applications are reported, i.e. applications which were initiated in the system but never fully completed are not included above. The total number of initiated applications was 240, with 107 completed before the application period ended, of which 76 corresponded to schools included in the special admission program awareness campaign. Note that "email contact" and "phone contact" refers only to targeted contact within the scope of the special admission program awareness campaign carried out by the Faculty of Economic and Administrative Sciences of the Pontificia Universidad Católica de Chile, in charge of the Commercial Engineering Degree. Some secondary schools which were successfully contacted by phone asked for a follow-up email with more details about the special access program, which was later provided to them. Also, the university organized an earlier awareness campaign of special admission programs at the university level among some secondary schools. Earlier contact at the university level in the context of this other campaign was included as a stratum at the time of random assignment of secondary schools to control and treatment groups for the purpose of this analysis. Note also that this is an "Intention-to-Treat" approach, i.e. there was no verification that schools had actually read or acted upon the emails sent or calls made, and it was not possible to successfully contact all schools to which a call was made by phone. In particular, out of the 96 schools in the phone call treatment group only 25 could be successfully contacted in the round of calls performed over three days, i.e. the rate of success for phone contact was 26% (a successful contact means that the person responsible for career advice at the school or its principal or other person of responsibility could be reached and had time to go through the established informational protocol). Huber-White heteroskedasticity-consistent standard errors are reported between parentheses.

"Jails and prisons are the complement of schools; so many less as you have of the latter, so many more must you have of the former."

H. Mann

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"Revolutionaries should not think through other people's minds.
Or, perhaps they should? Or even ought to?
How can one change the world if one identifies oneself with everybody?
How else can one change it?
He who understands and forgives ? where would he find a motive to act?
Where would he not?"

A. Koestler