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IZA DP No. 10610

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ABSTRACT

Efficient Supply of Human Capital: Role of College Major*

This study examines the extent to which changing the composition of college majors among working-age population may affect the supply of human capital or effective labor supply. We use the South Korean setting, in which the population is rapidly aging, but where, despite their high educational attainment, women and young adults are still weakly attached to the labor market. We find that Engineering majors have an advantage in various outcomes such as likelihood of being in the labor force, being employed, obtaining long-term position, and earnings, while Humanities and Arts/Athletics majors show the worst outcomes. We then conduct a back-of-the-envelope calculation of the impact of the recently proposed policy change to increase the share of Engineering majors by 10 percent starting in 2017. Our calculation suggests that the policy change may have a positive but small impact on labor market outcomes.

JEL Classification: I2, J2, J4

Keywords: economics of education, college major, returns to schooling, gender gap, human capital, aging

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I. Introduction

The economic growth and productivity of a country hinges on efficient supply and allocation of inputs (e.g., Hsieh and Klenow 2009 and Hsieh et al. 2013). In the context of developed countries, appropriate investment in human capital is particularly important because many of them have been experiencing sharp population aging, resulting in a shrinking working-age population. For example, in 2012, OECD countries on average had 4.2 persons of working-age (20 to 64) per person of pension age (65 or higher) and are expected to have only half of a working-age person per person of pension age by 2050 (OECD 2014). Therefore, unless available labor resources are better mobilized, population aging will lead to a reduced supply of labor, making it difficult to maintain continued increases in living standards (see Neumark et al. 2013 and OECD 2005). Possible economic shocks associated with population aging can be mitigated if each individual on average is better equipped with skills that are well appreciated in the labor market, namely higher human capital. Alternatively, a country could reduce the shocks if it induces a greater supply of labor from individuals that are weakly attached to the labor market (e.g., youth, elderly, and women, OECD 2005, 2006).

This study examines the possibility that policies impacting the supply of college majors may be used to address the shortage of human capital as well as the weak labor market attachment shown in some populations. We focus on college major supply because of growing evidence of the impact of college major on labor market outcomes (e.g., Hamermesh and Donald 2008; Altonji et al. 2012; Kinsler and Pavan 2014; Hastings et al. 2013; Kirkebøen et al. 2015). Specifically, we hypothesize that these findings may be generated by the following mechanisms: a labor market appreciates a certain type of human capital, and college majors differ from one another in terms of the extent to which they help their graduates attain that human capital. If our hypothesis is correct, a country can offset a labor shortage due to an aging population by properly incentivizing people to select college majors that yield higher human capital.

We assess this possibility in the context of South Korea because population aging poses imminent threats to the country and, at the same time, existing socioeconomic policies to promote fertility or to increase female labor market participation or youth employment have not shown any visible impact.[1] In fact, our conjecture of the possibility of using college major supplies to cope with the labor market's needs is in line with the recent policy discussions in South Korea.

Specifically, in December 2015, the Ministry of Employment and Labor (MOL) released its medium-term projections of supply and demand for each college major, predicting a shortage of Engineering majors but an excess supply of Humanities and Social Science majors. Based on these projections, Korea's Ministry of Education (MOE) introduced various monetary incentive schemes that urge colleges to reallocate seats to Engineering majors.[2] After these policy announcements by the MOL and MOE, Korean

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[1] South Korea has been experiencing a sharp population aging due to an increase in life expectancy and a dramatic decrease in fertility rate (the rate fell from 6 children per woman in the 1960s to 1.15 in 2009, the lowest among the OECD countries; OECD average is 1.74). It has exhibited the most rapid rate of population aging since 1984, to the point where it was classified as an aging society in 2000 (Lim 2011; OECD 2010; Hayutin 2009). Numerous social policies have been introduced to promote fertility in South Korea, but there is no sign of increasing fertility so far (Kim et al. 2014). For example, several types of monetary support are given to parents who have at least three children (e.g., reduction of vehicle acquisition tax and discount on electricity charges and transportation, leisure, and education services); children of such families have priority in day-care and pre-school assignments, which is an important benefit because there is a shortage of daycare and preschool seats relative to the demand (Korea Institute of Child Care and Education, 2013).

[2] For example, in 2015, the Ministry of Education (MOE) launched an incentive system, the "PRIME" (Program for Industrial needs - Matched Education) project, that provides transfers to universities when they reallocate quotas from under-performing majors to over-performing majors with respect to labor market outcomes (e.g., from Humanities to Engineering). Among applicants, the MOE chose 21 colleges that plan to reallocate on average 10 percent of their seats to increase the number of Engineering majors.

colleges decided to increase the number of seats assigned to Engineering majors by approximately 10 percent starting with the 2017 college admission cycle, while reducing the shares of Humanities, Social Science, Arts/Athletics, and Natural science/Mathematics majors.

This manuscript conducts the following exercises. Based on Korea's institutional features, we first theoretically examine students' college application behaviors and where they enroll. Based on these theoretical results, we devise an empirical strategy to estimate the impact of college major on labor market outcomes in South Korea. Using the empirical results, we conduct a back-of-the envelope calculation to determine the labor market outcomes if the college major supply is altered due to the 2017 college-major quota changes described above.

Each academic year, the South Korean central government (i.e., MOE) regulates the number of students a college can accept overall while each college allocates the total number across its majors. After the quota specific to a college and a major is set, students are allowed to apply for a handful of options. By option, we mean a specific combination of college and major. An applicant's chance of being admitted to a specific college and major depends on his/her test scores, not on unobservable major-specific talents. South Korea has a well agreed upon ranking of colleges and majors within a college, and the premiums of graduating from a highly-ranked college and major are large.[3] Due to this feature, a college applicant may face a tradeoff between the benefit from the prestige of a college and major for which she can be admitted – not considering her talents – and the benefit from her underlying talents. Using theoretical analyses, we show that among

[3] For example, Lee (2007) reports that among the companies listed in the South Korean stock exchange, 48 percent of the CEOs graduated from Seoul National University (just 0.4 percent of all college graduates), 14 percent from Korea University, and 12 percent from Yonsei University.

those who enroll in a major, both positive and negative selections may take place. We use the insights from the theoretical analyses to design our empirical strategy and examine the sensitivity of our main findings. See details in Sections III to VI.

We use the dataset from the Graduates Occupational Mobility Survey (GOMS), a nationally representative survey of new college graduates in South Korea. Our sample consists of individuals who graduated from a four-year college between August 2004 and February 2008, and it includes their academic quality at the time of college application, their initial labor market outcomes, and their outcomes three years after graduation. We classify college majors into seven groups: Engineering, Humanities, Social Science, Education, Natural science/Mathematics, Medicine/Public Health, and Arts/Athletics.[4] We estimate the impact of college major by estimating regression models controlling for a person's test scores on the college entrance exam and other observables. Our identification assumption is that, conditional on an applicant's academic quality, the degree of selection with respect to college major-specific unobservable talents, if any, is the same across college majors. Under this assumption, we find that Engineering and Medicine/Public Health yield the most favorable outcomes in terms of almost all labor market outcomes we examine: being in the labor force, likelihood of being employed, likelihood of having a long-term labor contract, and monthly earnings. Arts/Athletics is the category of majors least likely to lead to favorable labor market outcomes. This difference in labor market outcomes across college majors may account for approximately half of the gender gap in those outcomes because women are less likely to select more profitable college majors than their male counterparts.

[4] Medicine/Public Health majors train individuals to be medical doctors, nurses, pharmacists, physiologists, chiropractors, dental hygienists, nutritionists, therapists, and other healthcare providers.

We empirically examine the extent to which our identification strategy is valid and conduct robustness checks by relaxing our identification assumption. For example, we show that, in our setting, a sizable fraction of college graduates majored in fields different from what they intended to choose in high school. This gap between the actual and intended college majors illustrates that South Korea is difficult to characterize as a setting in which students observe their major-specific talents and positively select into a major (i.e., positive selection). In addition, for a given major, we calculate the share of those who majored in their intended major out of all graduates with that major. Assuming positive selection for those whose intended major is the same as actual major, we conduct a bounding exercise in the spirit of Lee (2009) and find that our main results are stable.

Using the estimated impact of college majors, we examine the extent to which the proposed college-major quota change may alter the labor market outcomes. Our back-of-the-envelope calculation suggests that if student enrollment is bound by the college-major quotas, the 10 percent quota increase in the Engineering major may increase employment and earnings, but these impacts are likely to be small in magnitude. For example, all else being equal, ignoring possible general equilibrium effects, the change may increase the labor market participation rate by 0.14 percent, the employment rate by 0.08 percent, and monthly earnings by 0.38 percent. Our findings suggest that although college quota changes may be a feasible policy option, the higher education policy recently introduced by the MOE is not likely to improve the labor market outcomes of college graduates.

The remainder of our paper proceeds as follows: in Section II, we describe the institutional background. Section III discusses possible sources of endogeneity and the implications for our identification strategy. Sections IV and V present our empirical strategy and data. We present empirical results in Section VI, while in Section VII, we discuss the robustness of our findings. Section VIII concludes.

II. Institutional Background

This section provides a brief summary of the college admissions system in South Korea. Interested readers can find more details in Avery, Lee and Roth (2014). Competition among students is intense to gain admission to a prestigious college and major. Perhaps due to this intense competition, the South Korean government has been deeply involved in designing the college admissions system and regulating the admissions policies of both public and private colleges (see Kim and Lee, 2006). In our period of study, the South Korean government employed the following rules: (i) applicants are allowed to apply for only a few options (by option, we mean a combination of a college and major. The average number of applications ranges from 2 to 3 in our setting); (ii) each college announces the quotas for each major before students apply for options; (iii) students are evaluated based on their scores on the national examination for college entrance (the College Scholastic Ability Test, or CSAT), college-specific interviews/tests, and academic performance in high school. College applicants have the same exam questions on the national college entrance exam regardless of what majors they applied for. College-specific interviews/tests are required to test students on the high school curriculum, and thus a college cannot select students based on their underlying talents specific to the college majors for which they applied[5].

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[5] The only exception is Arts/Athletics majors, who require an additional admissions process including actual performance and portfolios. However, even these majors also substantially rely on test scores on the national college entrance exam and relative ranking in high school.

Finally, it is important to highlight two more features of South Korea's college admissions before we lay out our conceptual framework. One is that in our period of study, being admitted to even one four-year college is quite difficult due to the government's college quota restriction. Over 80 percent of all high school seniors take the CSAT and apply to college, while the total number of seats available at four-year colleges is less than half the number of high school seniors. Over half of the applicants who do not get admitted repeat the entire college admission process, including taking the CSAT again, in a subsequent academic year. This feature suggests that a change in college-major quota is likely to change student's enrollment, and thus college major supply, due to the excess demand for college admission.

The other feature is that in South Korea there exists a well agreed upon ranking of colleges and of majors within a college, based on how prestigious a college or major is perceived by the South Korean society, and graduating from a prestigious college/major generates substantial premiums (Sorensen 1994; Lee 2007). For example, Seoul National University is considered the best, followed by a second group of colleges such as Yonsei, Korea, KAIST, and POSTECH. Given a college, undergraduate law and medicine majors are the two best-regarded ones, followed by economics/business administration and engineering majors. See details in Avery et al. (2014).

III Endogeneity in College Major Choice: Sources and Prevalence

Given the features in college admission systems in Section II, individuals in South Korea may be able to graduate with a college major in line with their unobservable college major-specific talents (i.e., endogeneous college major choice) if two conditions hold.

First, they should know their major-specific unobservable talents. Second, they should get at least one admission from the college major that they have a comparative advantage in terms of unobservable talents.

It is extremely challenging to empirically examine the extent to which the two conditions may hold in our setting. However, as for the second condition, it would be unlikely for it to hold in the South Korean setting for the following reasons. As explained in Section II, over half of the college applicants do not get any suitable admission and repeat the entire college admission process, including taking the CSAT again, in a subsequent academic year. Therefore, college applicants need to weigh both their preferences and the likelihood of getting an admission from a specific option (i.e., a combination of college by major).

Furthermore, in South Korea, there exists a well-agreed upon ranking of colleges and of majors within a college based on how prestigious a college or major is perceived in the Korean society. Graduating from a prestigious college/major generates substantial premiums (Sorensen 1994; Lee 2007)[6]. For example, Seoul National University is considered the best, followed by the second group of colleges such as Yonsei, Korea, KAIST, and POSTECH[7]. Over the period we study, undergraduate law and medicine majors are the two best-regarded ones in a college, followed by economics/business administration and engineering majors.

The intense competition in getting an admission and well-established ranking and associated premiums across colleges and majors imply that some applicants may select a

[6] Lee (2007) reported that 48 percent of Korean CEOs graduated from Seoul National University, which accounts for just 0.4 percent of all college students, while a group of top U.S. colleges, which accounts for the same percentage of college graduates, produced only 19 percent of U.S. CEOs.
[7] KAIST stands for Korea Advanced Institute of Science and Technology whereas POSTECH stands for Pohang University of Science and Technology.

college major that they do not have comparative advantage in order to sign up for a better-ranked college than the college they could have signed up for if they chose their preferred major in line with their unobservable talents. Likewise, other college applicants may select the major in line with their unobservable talents but enroll in a lower-ranked college than the college they could have get an admission from if they chose alternative major. If the positive selection driven by the former type of applicants has the same magnitude as the negative selection driven by the latter type of applicants, then, on average, we will face no selection bias or endogeneity in college major choice among college graduates. The next subsection examines this possibility over the sample period we examine in empirical analysis in Section IV.

III.1 Empirical Examination of Prevalence

This subsection presents empirical patterns, not conclusive but jointly supporting the possibility that college major-specific talents may not play a dominant role in explaining what majors college enrollees actually select.

For this purpose, we use a dataset called the Korean Education and Employment Panel (KEEP). The KEEP is a panel dataset, surveying high school seniors in 2004 and their subsequent outcomes until 2013. KEEP's initial survey contains information on the college major a student wants to enroll in approximately 6 months before s/he takes the college entrance exam. In the later surveys, the dataset indicates whether the student enrolled in college and, if so, the student's college major and performance on the national college entrance exam in the year that the student was admitted to the currently enrolled-in college. We examine all of the follow-up surveys until 2013 and compile a sample of

882 individuals, consisting of the information about a person's college major, matched with the person's intended college major as well as his/her CSAT score. By doing so, we can include individuals who were not admitted to college during their high school senior year and may have spent multiple years applying to college.

In our sample, 25 percent of high school seniors reported that they did not have any intended major before the actual applications started. Among those who reported their intended major, only half of them (i.e., 53%) indeed studied that major in college.[8] If a person chooses an intended major in line with his/her unobservable major-specific talents, then the first group would be the set of students who do not know their talents well; the second group, who were able to enroll in their intended majors, is the set of students with positive selection; the remaining group, who failed to enroll in their intended majors, is the set of students with negative selection. The first group is large, and the size of the second group (positive selection) is almost equal to that of the third group. This suggests that selection bias may be cancelled out in our sample.

Next, we further investigate the relationship between a person's intended major and actual major using regression analyses. To do so, we estimate the following multinomial Logit models:

$$M_{i,m,t} = 1\left(M^*_{i,m,t} = \max\{M^*_{i,1,t}, M^*_{i,2,t}, \dots, M^*_{i,M,t}\}\right)$$

$$M^*_{i,m,t} = \alpha^m female_i + \beta^m CSAT_i + \gamma^m Intended_{i,m} + \theta^m_t + \varepsilon^m_{i,m,t} \quad (1)$$

[8] Our finding may not be surprising considering that South Korea's high school curriculum does not offer advanced courses for students to explore what college majors may be like; students have to make their decision before they start college. Even if they may have some information about their talents, this information may not be accurate. For example, in the U.S., where high school students have more opportunities to learn about college majors, 40 percent of four-year college graduates in 2009 had majors different from their initial field of study. This calculation is based on the 2004/2009 Beginning Postsecondary Students Longitudinal Study, from the National Center for Education Statistics (NCES, http://nces.ed.gov/datalab/powerstats, Table 2-9).

where $M_{i,m,t}$ is 1 if the college major of person i is major m, and 0 otherwise, and $M^*_{i,m,t}$ is the corresponding latent index. The latent index is linear in a person's sex ($female$), test score ($CSAT$), whether the specific college major (m) is the major the person intended to pursue before college application ($Intended_{i,m}$), and fixed effects for the year of college application (θ_t^m). The logit estimate of γ^m determines the extent to which the intended college major a person stated has explanatory power on the person's actual major, relative to the omitted category (Engineering). If unobservable productivity dictates student's college application, then a student's stated intended major will have a positive impact on his/her actual college major. For easy interpretation, Table 1 reports the marginal effects evaluated for the average person in the sample. We find that the marginal effect of the intended major is insignificant in explaining college-major enrollment. For example, the person's chance of graduating with a Humanities major is 8 percent less if s/he intended to major in Humanities in high school, although the impact is insignificant at conventional levels.

Assuming that a person's intended major reflects his/her unobservable major-specific talents, then these empirical patterns imply that, under the South Korean setting, the unobservable talents play little role in accounting for what major an average college graduate has. Thus, although the patterns are not definitive proof of our argument, these types of evidence jointly point out that, different from other settings including the U.S., positive sorting along unobservable productivity may not necessarily prevail in South Korea during the period we examine.

IV. Empirical Framework

We examine the impact of college major on labor market outcomes. The outcome variables of interest include whether a person participates in the labor market, whether s/he is employed, whether s/he has a long-term employment contract (i.e., regular position) instead of a temporary position, and earnings. When we analyze binary outcomes, we use Logit models[9]:

$$Y_{i,m,t,l} = 1\left(Y^*_{i,m,t,l} > 0\right)$$

$$Y^*_{i,m,t,l} = \alpha^y female_i + \beta^y CSAT_i + \gamma^y age_i + \delta^y age_i^2 + \theta^y_m + \rho^y_t$$

$$+\mu^y_l + E\left(u_{i,m} \middle| major = m\right) + \varepsilon_{i,m,t,l} \quad (2)$$

where $Y_{i,m,t,l}$ is a binary outcome and $Y^*_{i,m,t,l}$ is the corresponding latent index for person *i* who majored in *m*, graduated from a college in year *t,* lives in location *l*; $female_i$ is 1 if person *i* is female and 0 if male; $CSAT_i$ is person *i*'s test score on college admission tests; and age_i is the person's age. Variables ρ^y_t and μ^y_l capture cohort and location specific fixed effects, respectively. Variable $E\left(u_{i,m} \middle| major = m\right)$ captures the expected value of unobservable college major-specific talent conditional on enrolling in that major. When we analyze continuous variables, we regress the outcome variable on the regressors specified in Equation (2). For example, we regress a person's logarithm of earnings on gender, age, age-squared, and so on, consistent with Mincerian regression (Mincer 1974).

Parameters of interest are $\{\theta^y_m\}$. As we do not observe a person's major-specific productivity (i.e., $u_{i,m}$), we cannot separately identify θ^y_m and $E\left(u_{i,m} \middle| major = m\right)$. Rather, the coefficient of a college-major dummy will measure the sum of both parameters. However, we can identify $\{\theta^y_m\}$ under certain conditions and the following

[9] Our results reported in Section V are robust when we use Probit models.

subsection examines such conditions.

IV.1 Identification Assumption and Empirical Strategy

We denote by $\hat{\theta}_m^y$ the estimated coefficient of the college-major dummy in equation (2). Due to collinearity, $\hat{\theta}_m^y$ measures $\theta_m^y + E(u_{i,m}|major = m)$ relative to the omitted category, that is Engineering:

$$\hat{\theta}_m^y = \theta_m^y - \theta_{engineering}^y +$$
$$\{E(u_{i,m}|major = m) - E(u_{i,Engineering}|major = engineering)\}. \quad (3)$$

For our empirical analyses, we need estimates, $\theta_m^y - \theta_{engineering}^y$, for each non-Engineering major.

In Section III.2, we presented suggestive evidence that the role of unobservable college-major specific talent in deciding college major may not be severe in South Korea. If our argument is correct, then $E(u_{i,m}|major = m)$ will be zero. As we already admit, the aforementioned evidence is suggestive, not definitive. Therefore, in our empirical analysis, we first estimate our baseline model (equation (2)) under the assumption that the degree of selection is the same as that of the Engineering major. Then, we conduct robustness check by employing a bounding exercise in the spirit of Lee (2009). That is, we simulate positive sorting based on $u_{i,m}$ and estimate the impact of college major conditional on simulated $u_{i,m}$ (See Section VII.1). We find that our results are robust to the bounding exercise.

V. Data

V.1 Data Source

For baseline analysis, we use the Graduates Occupational Mobility Survey (GOMS), a nationally representative survey of young adults in South Korea who graduated from either a two-year or four-year college program. The GOMS surveys demographic information on individuals and their labor market outcomes 20 months after college graduation and two years after the initial survey. Our sample consists of three waves of GOMS: from 2005, 2007, and 2008. The 2005 GOMS includes individuals who graduated from college in August 2004 or February 2005 and it surveys their initial labor market outcomes in 2006 and then two years later, in 2008.[10]

We narrow our sample to only four-year college graduates (66.81 percent of the survey participants) for two reasons. First, for four-year colleges, we have reliable information on the quality of students measured upon admission to these institutions. This information is important to control for a student's underlying cognitive ability, which can affect a student's major choice and labor market outcomes. Second, two-year colleges in South Korea are vocational schools typically tied to certain firms where they send their graduates to work, and vocational and four-year colleges are not comparable to each other even if they offer the same majors.

We further restrict our sample to those who graduated from a college within a time span ranging from 4 to 8 years. The four-year restriction is to omit transfer students whose college entrance test scores are hard to infer, while the 8-year restriction is to avoid possible selection bias by excluding those who greatly surpassed the normal length

[10] In South Korea, the academic year begins in March and continues through February. An academic year has two regular semesters, spring and fall, with students graduating in February. Note that the 2006 GOMS does not exist because the survey design was reconstructed in 2007.

of college enrollment (up to 6 years including 2 years of military service). This restriction excludes 12 percent of the individuals who graduated from four-year colleges. In this manuscript, we report our empirical results based on follow-up surveys for simplicity because almost all results quantitatively remain the same[11].

It may be worth noting that we use the GOMS in our baseline analysis because it is the largest representative dataset available in South Korea among those that contain detailed information on individuals' colleges and majors. Several alternative datasets contain similar or sometimes more information about a person's tertiary education, but they have very small sample sizes (e.g., the KEEP and Korean Labor and Income Panel Study, KLIPS). Finally, the college admission process in South Korea is completely decentralized, and there is no dataset that combines the application and outcomes at major universities (see details of the admission system in Avery et al. 2014). For this reason, we cannot use the approach that is used in the setting of Chile or Norway (e.g., Hastings et al., 2013; Kirkebøen et al., 2015). In both countries, college application process is centralized and the researchers access the information from the agency in charge of the process.

V.2 Test Scores

To estimate the causal impact of college major, we need to control for a person's test score (e.g., CSAT test score). Although GOMS does not provide a person's CSAT score, it provides sufficient information for us to construct a proxy for this score. Specifically, GOMS records three characteristics of the university a person graduated from: its location (city or province level), type (i.e., public or private), and whether the university

[11] The relevant tables for initial surveys are available upon request.

was established to educate public elementary school teachers. Using this information, we calculate the minimum CSAT score for the college a person graduated from as follows.

Every year, major private institutions that specialize in teaching how to score high on the CSAT release the minimum CSAT scores required for a student to apply to a specific college and major with a reasonable chance of admission. We obtained press releases from *Daesung*, a well-known private institute, from between 2006 and 2013. For each year, we take the average of the minimum scores across majors in a university and ranked the universities in ascending order. That is, a rank of one denotes that the university requires the lowest CSAT score, followed by the university with a rank of two, and so on. College rankings are stable across years. For example, the pair-wise Spearman's rank correlation ranges from 0.85 to 0.97. Using the 2006 rankings, we construct the average ranking of the colleges given the colleges' characteristics available in GOMS and use that ranking as a proxy for a person's CSAT score. Finally, to make interpretation easier, we standardize the CSAT proxy in our sample so that it has a mean of zero and a standard deviation of one in our empirical analyses in Section IV.[12]

It is important to note that our imputation method based on the three characteristics accounts for the majority of variations in cross-university CSAT scores. We regress a college's standardized ranking on dummies for location, school type, and whether the college was established to supply public elementary school teachers, and its R-squared is around 0.53 (see Table 2, column 2). Furthermore, our imputed test score is highly correlated with the actual CSAT score (correlation coefficient is 0.41) when we compare them with the alternative dataset, KEEP (see Section III.2). Finally, using

[12] The average of imputed CSAT reported in column (1) of Table 2 is not zero despite the standardization. This is because we standardized the test scores based on the entire sample including the baseline survey, instead of the follow-up survey only.

KEEP, we regress the actual CSAT scores on the three college characteristics we used for our imputation. We find that those college characteristics account for a large variation in the data (R-squared is over 20 percent, see Table 3, column 3). Because most of the variation is explained by the three characteristics, our empirical results quantitatively remain the same when we directly use those three variables instead of the imputed CSAT (see details in Section VI and Table 5).

V.3 Summary Statistics

Table 3 reports summary statistics from the follow-up survey depending on gender. Several variables require explanation. A person is defined as employed if s/he worked at least one hour during the week before the survey was conducted, or has a job but is not working due to temporary events such as sick leave, family care, or a strike. An employment position is regarded as regular if the associated labor contract does not specify a termination date and provides a full-time job. Otherwise, a position is referred to as an irregular position, which includes a labor contract with a termination date, part-time jobs, and freelancing. A person’s earnings are reported on a yearly, monthly, weekly or hourly basis in GOMS. We convert the reported earnings to a monthly basis using the reported hours of work.

Our sample includes 17,016 men and 13,566 women in total. On average, male respondents are two years older than female respondents in the follow-up survey. This is not surprising because in general Korean men participate in two-year compulsory military service before they graduate from college.

Table 3 shows noticeable differences between men and women in terms of their college majors, earnings, and likelihood of having a regular position, even though our sample consists of college-educated people, most of whom are single without a child. For example, approximately 41 percent of male college graduates major in Engineering, while only 10 percent of female graduates do. Note that the distribution of college majors among men is different from that of women at a one percent significance level, based on the Kolmogorov-Smirnov test. The fraction of people in the labor force is 82 percent for women and 88 percent for men. While the employment rate of those in the labor force is comparable between men and women (about 85 to 87 percent), the share of short-term contract positions (irregular position) among female employees is almost two times larger than that among male employees. Average monthly earnings are 2.77 million won for men (roughly 2,770 U.S. dollars), about 29 percent higher than that of female employees. All of these differences are statistically significant at a one percent level, based on two-sided t-tests.

VI. Results

Using the Logit models described in Section III, we first examine the effect of college major on labor market participation and employment status. We examine all college graduates in this section, but our results remain qualitatively the same when we exclude individuals who expressed their interest in Arts/Athletics majors in high school (see Section VI.4).

We report marginal effects at the mean values of explanatory variables in Table 4. We include dummy variables for college majors in the models reported in Panel A, whereas we omit them in the models reported in Panel B. The omitted category of college majors is Engineering. In column 1, we use all individuals in the follow-up survey year to examine their labor market participation status. In column 2, we examine those who are in the labor force, to study whether a person is employed. In column 3, we examine whether a person has a regular position, instead of temporary position, conditional on being employed. In South Korea, a regular position provides a worker not only with a long-term contract but also company-supported insurance for healthcare, disability, unemployment, and retirement. In contrast, a temporary position is designed for short-term fixed employment, up to 2 years with a one-time extension. Compared to regular position holders, temporary position holders are much less likely to be covered by unemployment insurance and social security, and earn less.[13] In column 4, we regress the logarithm of monthly earnings on college majors and other controls.

Table 4 shows that individuals with an Engineering major on average outperform their counterparts in almost all outcomes. For example, compared to his/her counterpart with an Engineering degree, a person with a Humanities major is 6.3 percentage points less likely to be in the labor force, 1.6 percentage points less likely to be employed conditional on being in the labor force, 9.8 percentage points less likely to hold a regular position, and earns 19.0 percent less. Compared to other majors, those who majored in Arts/Athletics perform poorly in terms of employment and holding a regular position.[14]

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[13] For example, as of 2010, the share of workers with unemployment insurance was 86% for regular workers but only 52 percent for temporary workers; the share of workers holding retirement benefits (or social security) was over 87 percent for regular workers but only 47 percent for temporary workers. (source: Ministry of Employment and Labor: http://www.moel.go.kr/policyinfo/protection/view.jsp?cate=3&sec=1)

[14] We acknowledge that higher labor market participation rate does not necessarily mean a "better" labor market outcome. This is because people may value their other, non-market activities and decide to be out of the labor market. Although such a case is possible, we suspect that in the South Korean setting, involuntary labor market detachment may dominate voluntary detachment for the following reason. Lack of job opportunities for the young is one of the most difficult challenges the South Korean society faces. Although

The exception is Medicine/Public Health majors, which include medical doctors with private practices. It is worth noting that the earnings of people majoring in Natural science/Mathematics are lower than those of Education majors, and their average earnings are only 7.6 percent higher than the earnings of workers majoring in Humanities. This result is somewhat surprising because the gap between Natural science /Mathematics majors and Humanities majors is generally observed to be much wider in existing studies.[15] These estimated effects quantitatively remain comparable when we use Probit models.

We further examine other labor market outcomes – income growth and job turnover – using the short-panel structure the GOMS provides (a two-year gap). We find no significant difference in monthly income growth across college majors, suggesting that the college premiums we find will be maintained. Regarding job turnover, we examine whether a college graduate works for a different company or different industry. Since the individuals in our sample are young, just graduated from college, such a job turnover may indicate poor initial match with their employers. In both outcomes, we find that college majors disadvantageous in our baseline outcomes also exhibit high job turnover[16].

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the official unemployment rate in our sample period is less than 4 percent, the unemployment rate among young adults (i.e., aged between 15 and 29) is over 8 percent. Furthermore, the effective unemployment rate among young adults should be much higher because many of them are in college, postponing their graduation in order to find a job. That is, even though they can finish their education in 4 years, many four-year college students do not complete their degrees until they become employed. This delay is based on the fear that, when hiring, firms may discriminate against the unemployed relative to college students. Major colleges in South Korea report that they have 20 to 40 percent more undergraduates on campus compared to their quotas, because of those who delay graduation.

[15] For example, Hamermesh and Donald (2008) use the surveys of University of Texas at Austin graduates aged between 23 and 43 and report an approximately 20 percent advantage to being a Natural science major compared to a Humanities major (Table 3). Similarly, Kirkebøen et al. (2015) show that in Norway, individuals can triple their earnings by choosing Science instead of Humanities (Table 5). They also report that Engineering and Science majors yield comparable outcomes.

[16] The relevant unpublished online appendix is available upon request.

Finally, we examine the extent to which college major may account for the gender gap in labor market outcomes. To do so, we compare the coefficient of "female" in Panel A with that in Panel B of Table 4. That is, if the gender gap in college majors fully accounts for the gender gap in the labor market outcomes, the coefficient reported in Panel A (the models controlling for college majors) will be zero, while the coefficient reported in Panel B (the model not controlling for college majors) will not.[17]

Even though the women are young (less than 30 years old) and most of them are single, we find sizable gender gaps in all outcome variables. Compared to their male counterparts, women are 4.2 percentage points less likely to be in the labor force, 0.6 percentage points less likely to be employed conditional on being in the labor force, 2.3 percentage points less likely to have a regular position, and have 13.9 percent lower monthly earnings. These gaps are immense and difficult for women to overcome. For example, to overcome a 13.9 percent penalty in monthly earnings, the coefficients suggest that women need to have test scores 2 standard deviations higher than their male counterparts. However, the coefficients of female in Panel A are 6 to 47 percent smaller than their counterparts in Panel B, suggesting that college major accounts for a substantial part of these gender gaps.

Finally, our findings are robust when we replace the imputed CSAT score with the three variables that we use to impute the score (See Table 5).

[17] A vast number of economics studies have conducted decomposition analyses of the factors accounting for the gender gap in labor market outcomes, using, for example, Oaxaca decomposition or model predictions based on structural estimation. This paper uses a rather simple approach to examine a specific factor – namely college major – in an understudied setting, namely South Korea.

VI.1 Implications of the 2017 Policy Change in College Major Quota

Since late 2015, the South Korean government has introduced several policy reforms to adjust overall college quota as well as the distribution of quotas across college majors. Specifically, the Ministry of Education (MOE) introduced an incentive system called the "PRIME project" that provides monetary incentives and priority in receiving government resources to universities if they reallocate major quotas to increase employment rates.[18] Accompanying these policies, the Ministry of Employment and Labor (MOL), South Korea, announced its projections of the list of majors that have excess supply or demand between 2014 and 2024. According to the MOL's projections, if the current status of college major quota continues, there will be an excess demand for Engineering graduates, while there will be a sizable excess supply of Humanities, Social Science and Education[19].

In May 2016, the MOE chose 21 colleges for the PRIME project. Starting with the 2017 admission cohort, the 21 colleges decided to reallocate approximately 10 percent of their seats to increase quotas for the Engineering major, while reducing seats from Humanities, Social Science, Natural science/Mathematics, and Arts/Athletics majors.[20] Colleges that were not part of the PRIME project nonetheless designed upcoming college admission quotas in line with those of these 21 colleges.[21]

[18] The official title of the project is the "Program for Industry Needs - Matched Education (PRIME) project." This project, devised in 2015, has been effective since March 2016. The project's objectives are twofold. One is to reduce the total quota of a university to address the fact that the schooling age population has been shrinking. The other objective is to reduce the relative quota of a major that is not well demanded in the Korean labor market and reallocate that freed quota to another major that is well demanded (e.g., from Humanities to Engineering).

[19] All relevant information is available upon request from the corresponding author.

[20] See Ministry of Education, Press release on May 4, 2016.

[21] See the 2017 college admission plans proposed by the four-year college associations. See a recent press report at a local news media: http://news.mk.co.kr/newsRead.php?sc=30000022&year=2016&no=438955

In this subsection, we conduct a back-of-the-envelope calculation of the labor market status when the college major quota change is implemented. Specifically, in line with the 2017 college admission plan, for each gender, we reduce the number of graduates majoring in Humanities and Social Science by 6.0 percent each, Arts/Athletics by 4 percent, and Natural science/Mathematics by 2.0 percent while increasing the Engineering quota by 10.2 percent. We assume that the number of graduates majoring in Education and Medicine/Public Health remains unchanged. Under this assumption, we calculate the counterfactual composition of graduates by college major. Then, we compute the changes in labor market outcomes for each major, by interacting the coefficient, θ_m^y in Equation (2) with the difference between actual and counterfactual compositions. The sum of all changes across college majors is reported in Table 6. We repeat the same procedure for a back-of-the-envelope calculation by gender.

Table 6 presents the results. Panel A shows that the changes in college-major quota effective as of the 2017 admission cycle may increase the labor market participation rate by 0.12 percentage points or 0.14 percent (0.09 ppts. for men and 0.15 ppts. for women), the employment rate by 0.07 percentage points or 0.08 percent (0.05 ppts. for men and 0.09 ppts. for women), the share of long-term position holders among employees by 0.17 percentage points or 0.19 percent (0.13 ppts. for men and 0.22 ppts. for women), and monthly earnings by 0.38 percent (0.29 percent for men and 0.48 percent for women). The quota change may generate a larger impact on women because they are more likely to be in majors under quota reduction compared to men, and thus more likely to be pushed to Engineering majors. Our finding suggests that that the current intensity of the college quota change may cause only a mild change in the labor market outcomes of college graduates. Although further in-depth investigation will be required, our finding indicates that the current intensity of the quota change may be insufficient to achieve the MOE's stated policy goal.

We suspect that two features of the policy may account for its limited impact on labor market outcomes. One is that the magnitude of the increase in the Engineering major (a 10 percent increase in the quota, or 3 percentage points in terms of college major composition) may be too small to make a sizable impact on labor market outcomes.[22] The other is that the college quota adjustment for other college majors is not well designed to maximize the potential benefits in labor market outcomes. For example, compared to other non-Engineering majors, Social Science majors perform well in terms of employment and earnings. However, the policy we examine reduces this major's quota as much as Humanities (6 percent). In addition, although Arts/Athletic majors perform the worst in terms of labor market outcomes, this major's quota is reduced only by 4 percent. Furthermore, the policy does not target women in promoting choice of the Engineering major.

To highlight the second feature, we calculate the labor market outcomes under the alternative scenario when the number of the Engineering majors is increased by 10 percent (or 3 percentage points), the same as the PRIME project, but the Arts/Athletics major is reduced by 3 percentage points to hold the total number of seats constant. In that scenario, the labor market participation rate may increase by 0.15 percentage points or 0.74 percent, the employment rate by 0.30 percentage points or 0.35 percent, the share of long-term position holders among employees by 0.40 percentage points or 0.46 percent,

[22] That is, in our data, 27.5 percent of college graduates have Engineering major. In the counterfactual inspired by the PRIME project, we increase the share to 30.3 percent, approximately 3 percentage point increase (or 10 percent increase).

and monthly earnings by 0.82 percent. These impacts are almost two times larger than the calculated impacts under the PRIME project, illustrating the possible benefit of a well-designed college major quota policy. Thus, our findings suggest that if the main policy goal of the PRIME project is to improve labor market outcomes, it may be worth carefully examining the college major quota adjustment in terms of both magnitude and allocation. We postpone discussing columns 2 and 3 of Table 6 until the next section.

VII. Discussion

VII.1 Selection Bias and Bounding Exercise

Related to Section IV.1, this subsection conducts a simulation analysis assuming that an applicant selects her intended major based on the largest value of $\{u_{i,m}\}$. We run our regression models without controlling for college major and take the residuals. We then sort individuals by residual in a given major and select the top "T" percent of them, where the value "T" is the share of individuals who intended to enroll in that major out of all students in that major. We calculate "T" based on the KEEP data explained in Section IV.1: 36.8 percent for Engineering, 27.8 percent for Humanities, 47.1 percent for Social Science, 46.7 percent for Education, 26.8 percent for Natural Science/Mathematics, 45.7 percent for Medicine/Public Health, and 74.0 percent for Arts/Athletics.

We create a variable called "intended" that has value 1 if a person is selected in the process above and 0 otherwise. We estimate our models additionally including the variable "intended." To calculate standard errors, we bootstrap 100 times. This simulation depicts the worst-case scenario because we attribute all intention to major to unobservable productivity. As shown in Table 7, the estimated coefficients are comparable to the baseline results and thus so are the results from the back-of-the-envelope calculation (see column 2, titled "Simulated U", Table 7). Note that the coefficients of Arts/Athletics become more negative than the baseline because that major has the largest share of people who intended to major in it.

VII.2 Gender-Specific Labor Market Returns

To examine the possibility that men and women may face different returns to college majors, we re-examine the labor market outcomes reported in Table 4, but allowing for gender-specific returns. Table 8 reports the results, showing that most coefficients of the interaction terms are small in magnitude and statistically insignificant at conventional levels. Notable exceptions are "Female×Education" and "Female×Medicine/Public Health," which yield positive additional returns relative to their male peers. However, these results do not change our baseline result that women's college major choices are less efficient than men's in terms of the labor market outcomes. Therefore, when we conduct counterfactuals using these new estimates, the results remain comparable to our baseline ones (column 3, titled "Gender-specific returns," Table 7).

VII.3 Non-Labor Market Outcomes

It is possible that women may choose certain college majors that are less profitable in terms of the labor market outcomes we examined so far but profitable in other outcomes such as marriage. We examine this possibility by analyzing a data called the 1999 KLIPS, which has a small sample size but includes older cohorts, to examine the marriage market outcomes. We construct a sample of four-year college graduates aged between 30 and 65, and run OLS regressions to measure the correlation between college majors and the likelihood of being married, and, conditional on marriage, spouse's educational attainment and labor market outcomes. For all these outcomes, we find no significant correlation with college majors, suggesting that the less profitable college majors in terms of the labor market outcomes fail to provide premiums in marriage market outcomes[23].

VII.4 High School Tracks

In South Korea, students choose between the Humanities/Social Studies track and the Mathematics/Science track when they become high school sophomores. The high school curriculum puts more emphasis on reading and English in the Humanities/Social Studies track, whereas more class hours are allocated to mathematics, physics, and chemistry in the Mathematics/Science track. In our baseline analyses, we control for a person's track choice in our regression because, in our sample period, students can apply for any college major regardless of their high school tracks. However, although students in the Humanities/Social Studies track can apply for an Engineering major, such switching can be difficult because a university may put more weight on the mathematics, physics, and chemistry subjects. We conduct a sensitivity check of our results with regard to this possibility by separately conducting our analysis by high school track. The estimated coefficients of college majors in each high school track are comparable to our baseline results from the pooled sample in Table 4[24].

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[23] Further details are available upon request.
[24] The relevant estimates are reported in our unpublished appendix. It is available upon request.

VIII. Conclusion

Using nationally representative datasets of young adults who graduated from a four-year college in the mid- and late 2000s, we have examined the impact of college major on labor market outcomes. We find sizable returns from majoring in Engineering and Medicine/Public Health, followed by Social Science and Education. Majors in Humanities and Arts/Athletics, which are the most preferable majors among women, are subject to the least favorable labor market outcomes. Accordingly, a college major is shown to account for about half of the gender gap in labor market outcomes. These findings imply that the composition of college majors among young adults does not match the demand of human capital by firms.

Based on estimates from our model, we conduct a simple back-of-the-envelope calculation to infer the short-term effects of the recent policy change, whose purpose is to tie higher education to the labor demand by firms in South Korea. The change, which reallocates 3 percent of incoming freshman seats to Engineering majors, may improve labor market participation rate, employment rate, the share of long-term position, and monthly earnings, but only by a limited amount (less than 1 percent). This limited impact of the college major quota change is driven by the relatively small increase in the Engineering major quota and also by the fact that the quota adjustments in other college majors are not designed to maximize the labor market benefits. If the latter feature were addressed, we find that the expected improvement in labor market outcomes would have been sizable, almost two times as large as the expected impact under the current PRIME project. Our findings illustrate the possibility of carefully designed tertiary education policies as feasible policy instruments for better use of the work force.

Although these implications are drawn specifically for the South Korean context, they may provide useful lessons to other countries. Similar to South Korea, in many other countries, women are generally less likely than their male counterparts to major in Engineering, which is in demand by the labor market (Joy 2003; Gemici and Wiswall 2013; Turner and Bowen 1999; Zafar 2013; Wiswall and Zafar 2015). At the same time, in many developed countries, the population is rapidly aging, which leads to the need for better utilization of the female work force. If a country has policy instruments directly affecting college major choices, such as South Korea, it could devise a policy to meet its policy goal, such as adjusting college major quotas. Even if it does not have such a policy instrument, the country may be able to devise policies indirectly affecting college major choices of individuals, especially women. For example, in 2009, the Obama administration launched the "Educate to Innovate" initiative to promote STEM majors among American students, especially among women and minorities, by bolstering tremendous federal investment in STEM (White House, 2013a, 2013b, 2015).

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Table 1. Actual and Intended College Majors

	Regressors		
	Female	CSAT	Dummy 1 if intended major
	(1)	(2)	(3)
Actual major	0.067	0.051	-0.084
- 1 if Humanities	(0.504)	(0.398)	(0.574)
	0.035	0.071	0.106
- 1 if Social Science	(0.332)	(0.388)	(0.353)
	0.045	0.038	0.016
- 1 if Education	(0.148)	(0.128)	(0.075)
	-0.327	-0.056	-0.016
- 1 if Engineering	(0.604)	(0.241)	(0.281)
	0.099	-0.023	-0.094
- 1 if Natural science/ Mathematics	(0.358)	(0.151)	(0.261)
	0.032	0.023	0.005
- 1 if Medicine/Public Health	(0.552)	(0.408)	(0.083)
	0.049	-0.105	0.067
- 1 if Arts/Athletics	(0.345)	(0.680)	(0.453)
	0.067	0.051	-0.084
	(0.504)	(0.398)	(0.574)

Notes: - Multinomial Logit models described in Section III, marginal effects reported. Regressions additionally include dummies for college entrance years fixed effects. Variable “Dummy 1 if intended major” is 1 if the actual major is the same as the intended major stated before applying to a college and 0 otherwise. The standard errors are in parentheses. The number of observations is 822, and its pseudo R-squared is 0.141.

Table 2. Imputation of CSAT: Fit

Data		Summary Stats.(%) Daesung (1)	OLS Daesung (2)	OLS KEEP (3)
Information Type	Public	19.07	omitted	omitted
	Private	80.93	-0.762***	-0.433***
			(0.163)	(0.064)
Teachers' college	No	94.33	omitted	omitted
	Yes	5.67	1.126***	1.006***
			(0.265)	(0.295)
Region	- Seoul	20.62	omitted	omitted
	- Busan	6.70	-1.175***	-1.023***
			(0.234)	(0.097)
	- Daegu	1.55	-0.907**	-0.558***
			(0.441)	(0.142)
	- Incheon	3.61	-0.304	-0.083
			(0.297)	(0.169)
	- Gwangju	3.61	-1.604***	-0.762***
			(0.297)	(0.171)
	- Daejeon	4.12	-0.902***	-0.729***
			(0.279)	(0.108)
	- Ulsan	0.52	-0.938	-0.467
			(0.729)	(0.369)
	- Gyeonggi	13.92	-0.811***	-0.475***
			(0.180)	(0.086)
	- Gangwon	5.15	-1.520***	-0.909***
			(0.257)	(0.139)
	- North Chungcheong	5.15	-1.208***	-0.964***
			(0.257)	(0.121)
	- South Chungcheong	9.79	-1.241***	-0.950***
			(0.201)	(0.101)
	- North Jeolla	4.64	-1.564***	-0.761***
			(0.268)	(0.128)
	- South Jeolla	5.15	-1.816***	-1.157***
			(0.261)	(0.149)
	- North Gyeongsang	9.79	-1.703***	-0.862***
			(0.201)	(0.097)
	- South Gyeongsang	4.12	-1.471***	-1.248***
			(0.282)	(0.120)
	- Jeju	1.55	-1.512***	-
			(0.441)	-
R-squared			0.527	0.201
No. of observations			194	1,118

Notes: Based on the 2006 ranking. Column 1 report the average of each variable and column 2 reports the OLS regression results. The standard errors are in parentheses. The asterisks *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 3. Summary Statistics

	Total	Male	Female
	(1)	(2)	(3)
No. of observations	30,582	17,016	13,566
Age	28.53	29.56	27.23
Married (%)	22.42	26.68	17.08
College major (%)			
- Humanities	13.07	8.63	18.63
- Social Science	22.63	22.37	22.96
- Education	8.95	4.54	14.49
- Engineering	27.47	41.06	10.42
- Natural science/Mathematics	15.10	13.72	16.83
- Medicine/Public Health	3.83	3.21	4.59
- Arts/Athletics	8.95	6.47	12.07
In the labor force (%):	85.55	88.41	81.96
Employed among those in the labor force (%)	85.97	86.63	85.08
Among those employed:			
- Monthly Earnings (10,000 2010 won)	250.33	276.70	214.74
- Regular position (%)	87.01	90.13	82.72
- Irregular position (%)	12.99	9.87	17.28
Among regular position (%):			
- Working at a large-scale firm	42.26	48.92	32.26
Imputed CSAT score (standardized)	0.01	-0.08	0.11

Notes: All gender differences are statistically significant at the 1 percent level (average is based on t-test and the distribution of college majors is based on Kolmogorov-Smirnov test).

Table 4. College Majors and Labor Market Outcomes

Outcome	1: labor	1: employed	1: regular workers	Log monthly earnings
Sample	All	Labor force participants	Employees	Employees
	(1)	(2)	(3)	(4)
No. of observations	30,582	26,156	22,487	22,357
Panel A: Major Controls				
Female	-0.028***	-0.000	-0.008	-0.093***
	(0.007)	(0.006)	(0.007)	(0.009)
Imputed CSAT	0.004*	0.005**	0.017***	0.071***
	(0.002)	(0.002)	(0.002)	(0.003)
College major				
- Humanities	-0.063***	-0.016**	-0.098***	-0.190***
	(0.008)	(0.007)	(0.011)	(0.009)
- Social Science	-0.025***	-0.006	-0.019***	-0.064***
	(0.006)	(0.006)	(0.007)	(0.007)
- Education	0.013	-0.004	-0.026**	-0.090***
	(0.008)	(0.008)	(0.011)	(0.011)
- Natural science/Mathematics	-0.058***	-0.048***	-0.074***	-0.114***
	(0.008)	(0.007)	(0.010)	(0.008)
- Medicine/Public Health	0.058***	0.006	-0.143***	0.110***
	(0.009)	(0.010)	(0.017)	(0.013)
- Arts/Athletics	-0.044***	-0.091***	-0.122***	-0.294***
	(0.009)	(0.010)	(0.013)	(0.011)
(Pseudo) R-squared	0.026	0.085	0.057	0.214
Panel B: No Major Controls				
Female	-0.042***	-0.006	-0.023***	-0.139***
	(0.006)	(0.006)	(0.007)	(0.009)
Imputed CSAT	0.006***	0.006***	0.021***	0.070***
	(0.002)	(0.002)	(0.002)	(0.003)
(Pseudo) R-squared	0.018	0.077	0.041	0.169

Notes: Columns (1) to (3) - Logit model, marginal effects reported. Column (4) – OLS. Dummies for college entrance years, survey years, and residence fixed effects are included. Other controls include age, age-squared and dummy for being married. The standard errors are in parentheses. The asterisks *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 5. College Major and Labor Market Outcomes: Imputed CSAT vs. Direct Controls

Outcome	1: labor	1: employed	1: regular workers	Log monthly earnings
Sample	All	Labor force participants	Employees	Employees
	(1)	(2)	(3)	(4)
Panel A. Baseline				
Female	-0.028***	-0.000	-0.008	-0.093***
	(0.007)	(0.006)	(0.007)	(0.009)
Imputed CSAT	0.004*	0.005**	0.017***	0.071***
	(0.002)	(0.002)	(0.002)	(0.003)
College major				
- Humanities	-0.063***	-0.016**	-0.098***	-0.190***
	(0.008)	(0.007)	(0.011)	(0.009)
- Social Science	-0.025***	-0.006	-0.019***	-0.064***
	(0.006)	(0.006)	(0.007)	(0.007)
- Education	0.013	-0.004	-0.026**	-0.090***
	(0.008)	(0.008)	(0.011)	(0.011)
- Natural science/ Mathematics	-0.058***	-0.048***	-0.074***	-0.114***
	(0.008)	(0.007)	(0.010)	(0.008)
- Medicine/Public Health	0.058***	0.006	-0.143***	0.110***
	(0.009)	(0.010)	(0.017)	(0.013)
- Arts/Athletics	-0.044***	-0.091***	-0.122***	-0.294***
	(0.009)	(0.010)	(0.013)	(0.011)
(Pseudo) R-squared	0.026	0.085	0.057	0.214
Panel B. Alternative				
Female	-0.026***	0.001	-0.003	-0.075***
	(0.006)	(0.006)	(0.006)	(0.009)
College major				
- Humanities	-0.061***	-0.016**	-0.087***	-0.183***
	(0.008)	(0.007)	(0.010)	(0.009)
- Social Science	-0.024***	-0.006	-0.016**	-0.059***
	(0.006)	(0.006)	(0.007)	(0.007)
- Education	-0.022**	-0.028***	-0.071***	-0.089***
	(0.010)	(0.009)	(0.012)	(0.012)
- Natural science/ Mathematics	-0.056***	-0.045***	-0.066***	-0.108***
	(0.008)	(0.007)	(0.009)	(0.008)
- Medicine/Public Health	0.058***	0.005	-0.134***	0.098***
	(0.009)	(0.010)	(0.016)	(0.014)
- Arts/Athletics	-0.043***	-0.092***	-0.114***	-0.301***
	(0.009)	(0.010)	(0.013)	(0.011)
(Pseudo) R-squared	0.030	0.089	0.068	0.196
No. of observations	30,582	26,156	22,487	22,357

Notes: Columns (1) to (3) - Logit model, marginal effects reported. Column 4 - OLS. Dummies for college entrance years, survey years, and residence fixed effects are included. Other controls include age, age-squared and dummy for being married. The standard errors are in parentheses. The asterisks *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 6. Policy Implications of the Proposed Education Reform

	Baseline (1)	Simulated U (2)	Gender-specific returns (3)
Panel A. Overall			
Labor market participation rate (ppt.)	0.12	0.13	0.10
Employment rate (ppt.)	0.07	0.16	0.07
Share of long-term position (ppt.)	0.17	0.27	0.16
Monthly income (%)	0.38	0.49	0.41
Panel B. Men			
Labor market participation rate (ppt.)	0.09	0.11	0.10
Employment rate (ppt.)	0.05	0.13	0.04
Share of long-term position (ppt.)	0.13	0.21	0.11
Monthly income (%)	0.29	0.40	0.25
Panel C. Women			
Labor market participation rate (ppt.)	0.15	0.16	0.11
Employment rate (ppt.)	0.09	0.21	0.10
Share of long-term position (ppt.)	0.22	0.35	0.22
Monthly income (%)	0.48	0.61	0.62

Notes: The counterfactual scenario depicts the case in which the share of Humanity and Social Science majors are reduced by 6 percent each, that of Arts/Athletics and Natural science/Mathematics by 4 and 2 percent, respectively, while the share of Engineering majors is increased by 10.2 percent to hold the number of college graduates constant. This scenario is in line with the 2017 college quota adjustment plan proposed by the four-year colleges associations. See details in page 28.

Table 7. Simulated Selection in College Majors

	1: labor	1: employed	1: regular workers	Log monthly earnings
	(1)	(2)	(3)	(4)
Female	-0.038***	0.005	-0.005	-0.120***
	(0.005)	(0.004)	(0.005)	(0.006)
Imputed CSAT	0.007***	0.005***	0.015***	0.061***
	(0.002)	(0.001)	(0.002)	(0.002)
Imputed Intended Major (simulated)	0.198***	0.208***	0.230***	0.533***
	(0.004)	(0.004)	(0.005)	(0.004)
College Major				
- Humanities	-0.027***	-0.001	-0.055***	-0.136***
	(0.006)	(0.005)	(0.007)	(0.007)
- Social Science	-0.037***	-0.019***	-0.033***	-0.132***
	(0.006)	(0.004)	(0.006)	(0.005)
- Education	-0.006	-0.021***	-0.050***	-0.125***
	(0.007)	(0.007)	(0.009)	(0.008)
- Natural science/Mathematics	-0.024***	-0.019***	-0.039***	-0.056***
	(0.006)	(0.005)	(0.006)	(0.006)
- Medicine/Public Health	0.036***	-0.011	-0.145***	0.094***
	(0.007)	(0.008)	(0.017)	(0.010)
- Arts/Athletics	-0.154***	-0.364***	-0.472***	-0.534***
	(0.012)	(0.018)	(0.021)	(0.008)
(Pseudo) R-squared	0.209	0.334	0.287	0.602
No. of observations	30,582	26,156	22,487	22,357

Notes: Column (1) - Logit model, marginal effects reported. Column (2) – OLS. Dummies for college entrance years, survey years, and residence fixed effects are included. Other controls include age, age-squared and dummy for being married. The standard errors are based on 100 bootstraps, reported in parentheses. The asterisks *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 8. College Majors and Labor Market Outcomes: Gender-Specific Returns

Outcome	1: labor	1: employed	1: regular workers	Log monthly earnings
Sample	All	Labor force participants	Employees	Employees
	(1)	(2)	(3)	(4)
College major				
- Humanities	-0.062***	-0.020**	-0.098***	-0.217***
	(0.013)	(0.010)	(0.016)	(0.013)
- Social Science	-0.031***	-0.002	-0.005	-0.034***
	(0.008)	(0.007)	(0.009)	(0.009)
- Education	-0.037**	-0.010	-0.127***	-0.159***
	(0.016)	(0.013)	(0.022)	(0.017)
- Natural science/Mathematics	-0.063***	-0.052***	-0.074***	-0.108***
	(0.011)	(0.009)	(0.013)	(0.011)
- Medicine/Public Health	0.050***	-0.021	-0.231***	0.086***
	(0.015)	(0.015)	(0.027)	(0.019)
- Arts/Athletics	-0.031**	-0.064***	-0.139***	-0.236***
	(0.014)	(0.013)	(0.020)	(0.015)
Female×College major				
- ×Humanities	0.009	0.005	0.014	0.019
	(0.014)	(0.014)	(0.014)	(0.019)
- ×Social Science	0.018	-0.011	-0.012	-0.091***
	(0.012)	(0.014)	(0.015)	(0.016)
- ×Education	0.061***	0.005	0.079***	0.069***
	(0.012)	(0.016)	(0.008)	(0.022)
- ×Natural science/Mathematics	0.015	0.005	0.013	-0.036*
	(0.012)	(0.013)	(0.013)	(0.019)
- ×Medicine/Public Health	0.027	0.044***	0.066***	0.020
	(0.024)	(0.014)	(0.009)	(0.028)
- ×Arts/Athletics	-0.005	-0.037**	0.027**	-0.127***
	(0.017)	(0.018)	(0.013)	(0.022)
(Pseudo) R-squared	0.027	0.086	0.061	0.218
No. of observations	30,582	26,156	22,487	22,357

Notes: Columns (1) to (3) - Logit model, marginal effects reported. Column (4) - OLS. Dummies for college entrance years, survey years, and residence fixed effects are included. Other controls include age, age-squared and dummy for being married. The standard errors are in parentheses. The asterisks *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.