Efficient Supply of Human Capital: Role of College Major

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Abstract

This study measures the importance of college majors in explaining individuals' labor market outcomes, paying special attention to the gender gap in those outcomes. We use the Korean setting, in which, conditional on an applicant's test scores at the time of college application, the applicant's college major is likely to be uncorrelated with his/her major-specific unobservables that may affect his/her labor market outcomes. Our results suggest that college majors do have strong implications for labor market participation, employment, obtaining a long-term position, and earnings, and that women on average are less likely to be in advantageous college majors such as engineering and medicine than their male counterparts. Therefore, we find that the college major disparity accounts for a significant fraction of the gender gap in labor market outcomes. Furthermore, the more time passes since individuals graduated from college, the more the disparity in college major accounts for the gender gap in labor market outcomes. Our results suggest that education policies that may incentivize people to choose a much-demanded college major can give significant benefit to a country with aging population, by increasing the effective supply of labor, namely human capital, as well as female labor supply.

Keywords: Economics of education, College Major, Returns to Schooling, Gender Gap, Human Capital
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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 for capital input and Hsieh et al. 2013 for human capital). 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 number of the 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 (e.g., Neumark et al. 2013, studying the implication of the retirement of the baby boom cohort for the supply of skilled labor; see OECD 2005 for further discussion).

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 the individuals that are weakly attached to the labor market (e.g., youth, elderly, and women, OECD 2005; OECD 2006). This study examines a factor that could affect these two conditions to address the shortage of labor supply: college major choice.

Various studies in economics report robust patterns reporting the correlation between a person's college major and his/her later earnings (e.g., see more in Hamermesh and Donald 2008; Altonji et al. 2012; Kinsler and Pavan, 2014; Hastings et al. 2013). For example, in the United States, college graduates with engineering degree are consistently found to have higher earnings than their counterparts with other degrees. At the same time, women are on average less likely to choose well-paid majors compared to men and they provide less labor supply (both labor market participation and hours worked). 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 with that human capital. Women are less active in labor supply because their college majors do not very well equip them with the human capital appreciated in the labor market; thus, their net benefits from labor supply may be smaller than those of men. If our hypothesis is true, then a country may be able to offset a labor shortage due to an aging population by properly incentivizing people, particularly women, to select college majors that yield higher human capital.

We empirically examine our hypothesis using the Korean setting, which provides a uniquely suitable environment for this study for two reasons. First, the purpose of our study is relevant to South Korea because, similar to many developed countries, South Korea is experiencing a sharp population aging due to the low fertility rate (1.15 children per women in 2009, the lowest among the OECD countries, OECD average is 1.75) and a growing number of people getting a tertiary education (39 percent of people with age 25 to 64, in 2009, OECD average is 30 percent). Second, the college admission system in South Korea allows us to cleanly address endogenous choice of college major and thus to measure the causal impact of college major without heavily relying on model assumptions. In many countries, including the U.S., addressing endogenous choice of college major is extremely difficult because students can try a few majors in college before they choose one, potentially based on their unobservable college-major specific talents. In contrast, in the period this paper studies, students in South Korea have to select a major when they apply for college, and their chances of being admitted to a specific college and major do not depend on their unobservable major-specific talents. Furthermore, high-school students have little information on the coursework and career paths of each college major, and therefore it is unlikely that they may be able to predict their college-major specific productivity. Lastly, in South Korea, ranking of colleges and majors within a college are well agreed upon in the population, and the socioeconomic premium associated with graduating from a highly-ranked college is immense. Therefore, students are often incentivized to get an admission from the best college as they can get it, regardless of majors. See further institutional details in Section II.

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 initial labor market outcomes and their outcomes three years after graduation. We use this sample of young adults for our analysis because we have information on their academic quality at the time of college application[1]. We classify college majors into seven groups: Engineering, Humanities, Social Sciences, Education, Natural Sciences/Mathematics, Medicine/Public Health[2], and Arts/Athletics.

[1] Note that when we use another dataset containing older cohorts with less information about their academic quality, we find results qualitatively comparable to our baseline ones.

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

We examine the impact of college major on labor outcomes 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 major for which an applicant is admitted is not correlated with the applicant's unobservables that may affect his/her labor market outcomes. We find empirical evidence supporting the identification assumption in the Korean context.

We find that Engineering and Medicine/Public Health yield the most favorable outcomes in terms of almost all the labor market outcomes we examine: being in the labor market, likelihood of being employed, likelihood of having a long-term labor contract, monthly earnings, and job stability. Arts/Athletics is the category of majors least likely to lead to favorable labor market outcomes. The difference in labor market outcomes across majors remains the same or even widens as more time passes after college graduation. Regarding the gender gap, we find that even though the majority of adults in our data are young, college-educated, and single without children, free from standard household duties, there exists a sizeable gender gap in the labor market outcomes, which widens with time. However, once we control for college majors, the gender gap is reduced by approximately 50 percent.

Our results provide important policy implications. South Korea may be able to increase the total supply of human capital despite a shrinking working age population by inducing more people to major in fields that are appreciated in the labor market, namely Engineering and Medical/Public Health. Furthermore, promoting women to major in those fields can significantly increase women's labor market participation, employment, and likelihood of having a long-term position, which may be worth considering as a policy instrument because South Korea has been trying, without much success, to improve women's attachment to the labor market.

This study proceeds as follows: Sections II and III present the institutional background and empirical framework including the tests of our identification assumption, respectively. Section IV presents the data and summary statistics. Section V reports the main results and Section VI tests the sensitivity of our results. Finally, Section VII 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 et al. (2014). Competition among students is intense to gain admission to a prestigious college and major, and perhaps due to this intense competition, the Korean government has been deeply involved in designing the college admissions system and regulating the admissions policies of both public and private colleges. In our period of study, the Korean government employed the following rules: (i) applicants are allowed to apply for up to 5 options (by option, we mean a combination of a college and a major); (ii) each college announces the quotas of each major before students apply for options; (iii) students are evaluated based on their test scores on the national examination for college entrance (the College Scholastic Ability Test, or CSAT), college-specific interviews/tests, and performance in high school. Specifically, 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 regulated to test students within the high school curriculums and thus a college cannot select students based on their underlying talents specific to the college majors for which they applied[3].

These college admission rules in South Korea, together with behavioral patterns described below, are likely to make students sign up for a college-major that is uncorrelated with their college-major specific talents. Specifically, conditional on a student's performance when he/she applies for college majors, the major that he/she enrolls in will be correlated with his/her major-specific talents if the following two conditions hold. First, the student should have received reasonable information about his/her college-major-specific talents. Second, the student should allocate at least one option for the specific major in which he/she has a comparative advantage when applying for college majors, and receive admission for that option. As we reviewed earlier, the college admission rule does not incorporate a person's major-specific talents into evaluating applications. Therefore, conditional on test scores, a person's chance of getting admitted for a specific option is orthogonal to his/her talents.

These features imply that in South Korea, endogeneous choice of college major may take place only if students know their major-specific talents and if they get at least one admission from the options with the preferred major. We argue that possibility of endogenous choice may be small in the South Korean context, which is supported by the empirical analyses shown in Section III.1.

The first reason is that students are unlikely to have good knowledge about their major-specific talents when they apply for colleges. The primary and secondary curriculums in South Korea, determined by the government, provide little chance for

[3] 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.

students to know what it would be like to major in a certain discipline, such as coursework and the career paths of its graduates. Due to the intense competition for college admission, students tend to devote their time and energy as much as possible to enhancing their performance on tests, leaving little time to gather information that is not relevant to these tests. Therefore, students have little information on college majors and thus are not able to evaluate their talents for each major.

The second reason is that even if the students were aware of their talents, it is not easy to get an admission from the preferred major in general. Over 30 percent of high school seniors fail to receive a suitable admission and choose to spend another year in prep school to participate in the college application process again the subsequent year. Therefore, an applicant may end up having only one admission or even none. Furthermore, students are likely to construct their 5 options for college applications by mixing colleges and majors, instead of applying to only one major that they may have an unobservable talent for the following reason. 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, and graduating from a prestigious college/major generates substantial premiums (Sorensen 1994; Lee 2007)[4]. For example, Seoul National University (herein, Seoul National) is considered the best, followed by the second group of colleges such as Yonsei, Korea, KAIST, and POSTECH[5]. Given a college, undergraduate law and medicine majors are the two best-regarded ones, followed by economics/business administration and engineering majors. Due to the high premium

[4] 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.

[5] KAIST stands for Korea Advanced Institute of Science and Technology whereas POSTECH stands for Pohang University of Science and Technology.

associated with highly-ranked colleges, graduating from a higher-ranked school but a less desirable major may yield better labor market outcomes compared to graduating from a lower-ranked school but a major based on her talent. Therefore, students would not be likely to limit their application only to the majors they prefer.

III. 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 he/she is employed, whether he/she 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[6]:

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

$$Y^{*}_{i,j,c,l,r} = \alpha_r female_i + \beta_r CSAT_i + \gamma_r age_{i,r} + \delta_r age^2_{i,r} + \theta_{j,r} + \rho_{c,r} + \mu_{l,r} + \varepsilon_{i,j,c,l,r}, \quad (1)$$

where $Y_{i,j,c,l,r}$ is a binary outcome and $Y^{*}_{i,j,c,l,r}$ is the corresponding latent index for person *i* who majored in *j*, graduated from a college in year *c,* lives in location *l* and was surveyed in round $r \in \{0,1\}$; $female_i$ is 1 if person *i* is female and 0 if male; $CSAT_i$ is person *i*'s test score on college admission tests; and $age_{i,r}$ is the person's age at survey round *r*. Round *r* is 0 if the survey is conducted 20 months after the time of college graduation (i.e., initial survey), and 1 if it is conducted two years after the initial survey (i.e., follow-up survey). Variables $\rho_{c,r}$ and $\mu_{l,r}$ capture cohort and location specific fixed effects, respectively. The parameters are allowed to vary by survey round.

The parameter of interest is $\theta_{j,r}$, which measures the relationship between a

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

person's college major and his/her labor market outcomes. Our identification assumption is that, conditional on a person's CSAT score and other observable characteristics, a person's choice of college major is uncorrelated with the person's unobservable characteristics that may affect his/her labor market outcomes. As explained in Section II, this identification assumption is likely to hold in South Korea because a person's major is determined when he/she applies to a college without much information about how well he /she may do in a specific college major. Furthermore, even if the person knew of his/her college major-specific talents, the person may not be able to be admitted for the college major in which he/she would be the most productive.

Finally, when we analyze continuous variables, we regress the outcome variable on the regressors specified in equation (1). For example, we regress a person's logarithm of earnings on gender, age, age-squared and so on, consistent with Mincerian regression (Mincer 1974).

III.1. Testing Identification Assumption

If our identification assumption is correct, then, conditional on a person's performance that affects his/her chances of college admission, the person's unobservable major-specific talent should not be systematically correlated with the actual college major that the person studies in college. We empirically examine the extent to which our identification assumption is valid using 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 2011. The KEEP's initial survey contains the information on the college major a student wants to enroll in before he/she even takes the college entrance exam. Then, in the later surveys, the dataset concludes 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 when the student was admitted to the currently enrolled-in college. We examine all of the follow-up surveys until 2011 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.

Suppose that students may know their college-major specific talents and devise their college applications to get an admission for the major in which they would be the most successful. In such a case, in which our identification assumption fails, we would find a positive correlation between a person's intended college major and the actual major he/she enrolled in, conditional on his/her performance on national college entrance exam, high school ranking, and college-specific test/interviews.

Due to data limitations, we use a person's score on the national college entrance exam as a proxy for overall performance of the person and estimate following multinomial Logit models:

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

$$M^*_{i,k,t} = \alpha_k female_i + \beta_k CSAT_i + \gamma_k Preferred_i + \theta_{k,t} + u_{i,k,t}, \quad (2)$$

where $M_{i,k,t}$is 1 if the college major of person *i* is major *k*, and 0 otherwise, and $M^*_{i,k,t}$ is the corresponding latent index. That is, in our model, person *i* will choose major *k* if and only if $M^*_{i,k,t}$ is the largest among all latent indexes associated with college majors from 1 to *K*. The latent index is linear in person's sex ($female$), test score ($CSAT$), whether the specific college major is the major the person intended to pursue before college application ($Preferred$), and fixed effects for the year of college application ($\theta_{k,t}$). The parameter of interest is γ_k. That is, if people enrolled in a college major according to their preference, then $\{\gamma_k\}_{k=1}^{K}$ will be positive for all *k*s.

For our estimation, we classify college majors into seven categories: Humanities, Social Sciences, Education, Natural Sciences/Mathematics, Medicine/Public Health, Arts/Athletics, and Engineering (baseline group). As shown in Panel A of Table 2, the estimated $\{\gamma_k\}_{k=1}^{K}$ are mostly insignificant and often negative. The only exception is Arts/Athletics applicants, who require an additional specialty test (e.g., playing the instrument for a music major). Those who intended to major in Arts/Athletics have developed relevant skills and competence in their specialty during high school and are less likely to change their major after taking the CSAT. When we exclude individuals who major in Arts/Athletics (see Panel B, Table 2), the stated preferred major has no statistical power in explaining the actual major.

IV. Data

IV.1. Data Source

For baseline analyses, 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[7] and it surveys their initial labor market outcomes in 2006 and then two years later, in 2008[8].

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 students' 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.

Finally, it is worth noting that we use the GOMS in our baseline analyses 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. However, they have either very small sample sizes (e.g., the KEEP) or no information on a person's college major (e.g., "Korean Labor and Income Panel Study").

IV.2. Summary Statistics

Table 1 reports summary statistics from the initial and follow-up surveys depending on gender. Several variables require explanation. A person is defined as employed if he/she worked at least one hour during the week before the survey was

[7] 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.
[8] Note that the 2006 GOMS does not exist because the survey design was reconstructed in 2007, and the 2008 GOMS is the latest wave available to the public.

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. Finally, we classify college majors into seven groups in the same way as in Section III: Engineering, Humanities, Social Sciences, Education, Natural Sciences/Mathematics, Medicine/Public Health, and Arts/Athletics.

The initial surveys include 22,953 men and 18,305 women in total, and approximately 82 percent of them participated in the follow-up surveys. On average, male respondents are two years older than female respondents in both surveys. This is not surprising because in general Korean men participate in two-year compulsory military service before they graduate from college. This implies that male college graduates will be on average two years older than female graduates when they start joining the labor market.

Table 1 shows noticeable differences between men and women in terms of their college majors, earnings, and likelihood of having a regular position. For example, approximately 40 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.

In our sample, we find a small gender gap in terms of the labor market participation rate and employment, especially in the initial survey, which is perhaps not surprising because our sample consists of college educated people, most of whom are single without a child. For example, the fraction of people in the labor force is 76 percent among women and 78 percent among men. The share of the employed among those in the labor force is 95 percent for women and 96 percent for men. However, after only two years, the gender gap in labor market participation rate increases by approximately a factor of three, from two percentage points to seven percentage points, and the gender gap in employment rate increases by a factor of two, from one percentage points to two percentage points. This sharp increase in gender gap is alarming in that, because most individuals are single, these widening gaps are not accounted for by the traditional factors that make women more involved in home production, such as childcare and household chores.

The average monthly earnings are 2.44 million won for men (roughly 2,440 U.S. dollars), over 30 percent higher than that of female employees. Men are about 10 percentage points more likely to have a regular position than women. Furthermore, conditional on having a regular position, men are over 50 percent (i.e., over 16 percentage points) more likely to work for a large-scale firm than women. All of these differences are statistically significant at a one percent level, based on two-sided t-tests.

IV.3. Test Scores

To estimate the causal impact of college majors, we need to control for a person's test scores (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 was established to educate public-elementary-school teachers (see Appendix A.1, column 1). 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 obtain 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 V.

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. Specifically, 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 over 0.53 (see Appendix A.1, 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 alterative dataset, KEEP (see Section III.1). Finally, using KEEP, we regress the actual CSAT scores on the three characteristics of colleges we used for our imputation, and then we find that those college characteristics account for a large variation in the data (R-squared is over 20 percent, see Appendix A.1, column 3).

V. Results

V.1. Labor Market Participation, Employment, and Long-term Contract

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 details Section V.1).

We report marginal effects at the mean values of explanatory variables in Table 3 for the initial survey and Table 4 for the follow-up survey, respectively. 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 initial survey year to examine their labor market participation status. In column 2, we examine whether a person is employed regardless of his/her labor market participation status. We do this to account for the possibility that some individuals may intend to search for a job but are classified as not being in the labor force (i.e., discouraged workers). In column 3, we examine those who are in the labor force, to study whether a person is employed. In column 4, 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, whereas a temporary position is terminated on average every two to three years and is not provided any insurance. In addition, a regular position holder earns higher compensation than his/her counterparts with a temporary position.

Tables 3 and 5 show that in both the initial and follow-up surveys, individuals with an Engineering major on average outperform their counterparts in almost all outcomes. For example, Table 3 shows that compared to his/her counterparts with an Engineering degree, a person with a Humanities major is 2.2 percentage points less likely to be in the labor force, 3.5 percentage points less likely to be employed, 2.6 percentage points less likely to be employed conditional on being in the labor force, and 13.5 percentage points less likely to hold a regular position. These gaps do not narrow – they widen – three years after graduation. As shown in Table 4, compared to his/her counterparts with an Engineering degree, a person with a Humanities degree is 5.7 percentage points less likely to be in the labor force, and 6.9 percentage points less likely to be employed. Compared to other majors, those who majored in Arts/Athletics perform poorly in terms of employment and holding a regular position, especially in the follow-up survey. Note that these estimated effects quantitatively remain comparable when we use Probit models.

To examine the extent to which college major may account for the gender gap in labor market outcomes, we compare the coefficient of "female" in Panel A with that in Panel B. That is, if the gender gap in college majors fully accounts for the gender gap in the labor market outcomes, then 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 be.

For the initial survey that took place right after people graduated from college, we find no disadvantage for women in terms of participating in labor force or being employed (columns 1 and 2 of Table 3). However, columns (3) and (4) in Panel B show that women are approximately 2 percentage points less likely to be employed conditional on being in the labor force and 3 percentage points less likely to hold a regular position conditional on being employed. However, these gender gaps considerably widen when three years pass since college graduation. Even though they are young (less than 30 years old) and most of them are single, we find that compared to their male counterparts, women are 5.1 percentage points less likely to be in the labor force, 6.7 percentage points less likely to be employed, 2.2 percentage points less likely to be employed conditional on being in the labor force, and 4.8 percentage points less likely to have a regular position.

However, a comparison of Panels A and B shows that college major accounts for a substantial part of these gender gaps. For example, in the initial survey, the gender gap in employment conditional on being in the labor force is reduced from -0.018 to -0.009 (column 3, Panels B and A, Table 3, respectively), a 50 percent reduction. Similarly, the gender gap in having a regular position conditional on employment is reduced from -0.028 to -0.004 (column 4, Panels B and A, Table 3, respectively), an 86 percent reduction. In the follow-up year surveys, controlling for college major also substantially reduces the gender gap in labor market outcomes, ranging from a 14 percent to a 46 percent reduction in the estimated coefficients of "female."

In sum, we find a significant impact of college major on labor market outcomes as well as on the gender gap among young educated individuals in South Korea. We find that the gender gap widens rapidly within the three-year window after college graduation, although most of these individuals are single and free from household division of labor. However, once we control for college major, the estimated gender gap is significantly reduced in virtually all outcomes, that is, a significant fraction of the gap disappears.

V.1.1 Policy Implications

These results have important policy implications. First, reallocating more quotas to Engineering majors from Humanities and Arts/Athletics may be helpful to provide the kind of human capital that is demanded in the Korean labor market. In South Korea, such reallocation is a feasible policy instrument because the Ministry of Education is heavily involved in tertiary education, including the total size of quotas in each college in a given year and financial support to colleges and college students. Second, providing incentives for women to select majors highly in demand in the labor market, for example, by introducing affirmative action for women in Engineering majors, may improve women's labor market participation and employment as well as their likelihood of having a long-term position.

Using our baseline estimates, we conduct the following two back-of-the envelope calculations. First, we examine the scenario in which, for each sex, the share of all college majors except for Engineering is reduced by 10 percent, while Engineering takes all the shares released by other majors.[9] This scenario depicts an example in which the Engineering major increases its quota while the other college majors decrease their sizes proportionally. In this hypothetical case, the share of the Engineering major increases to 27.50 to 34.74. Our estimates (Table 4) imply that in the follow-up survey, the total labor market participation rate would have been increased by 0.20 percentage points (0.2 percent), the employment rate among labor market participants by 0.23 percentage points (0.3 percent), and the likelihood of having a long-term position by 0.49 percentage points (0.6 percent).

Second, we examine another scenario in which the distribution of college majors among women is the same as the men's, while the men's distribution is the same in our dataset. That is, in the follow-up survey, the share of women majoring in Engineering is assumed to be 40.51 percent, instead of 10.19 percent. In this hypothetical case, women's labor market participation rate increases by 0.62 percentage points (0.8 percent), employment rate by 1.05 percentage points (1.2 percent), and chance of having a long-term position by 2.48 percentage points (2.9 percent).

Although these implications are drawn specifically for the Korean context, they may provide useful lessons to other countries. Similar to South Korea, in many countries, women are generally less likely to major in Engineering than their male counterparts (see Joy 2003; Gemici and Wiswall 2013; Turner and Bowen 1999; Zafar 2013; Wiswall and Zafar 2015), women are less active in labor market participation (see OECD 2012), and

[9] For example, in the follow-up survey, 18.16 percent of women and 9.3 percent of men majored in Humanities. We assume that in our hypothetical case, the share of Humanities majors decreases to 16.34 percent for women and 8.22 percent for men, while the share of Engineering majors increases to 19.16 percent for women and 46.45 percent for men.

public sectors heavily subsidize tertiary education, for example by providing tax deductions and subsidized loans. Our findings from South Korea suggest that improving gender equality in college major choice may be an effective way to reduce the gender gap in the labor market outcomes and also to increase the labor supply, offsetting the shortage due to an aging population.

IV.2. Earnings

Columns 1 and 2 of Table 5 (Panel A) present the estimated Mincerian regression models as a function of college major based on the initial and follow-up surveys, respectively. College graduates with an Engineering degree on average outperform their peers in terms of earnings by five to 21 percent in the initial surveys. 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 Sciences/Mathematics are lower than those of Education majors, and their average earnings are only five to eight percent higher than the earnings of workers majoring in Humanities. This result is somewhat surprising because the gap between Natural Sciences/Mathematics majors and Humanities majors is generally observed to be much wider in existing studies. 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 Sciences major compared to a Humanities major (Table 3). The effects of college majors on earnings quantitatively remain stable in the follow-up surveys (column 2). We select the individuals who were employed in both initial and follow-up surveys and examine the earnings growth between the two periods as a function of college major (column 3). Overall, the earnings growth rate is the same across majors except for Education and Natural Sciences/Mathematics. For Education majors, the growth rate of earnings is six percent smaller than for Engineering majors, which may be due to the fact that teachers' compensation is strictly regulated by the central government and follows the payment schedule for civil servants, which is known to have small returns until tenure. Natural Sciences/Mathematics majors show four percent faster growth in earnings than Engineering majors.

The estimated coefficients of the rest of the variables match the standard Mincerian regression results. The imputed CSAT score that will be positively correlated with a person's cognitive skills is positive and significant. A one-standard-deviation-higher test score is associated with a 10 percent increase in earnings. However, the importance of this test score is reduced in the follow-up survey. Women earn less than men (about eight percent in the initial year and 15 percent in the follow-up survey). A person's earnings are concave in relation to his/her age, and married people on average receive larger earnings.

In Panel B, we report regression results without controlling for college majors. We conduct this analysis to measure the extent to which differences in college major between men and women may account for their earnings gap. Panel B shows that women earn 12 percent less than men in the initial survey (column 1), and this gap widens in the follow-up survey (column 2, 19 percent). This finding implies that, of the 12 percent earnings gap between men and women in the initial survey, the difference in college major choices between men and women accounts for 4.3 percentage points (about 35 percent), which is statistically significant at a 1 percent level. Our findings provide important policy implications. In South Korea, the central and local governments try to promote women's employment because South Korea faces a rapidly aging labor force, and married women's labor market participation is less than 50 percent. Most policies focus on expanding part-time jobs and flexible work-schedules, but they have had little success. Our findings show significant disadvantages for women, but it is likely that a significant part of this disadvantage would be eliminated if women chose the same college majors as men. Therefore, it may be worthwhile for the Korean government to introduce policies that intervene in women's decisions at the stage of college major choice in order to promote their employment, in contrast to current policies, which mostly focus on women who are already out of the labor force.

IV.3. Job Turnover

This subsection examines the relationship between college major and job turnover. By job turnover, we mean whether an employee switched his/her employer or industry between the initial and follow-up surveys. We examine these variables because switching jobs after less than two years may imply poor quality of one's initial job. Table 6 (Panel A) reports the results. Column 1 is based on whether an employee switches employers between the two surveys; column 2 is based on whether he/she switches to a different industry. Note that we classify jobs into eight industries: manufacturing, education, retail and wholesale services, public service, medical services, finance and business services, IT and transportation services, and the rest.

In both measures, the impact of college major on a person's likelihood of switching jobs is overall negatively correlated with the major's impact on employment and earnings. For example, Humanities majors are 10.7 percentage points more likely to switch employers compared to Engineering majors. Despite this switch, workers who majored in Humanities on average cannot narrow the gap in monthly earnings relative to their counterparts who majored in Engineering. The only exception is Education, whose graduates show four percentage points fewer switches. This is because teachers in South Korea are treated like civil servants, whose jobs are fairly well protected. These findings suggest that, in general, the economic benefits from majoring in a specific subject are generally well aligned across various labor market outcomes, including monthly earnings, likelihood of employment, having a regular position, and job stability.

Panel B reports the gender gap in terms of job stability without controlling for college majors. Although women are 2.5 percentage points more likely to switch employers, we find no difference between men and women once we control for college majors (Panel A, column 1). As for the likelihood of switching industries, women are more reluctant to switch than men (2.0 percentage points) and the gap widens once we control for college majors (2.4 percentage points).

V. Discussion

V.1. Excluding Arts/Athletics Majors

In Section III.1, we find that high school students who intend to select Arts or Athletics are likely to actually major in them in college. As we include those who major Arts or Athletics in our baseline analysis, the selection bias could affect our results. To address this possibility, we exclude all individuals who majored in Arts or Athletics from our sample and redo our analyses. Table 7 presents the results on labor market participation and employment outcomes in the follow-up survey. The estimated coefficients for college majors remain comparable to our baseline results reported in Table 4. All other results also remain stable (see Appendix Tables A.3 and A.4).

V.2. High School Tracks

In South Korea, students choose between the Humanities/Social Sciences track and the Mathematics/Natural Sciences track when they become high school sophomores. The high school curriculum puts more emphasis on reading and English in the Humanities/Social Sciences track, whereas more class hours are allocated to mathematics, physics, and chemistry in the Mathematics/Natural Sciences 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 Sciences 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 from a student's CSAT scores. Therefore, it is possible that a student may select a high school track depending on his/her comparative advantage.

We conduct a sensitivity check of our results with regard to this possibility by separately conducting our analysis by high school track. This means that we relax our identification assumption such that, conditional on high school track, CSAT scores, and other observable characteristics, college major is exogenous to a person's unobservable skills.

Tables 8 and 9 report the results on labor market participation and employment in the follow-up survey for individuals who were in the Humanities/Social Sciences track, and on the Natural Sciences/Mathematics respectively. The estimated coefficients of college majors in each high-school track are comparable to our baseline results from the pooled sample in Table 4. Our findings on other outcomes and initial survey remain stable when we separately analyze the two tracks (See results in Tables A.4 to A.6).

VI. Conclusion

Using nationally representative datasets of young Korean adults, we have examined the impact of college major on labor market outcomes and its role in accounting for the gender gap. We find sizable returns from majoring in Engineering and Medicine/Public Health, followed by Social Sciences and Education, then by Natural Sciences/Mathematics. Majors in Humanities and Arts/Athletics are subject to the least favorable labor market outcomes. However, women are under-represented in the majors with high labor market returns compared to their male counterparts, which accounts for approximately 50 percent of the gender gap in employment, the likelihood of working for a long-term contract job, and the logarithm of earnings.

The findings of this study suggest that for countries that need to better mobilize available labor resources, it is important to design education policies to increase human capital and offset the reduction in the working age population. Specifically, in the context of South Korea, majoring in Engineering and Medicine/Public Health is particularly valued in the labor market. Therefore, the Korean government could increase its effective supply of labor, i.e., human capital, by incentivizing colleges to increase quotas for those majors. Furthermore, if men's labor supply is not sensitive to their college majors, our findings suggest that women's labor supply will be increased by policies that promote gender equality in college majors (e.g., gender-specific quota or affirmative action to balance gender composition) and thus make more women select college majors demanded in the labor market.

References

Altonji JG, Blom E, Meghir C (2012) Heterogeneity in human capital investments: High school curriculum, college major, and careers. Annual Review of Economics 4(1):185-223. doi:10.1146/annurev-economics-080511-110908.

Avery C, Lee S, Roth A (2014) College admission as non-price competition, NBER Working Paper No. 20774. National Bureau of Economic Research, Cambridge, MA. doi:10.3386/w20774.

Dolado JJ, Felgueroso F, Jimeno JF (2001) Female employment and occupational changes in the 1990s: How is the EU performing relative to the US? European Economic Review 45(4-6):875-889. doi:10.1016/S0014-2921(01)00114-3.

Gemici A, Wiswall M (2013) Evolution of gender differences in post-secondary human capital investments: College majors. International Economic Review 55(1):23-56. doi:10.1111/iere.12040.

Goldin C (2014) A grand gender convergence: Its last chapter. American Economic Review 104(4):1-30. doi:10.1257/aer.104.4.1091.

Hastings JS, Neilson C, Zimmerman SD (2013) Are some degrees worth more than others? Evidence from college admission cutoffs in Chile, NBER Working Paper No. 19241. National Bureau of Economic Research, Cambridge, MA. doi:10.3386/w19241.

Hamermesh D, Donald S (2008) The effect of college curriculum on earnings: An affinity identifier for non-ignorable non-response bias. Journal of Econometrics 144(2):479-491. doi:10.1016/j.jeconom.2008.04.007.

Hsieh CT, Hurst E, Jones CI, Klenow PJ (2013) The allocation of talent and U.S.

economic growth, NBER Working Paper No. 18693. National Bureau of Economic Research, Cambridge, MA. doi:10.3386/w18693.

Hsieh CT, Klenow PJ (2009) Misallocation and manufacturing TFP in China and India. The Quarterly Journal of Economics 124(4):1403-1448. doi:10.1162/qjec.2009.124.4.1403.

Joy L (2003) Salaries of recent male and female college graduates: Educational and labor market effects. Industrial and Labor Relations Review 56(4):606-621. doi:10.2307/3590959.

Kinsler J, Pavan R (2014) The specificity of general human capital: Evidence from college major choice. Journal of Labor Economics 33(2): forthcoming.

Lee S (2007) The timing of signaling: To study in high school or in college? International Economic Review 48(3): 785-807. doi:10.1111/j.1468-2354.2007.00445.x.

Mincer J (1974) Schooling, experience, and earnings. Columbia University Press, New York.

Neumark D, Johnson H, Mejia MC (2013) Future skill shortages in the U.S. economy? Economics of Education Review 32:151-67. doi:10.1016/j.econedurev.2012.09.004.

OECD (2005) Ageing populations: High time for action. http://www.oecd.org/employment/emp/34600619.pdf. Accessed 21 Dec 2014

OECD (2006) Live longer, work longer: A synthesis report. OECD Publishing, Paris. http://www.oecd.org/els/emp/livelongerworklonger.htm. Accessed 10 Jan 2015

OECD (2012) Gender equality in education, employment and entrepreneurship: Final report to the MCM 2012. http://www.oecd.org/newsroom/50423364.pdf. Accessed

19 Jan 2015

OECD (2014) Society at glance: OECD social indicators. doi:10.1787/19991290. Accessed 27 Jan 2015

Sorensen C (1994) Success and education in contemporary South Korea. Comparative Education Review 38(1):10-35

Turner S, Bowen W (1999) Choice of major: The changing (unchanging) gender gap. Industrial and Labor Relations Review 52(2):289-313. doi:10.2307/2525167.

Wiswall M, Zafar B (2015) Determinants of college major choice: Identification using an information experiment. Review of Economic Studies: forthcoming. doi:10.1093/restud/rdu044.

Zafar B (2013) College major choice and the gender gap. Journal of Human Resources 48(3):545-595

Table 1. Summary Statistics

	Initial Survey			Follow-up Survey		
	Total	Male	Female	Total	Male	Female
	(1)	(2)	(3)	(4)	(5)	(6)
No. of observations	41,258	22,953	18,305	33,950	19,382	14,568
Age	26.92	27.96	25.62	28.91	29.91	27.56
Married (%)	9.20	10.75	7.25	24.66	28.79	19.16
College major (%)						
- Humanities	13.53	9.21	18.96	13.00	9.13	18.16
- Social Sciences	22.83	22.85	22.81	22.82	22.84	22.80
- Education	8.92	4.86	14.02	9.09	4.54	15.16
- Engineering	26.69	39.91	10.12	27.50	40.51	10.19
- Natural Sciences/Mathematics	14.63	13.28	16.32	14.74	13.46	16.44
- Medicine/Public Health	4.04	3.18	5.12	3.97	3.10	5.14
- Arts/Athletics	9.36	6.73	12.65	8.87	6.43	12.12
In the labor force (%):	77.25	78.47	75.71	85.78	88.64	81.97
Employed among those in the labor force (%)	95.78	96.07	95.40	85.56	86.10	84.79
Among those employed:						
- Monthly Earnings (10,000 2010 won)	221.73	244.00	192.65	254.82	280.26	217.64
- Regular position (%)	79.14	83.14	73.90	87.33	90.27	84.79
- Irregular position (%)	20.86	16.86	26.10	12.67	9.73	16.95
Among regular position (%):						
- Working at a large-scale firm	40.67	47.24	30.99	41.69	48.00	31.66
Imputed CSAT score (standardized)	0.00	-0.07	0.09	0.00	-0.07	0.10

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 2. Actual and Preferred College Majors

Actual major	1 if Humanities	1 if Social Sciences	1 if Education	1 if Natural Sciences/ Mathematics	1 if Medicine/ Public Health	1 if Arts /Athletics
Model A: All Majors						
Female	2.328***	1.735***	2.431***	2.201***	2.741***	2.426***
	(0.309)	(0.264)	(0.410)	(0.298)	(0.523)	(0.336)
CSAT	0.611***	0.542***	1.197***	0.182	1.371***	-1.417***
	(0.164)	(0.131)	(0.242)	(0.157)	(0.304)	(0.185)
Dummy 1 if preferred major	-0.627*	0.401	0.321	-0.555*	0.212	1.090***
	(0.259)	(0.207)	(0.350)	(0.252)	(0.426)	(0.305)
Model B: Excluding Arts/Athletics						
Female	2.306***	1.769***	2.444***	2.169***	2.748***	-
	(0.309)	(0.265)	(0.412)	(0.298)	(0.524)	-
CSAT	0.628***	0.541***	1.179***	0.199	1.363***	-
	(0.164)	(0.131)	(0.246)	(0.157)	(0.308)	-
Dummy 1 if preferred major	-0.589*	0.435*	0.355	-0.498*	0.244	-
	(0.261)	(0.209)	(0.353)	(0.254)	(0.428)	-

Notes: Both Models A and B report estimated coefficients of multinomial Logit models described in Section III. Standard errors are in parentheses. Regressions additionally include dummies for college entrance years and high school location fixed effects. Variable "Dummy 1 if preferred major" is 1 if the actual major is the same as the preferred major stated before applying to a college and 0 otherwise. The asterisks *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. For Model A, the number of observations is 882, and its pseudo R-squared is 0.193. For Model B, the number of observations is 765, and pseudo R-squared is 0.144.

Table 3. Labor Market Participation and Employment: Initial Survey

Outcome	1: labor	1: employed	1: employed	1: regular workers
Sample	All	All	Labor force participants	Employees
	(1)	(2)	(3)	(4)
No. of observations	41,258	41,258	31,796	30,454
Panel A: Major Controls				
Female	0.022***	0.008	-0.009***	-0.004
	(0.006)	(0.006)	(0.002)	(0.007)
Imputed CSAT	0.003	0.005*	0.001	0.022***
	(0.002)	(0.002)	(0.001)	(0.002)
College major				
- Humanities	-0.022**	-0.035***	-0.026***	-0.135***
	(0.007)	(0.008)	(0.005)	(0.010)
- Social Sciences	0.006	-0.004	-0.019***	-0.033***
	(0.006)	(0.007)	(0.004)	(0.008)
- Education	0.007	0.006	-0.004	-0.043***
	(0.008)	(0.009)	(0.005)	(0.011)
- Natural Sciences/ Mathematics	-0.069***	-0.090***	-0.036***	-0.095***
	(0.007)	(0.008)	(0.006)	(0.010)
- Medicine/Public Health	0.099***	0.080***	-0.033***	-0.113***
	(0.009)	(0.010)	(0.008)	(0.015)
- Arts/Athletics	0.031***	-0.060***	-0.149***	-0.183***
	(0.008)	(0.009)	(0.012)	(0.012)
Pseudo R-squared	0.022	0.019	0.113	0.069
Panel B: No Major Controls				
Female	0.021***	0.000	-0.018***	-0.028***
	(0.006)	(0.006)	(0.003)	(0.007)
Imputed CSAT	0.001	0.005*	0.004***	0.024***
	(0.002)	(0.002)	(0.001)	(0.002)
Pseudo R-squared	0.016	0.013	0.062	0.054

Notes: Logit model, marginal effects reported. 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 4. Labor Market Participation and Employment: Follow-up Survey

Outcome	1: labor	1: employed	1: employed	1: regular workers
Sample	All	All	Labor force participants	Employees
	(1)	(2)	(3)	(4)
No. of observations	33,950	33,950	29,112	24,909
Panel A: Major Controls				
Female	-0.044***	-0.053***	-0.013**	-0.026***
	(0.005)	(0.006)	(0.005)	(0.005)
Imputed CSAT	0.005*	0.010***	0.005*	0.017***
	(0.002)	(0.003)	(0.002)	(0.002)
College major				
- Humanities	-0.057***	-0.069***	-0.020**	-0.097***
	(0.008)	(0.009)	(0.007)	(0.010)
- Social Sciences	-0.023***	-0.030***	-0.010	-0.023***
	(0.006)	(0.008)	(0.006)	(0.007)
- Education	0.015*	0.008	-0.007	-0.034***
	(0.007)	(0.010)	(0.008)	(0.010)
- Natural Sciences/Mathematics	-0.054***	-0.094***	-0.051***	-0.076***
	(0.007)	(0.009)	(0.007)	(0.009)
- Medicine/Public Health	0.046***	0.045***	0.003	-0.139***
	(0.009)	(0.013)	(0.010)	(0.016)
- Arts/Athletics	-0.034***	-0.134***	-0.115***	-0.129***
	(0.008)	(0.011)	(0.010)	(0.013)
Pseudo R-squared	0.024	0.041	0.081	0.055
Panel B: No Major Controls				
Female	-0.051***	-0.067***	-0.022***	-0.048***
	(0.005)	(0.006)	(0.005)	(0.006)
Imputed CSAT	0.006**	0.012***	0.006***	0.020***
	(0.002)	(0.003)	(0.002)	(0.002)
Pseudo R-squared	0.017	0.033	0.071	0.039

Notes: Logit model, marginal effects reported. 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. Earnings

Dependent var.	Log monthly earnings (1)	Log monthly earnings (2)	Diff: log monthly earning (3)
Sample	Employed, Initial survey	Employed, Follow-up survey	Employed, Both surveys
No. of observations	30,242	24,767	22,704
Panel A: Major Controls			
Female	-0.078***	-0.146***	-0.050***
	(0.008)	(0.007)	(0.008)
Imputed CSAT	0.078***	0.069***	-0.009***
	(0.003)	(0.003)	(0.003)
Age	0.084***	0.077***	-0.017**
	(0.006)	(0.006)	(0.006)
Age-squared	-0.001***	-0.001***	0.000
	(0.000)	(0.000)	(0.000)
Married	0.097***	0.081***	-0.034***
	(0.010)	(0.006)	(0.009)
College major			
- Humanities	-0.207***	-0.195***	0.010
	(0.009)	(0.009)	(0.009)
- Social Sciences	-0.048***	-0.058***	-0.012
	(0.007)	(0.007)	(0.007)
- Education	-0.049***	-0.104***	-0.059***
	(0.011)	(0.010)	(0.010)
- Natural Sciences/Mathematics	-0.151***	-0.115***	0.036***
	(0.009)	(0.008)	(0.008)
- Medicine/Public Health	0.134***	0.101***	-0.003
	(0.013)	(0.013)	(0.013)
- Arts/Athletics	-0.329***	-0.303***	0.011
	(0.010)	(0.010)	(0.010)
R-squared	0.186	0.208	0.019
Panel B: No Major Controls			
Female	-0.121***	-0.191***	-0.052***
	(0.008)	(0.007)	(0.008)
Imputed CSAT	0.081***	0.067***	-0.015***
	(0.003)	(0.003)	(0.003)
Age	0.089***	0.076***	-0.018**
	(0.006)	(0.006)	(0.006)
Age-squared	-0.001***	-0.001***	0.000
	(0.000)	(0.000)	(0.000)
Married	0.105***	0.090***	-0.035***
	(0.010)	(0.006)	(0.009)
R-squared	0.138	0.161	0.015

Notes: OLS regression model. Dummies for entrance years, survey years, and residence fixed effects are included. The standard errors are in parentheses. The asterisks *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 6. Job Turnover

Dependent variable	1: switch employers (1)	1: switch industries (2)
Sample	Employed, Both surveys	Employed, Both surveys
No. of observations	22,985	22,985
Panel A: Major Controls		
Female	0.006	-0.024**
	(0.009)	(0.007)
Imputed CSAT	-0.050***	-0.022***
	(0.003)	(0.003)
College major		
- Humanities	0.107***	0.036***
	(0.012)	(0.009)
- Social Sciences	0.030***	0.019**
	(0.009)	(0.007)
- Education	-0.039**	-0.100***
	(0.012)	(0.007)
- Natural Sciences/Mathematics	0.074***	0.036***
	(0.011)	(0.009)
- Medicine/Public Health	0.039*	-0.054***
	(0.016)	(0.011)
- Arts/Athletics	0.186***	0.088***
	(0.014)	(0.012)
Pseudo R-squared	0.059	0.042
Panel B: No Major Controls		
Female	0.025**	-0.020**
	(0.009)	(0.007)
Imputed CSAT	-0.057***	-0.032***
	(0.003)	(0.003)
Pseudo R-squared	0.047	0.027

Notes: Logit model, marginal effects reported. Dummies for 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 7. Excluding Arts/Athletics: Follow-up Survey

Outcome	1: labor	1: employed	1: employed	1: regular workers
Sample	All	All	Labor force participants	Employees
	(1)	(2)	(3)	(4)
No. of observations	30,938	30,938	26,595	23,032
Panel A: Major Controls				
Female	-0.038***	-0.041***	-0.004	-0.022***
	(0.005)	(0.007)	(0.005)	(0.006)
Imputed CSAT	0.007**	0.014***	0.007***	0.018***
	(0.002)	(0.003)	(0.002)	(0.002)
College major				
- Humanities	-0.057***	-0.070***	-0.020**	-0.092***
	(0.008)	(0.009)	(0.007)	(0.010)
- Social Sciences	-0.023***	-0.032***	-0.012*	-0.022***
	(0.006)	(0.007)	(0.005)	(0.007)
- Education	0.013	0.003	-0.011	-0.035***
	(0.008)	(0.010)	(0.008)	(0.010)
- Natural Sciences/Mathematics	-0.053***	-0.093***	-0.047***	-0.072***
	(0.007)	(0.009)	(0.007)	(0.009)
- Medicine/Public Health	0.045***	0.043***	0.002	-0.131***
	(0.009)	(0.012)	(0.009)	(0.015)
Pseudo R-squared	0.026	0.041	0.088	0.052
Panel B: No Major Controls				
Female	-0.045***	-0.051***	-0.008	-0.042***
	(0.005)	(0.006)	(0.005)	(0.006)
Imputed CSAT	0.008***	0.014***	0.006**	0.020***
	(0.002)	(0.003)	(0.002)	(0.002)
Pseudo R-squared	0.019	0.035	0.085	0.039

Notes: Logit model, marginal effects reported. 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 8. Humanities/Social Sciences Track: Follow-up Survey

Outcome	1: labor	1: employed	1: employed	1: regular workers
Sample	All	All	Labor force participants	Employees
	(1)	(2)	(3)	(4)
No. of observations	14,305	14,305	12,170	10,354
Panel A: Major Controls				
Female	-0.034***	-0.047***	-0.015*	-0.035***
	(0.008)	(0.010)	(0.008)	(0.008)
Imputed CSAT	0.004	0.014***	0.010**	0.021***
	(0.003)	(0.004)	(0.003)	(0.003)
College major				
- Humanities	-0.056***	-0.076***	-0.029*	-0.093***
	(0.013)	(0.015)	(0.012)	(0.016)
- Social Sciences	-0.026*	-0.034**	-0.011	-0.016
	(0.011)	(0.013)	(0.010)	(0.011)
- Education	0.010	-0.018	-0.030*	-0.040*
	(0.013)	(0.017)	(0.014)	(0.017)
- Natural Sciences/Mathematics	-0.051***	-0.074***	-0.034*	-0.065***
	(0.014)	(0.017)	(0.014)	(0.017)
- Medicine/Public Health	0.052***	0.049*	0.005	-0.135***
	(0.016)	(0.022)	(0.018)	(0.028)
- Arts/Athletics	-0.032*	-0.136***	-0.119***	-0.123***
	(0.014)	(0.018)	(0.017)	(0.021)
Pseudo R-squared	0.019	0.037	0.077	0.056
Panel B: No Major Controls				
Female	-0.040***	-0.060***	-0.024**	-0.054***
	(0.008)	(0.009)	(0.007)	(0.008)
Imputed CSAT	0.005	0.015***	0.011***	0.024***
	(0.003)	(0.004)	(0.003)	(0.003)
Pseudo R-squared	0.013	0.030	0.067	0.042

Notes: Logit model, marginal effects reported. 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 9. Mathematics/Natural Sciences Track: Follow-up Survey

Outcome	1: labor	1: employed	1: employed	1: regular workers
Sample	All	All	Labor force participants	Employees
	(1)	(2)	(3)	(4)
No. of observations	14,755	14,755	12,784	11,025
Panel A: Major Controls				
Female	-0.044***	-0.053***	-0.012	-0.021*
	(0.008)	(0.010)	(0.008)	(0.008)
Imputed CSAT	0.007*	0.010*	0.003	0.013***
	(0.003)	(0.004)	(0.003)	(0.003)
College major				
- Humanities	-0.049***	-0.047**	0.001	-0.111***
	(0.013)	(0.016)	(0.011)	(0.018)
- Social Sciences	-0.010	-0.010	-0.002	-0.027*
	(0.009)	(0.012)	(0.009)	(0.011)
- Education	0.026*	0.045**	0.021*	-0.022
	(0.010)	(0.014)	(0.010)	(0.014)
- Natural Sciences/Mathematics	-0.044***	-0.093***	-0.055***	-0.077***
	(0.009)	(0.011)	(0.009)	(0.011)
- Medicine/Public Health	0.049***	0.053**	0.007	-0.151***
	(0.011)	(0.016)	(0.013)	(0.022)
- Arts/Athletics	-0.031*	-0.128***	-0.107***	-0.130***
	(0.013)	(0.018)	(0.017)	(0.021)
Pseudo R-squared	0.033	0.049	0.090	0.064
Panel B: No Major Controls				
Female	-0.049***	-0.062***	-0.017*	-0.043***
	(0.008)	(0.010)	(0.007)	(0.009)
Imputed CSAT	0.008**	0.013***	0.005	0.017***
	(0.003)	(0.004)	(0.003)	(0.003)
Pseudo R-squared	0.025	0.038	0.078	0.045

Notes: Logit model, marginal effects reported. 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.

Appendix A.

Table A.1. Imputation of CSAT

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 asterisks *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Table A.2. Excluding Arts/Athletics Exclude: Initial Survey

Outcome	1: labor	1: employed	1: employed	1: regular workers
Sample	All	All	Labor force participants	Employees
	(1)	(2)	(3)	(4)
No. of observations	37,398	37,398	28,716	27,780
Panel A: Major Controls				
Female	0.032***	0.022***	-0.005*	-0.002
	(0.006)	(0.007)	(0.002)	(0.007)
Imputed CSAT	0.005*	0.007**	0.002*	0.026***
	(0.002)	(0.003)	(0.001)	(0.003)
College major				
- Humanities	-0.025**	-0.038***	-0.024***	-0.130***
	(0.008)	(0.008)	(0.005)	(0.010)
- Social Sciences	0.005	-0.007	-0.017***	-0.032***
	(0.006)	(0.006)	(0.003)	(0.007)
- Education	0.005	0.001	-0.007	-0.048***
	(0.009)	(0.009)	(0.005)	(0.011)
- Natural Sciences/ Mathematics	-0.070***	-0.090***	-0.033***	-0.091***
	(0.007)	(0.008)	(0.005)	(0.009)
- Medicine/Public Health	0.099***	0.076***	-0.030***	-0.108***
	(0.009)	(0.010)	(0.007)	(0.014)
Pseudo R-squared	0.025	0.021	0.077	0.067
Panel B: No Major Controls				
Female	0.028***	0.015*	-0.009***	-0.025***
	(0.006)	(0.006)	(0.003)	(0.007)
Imputed CSAT	0.004	0.007**	0.003**	0.026***
	(0.002)	(0.002)	(0.001)	(0.002)
Pseudo R-squared	0.019	0.015	0.067	0.057

Notes: Logit model, marginal effects reported. 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 A.3. Excluding Arts/Athletics Exclude: Earnings

Dependent var.	Log monthly earnings (1)	Log monthly earnings (2)	Diff: log monthly earning (3)
Sample	Employed, Initial survey	Employed, Follow-up survey	Employed, Both surveys
No. of observations	27,588	22,907	21,000
Panel A: Major Controls			
Female	-0.061***	-0.134***	-0.054***
	(0.008)	(0.007)	(0.008)
Imputed CSAT	0.084***	0.074***	-0.009**
	(0.003)	(0.003)	(0.003)
Age	0.091***	0.078***	-0.024***
	(0.006)	(0.006)	(0.006)
Age-squared	-0.001***	-0.001***	0.000**
	(0.000)	(0.000)	(0.000)
Married	0.096***	0.081***	-0.033***
	(0.010)	(0.006)	(0.009)
College major			
- Humanities	-0.212***	-0.200***	0.010
	(0.009)	(0.008)	(0.009)
- Social Sciences	-0.051***	-0.061***	-0.013
	(0.007)	(0.007)	(0.007)
- Education	-0.063***	-0.115***	-0.060***
	(0.011)	(0.010)	(0.010)
- Natural Sciences/Mathematics	-0.155***	-0.118***	0.036***
	(0.009)	(0.008)	(0.008)
- Medicine/Public Health	0.129***	0.097***	-0.004
	(0.013)	(0.012)	(0.013)
R-squared	0.167	0.193	0.021
Panel B: No Major Controls			
Female	-0.101***	-0.173***	-0.056***
	(0.008)	(0.007)	(0.008)
Imputed CSAT	0.079***	0.065***	-0.014***
	(0.003)	(0.003)	(0.003)
Age	0.095***	0.079***	-0.026***
	(0.006)	(0.006)	(0.006)
Age-squared	-0.001***	-0.001***	0.000**
	(0.000)	(0.000)	(0.000)
Married	0.102***	0.085***	-0.035***
	(0.010)	(0.006)	(0.009)
R-squared	0.136	0.161	0.017

Notes: OLS regression model. Dummies for entrance years, survey years, and residence fixed effects are included. The standard errors are in parentheses. The asterisks *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Table A.4. Humanities/Social Sciences Track: Initial Survey

Outcome	1: labor	1: employed	1: employed	1: regular workers
Sample	All	All	Labor force participants	Employees
	(1)	(2)	(3)	(4)
No. of observations	18,159	18,159	14,078	13,419
Panel A: Major Controls				
Female	0.000	-0.015	-0.011**	-0.014
	(0.009)	(0.010)	(0.004)	(0.011)
Imputed CSAT	0.011**	0.014***	0.002	0.031***
	(0.003)	(0.004)	(0.002)	(0.004)
College major				
- Humanities	-0.047**	-0.053**	-0.009	-0.100***
	(0.016)	(0.017)	(0.008)	(0.020)
- Social Sciences	-0.022	-0.028	-0.007	-0.003
	(0.015)	(0.016)	(0.007)	(0.017)
- Education	-0.037*	-0.036	0.003	-0.020
	(0.018)	(0.019)	(0.008)	(0.020)
- Natural Sciences/Mathematics	-0.049*	-0.065**	-0.023	-0.038
	(0.020)	(0.022)	(0.014)	(0.023)
- Medicine/Public Health	0.068**	0.058*	-0.011	-0.041
	(0.021)	(0.024)	(0.014)	(0.030)
- Arts/Athletics	0.012	-0.082***	-0.119***	-0.142***
	(0.016)	(0.019)	(0.024)	(0.023)
Pseudo R-squared	0.014	0.014	0.120	0.066
Panel B: No Major Controls				
Female	-0.004	-0.021*	-0.014***	-0.027*
	(0.009)	(0.010)	(0.004)	(0.011)
Imputed CSAT	0.008*	0.014***	0.006***	0.034***
	(0.003)	(0.004)	(0.002)	(0.004)
Pseudo R-squared	0.011	0.011	0.065	0.054

Notes: Logit model, marginal effects reported. 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 A.5. Mathematics/Natural Sciences Track: Initial Survey

Outcome	1: labor	1: employed	1: employed	1: regular workers
Sample	All	All	Labor force participants	Employees
	(1)	(2)	(3)	(4)
No. of observations	19,274	19,274	14,667	14,204
Panel A: Major Controls				
Female	0.053***	0.048***	-0.003	0.019*
	(0.009)	(0.009)	(0.003)	(0.009)
Imputed CSAT	-0.002	-0.001	0.000	0.013***
	(0.003)	(0.003)	(0.001)	(0.003)
College major				
- Humanities	-0.046*	-0.066**	-0.041**	-0.155***
	(0.019)	(0.020)	(0.014)	(0.025)
- Social Sciences	0.013	-0.000	-0.023**	-0.031*
	(0.012)	(0.012)	(0.007)	(0.013)
- Education	0.037**	0.040**	0.002	-0.016
	(0.012)	(0.013)	(0.006)	(0.015)
- Natural Sciences/Mathematics	-0.072***	-0.092***	-0.031***	-0.093***
	(0.008)	(0.009)	(0.005)	(0.010)
- Medicine/Public Health	0.108***	0.082***	-0.035***	-0.112***
	(0.011)	(0.013)	(0.009)	(0.017)
- Arts/Athletics	0.024	-0.052**	-0.124***	-0.127***
	(0.016)	(0.018)	(0.019)	(0.022)
Pseudo R-squared	0.040	0.035	0.095	0.070
Panel B: No Major Controls				
Female	0.048***	0.039***	-0.008*	-0.001
	(0.009)	(0.009)	(0.004)	(0.009)
Imputed CSAT	-0.003	-0.000	0.003*	0.017***
	(0.003)	(0.003)	(0.001)	(0.003)
Pseudo R-squared	0.029	0.024	0.056	0.056

Notes: Logit model, marginal effects reported. 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 A.5. High School Track: Humanities/Social Sciences

Dependent var.	Log monthly earnings (1)	Log monthly earnings (2)	Diff: log monthly earning (3)
Sample	Employed, Initial survey	Employed, Follow-up survey	Employed, Both surveys
No. of observations	13,328	10,300	9,724
Panel A: Major Controls			
Female	-0.098***	-0.155***	-0.034**
	(0.012)	(0.010)	(0.012)
Imputed CSAT	0.084***	0.070***	-0.013**
	(0.004)	(0.004)	(0.004)
Age	0.074***	0.075***	-0.008
	(0.010)	(0.010)	(0.009)
Age-squared	-0.001***	-0.001***	0.000
	(0.000)	(0.000)	(0.000)
Married	0.093***	0.096***	-0.019
	(0.016)	(0.009)	(0.015)
College major			
- Humanities	-0.176***	-0.195***	0.001
	(0.018)	(0.014)	(0.017)
- Social Sciences	-0.029	-0.052***	-0.022
	(0.017)	(0.012)	(0.016)
- Education	-0.040	-0.098***	-0.068***
	(0.021)	(0.016)	(0.019)
- Natural Sciences/Mathematics	-0.113***	-0.107***	-0.000
	(0.023)	(0.015)	(0.022)
- Medicine/Public Health	0.173***	0.104***	-0.035
	(0.030)	(0.022)	(0.028)
- Arts/Athletics	-0.314***	-0.295***	-0.008
	(0.020)	(0.016)	(0.019)
R-squared	0.177	0.211	0.014
Panel B: No Major Controls			
Female	-0.119***	-0.194***	-0.033**
	(0.012)	(0.010)	(0.012)
Imputed CSAT	-0.089***	-0.070***	-0.019***
	(0.004)	(0.004)	(0.004)
Age	0.076***	0.074***	-0.008
	(0.010)	(0.010)	(0.009)
Age-squared	-0.001***	-0.001***	0.000
	(0.000)	(0.000)	(0.000)
Married	0.106***	0.106***	-0.021
	(0.016)	(0.010)	(0.015)
R-squared	0.132	0.166	9,724

Notes: OLS regression model. Dummies for entrance years, survey years, and residence fixed effects are included. Other controls include test scores, 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 A.6. High School Track: Mathematics/Natural Sciences

Dependent var.	Log monthly earnings (1)	Log monthly earnings (2)	Diff: log monthly earning (3)
Sample	Employed, Initial survey	Employed, Follow-up survey	Employed, Both surveys
No. of observations	14,109	10,974	10,961
Panel A: Major Controls			
Female	-0.030*	-0.128***	-0.064***
	(0.012)	(0.010)	(0.012)
Imputed CSAT	0.069***	0.063***	-0.006
	(0.004)	(0.004)	(0.004)
Age	0.089***	0.068***	-0.030*
	(0.014)	(0.010)	(0.013)
Age-squared	-0.001***	-0.001***	0.000
	(0.000)	(0.000)	(0.000)
Married	0.090***	0.066***	-0.045***
	(0.013)	(0.008)	(0.013)
College major			
- Humanities	-0.256***	-0.208***	0.003
	(0.022)	(0.015)	(0.023)
- Social Sciences	-0.063***	-0.087***	-0.024
	(0.014)	(0.011)	(0.014)
- Education	-0.022	-0.107***	-0.078***
	(0.016)	(0.014)	(0.016)
- Natural Sciences/Mathematics	-0.161***	-0.122***	0.041***
	(0.010)	(0.010)	(0.010)
- Medicine/Public Health	0.129***	0.081***	-0.008
	(0.016)	(0.017)	(0.016)
- Arts/Athletics	-0.267***	-0.288***	0.019
	(0.020)	(0.017)	(0.021)
R-squared	0.163	0.197	0.025
Panel B: No Major Controls			
Female	-0.057***	-0.168***	-0.067***
	(0.012)	(0.010)	(0.012)
Imputed CSAT	0.072***	0.060***	-0.013***
	(0.004)	(0.004)	(0.004)
Age	0.095***	0.067***	-0.034**
	(0.014)	(0.011)	(0.013)
Age-squared	-0.001***	-0.001***	0.000
	(0.000)	(0.000)	(0.000)
Married	0.097***	0.074***	-0.046***
	(0.014)	(0.009)	(0.013)
R-squared	0.123	0.155	0.020

Notes: OLS regression model. Dummies for entrance years, survey years, and residence fixed effects are included. Other controls include test scores, 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.