Title

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Author

Bleemer, Zachary

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HOW HELPFUL ARE AVERAGE WAGE-BY-MAJOR STATISTICS IN CHOOSING A FIELD OF STUDY?

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Zachary Bleemer
Princeton University

ABSTRACT
Average-wage-by-major statistics have become widely available to students interested in the economic ramifications of their college major choice. However, earning a major with higher average wages does not necessarily lead individual students to higher-paying careers. This essay combines literature review with novel analysis of longitudinal student outcomes to discuss how students use average-wage-by-major statistics and document seven reasons that they may differ, sharply in some cases, from the causal wage effects of major choice. I focus on the ramifications of two-sided non-random selection into college majors, mismeasurement of longitudinal student outcomes, and failures of extrapolation between available statistics and student interests. While large differences in average wages by major are likely to indicate causal ordinal differences between fields, small differences are probably best ignored even by students with strong interest in the economic consequences of their major choices. This essay is adapted from Chapter 6 of *Metrics that Matter: Counting What's Really Important to College Students*.

Keywords: Higher education, college majors, economic mobility

Learning What to Be

In 2015, Georgetown University's Center on Education and the Workforce (CEW) published a major report estimating "the economic benefit of earning an advanced degree by undergraduate major" (Carnevale *et al*, 2015). Analyzing responses to the Census Bureau's massive annual American Community Survey, the report found that employed college graduates who had earned engineering degrees—especially metallurgical and mining engineering—had average annual earnings more than double those of the college majors with the lowest annual average earnings, including early childhood and elementary education.

These gaps in annual wages seemed to persist throughout employees' careers; the authors calculate that "the top-paying college majors earn $3.4 million more than the lowest-paying majors over a lifetime".

* Bleemer: bleemer@princeton.edu. This essay has substantially benefitted from conversations with the other authors of *Metrics that Matter*: Mukul Kumar, Aashish Mehta, Christopher Muellerleile, and Christopher Newfield. A shorter version was published in the Chronicle of Higher Education under the title "Students Shouldn't Always Choose Higher-Paying Majors." All remaining errors are my own.

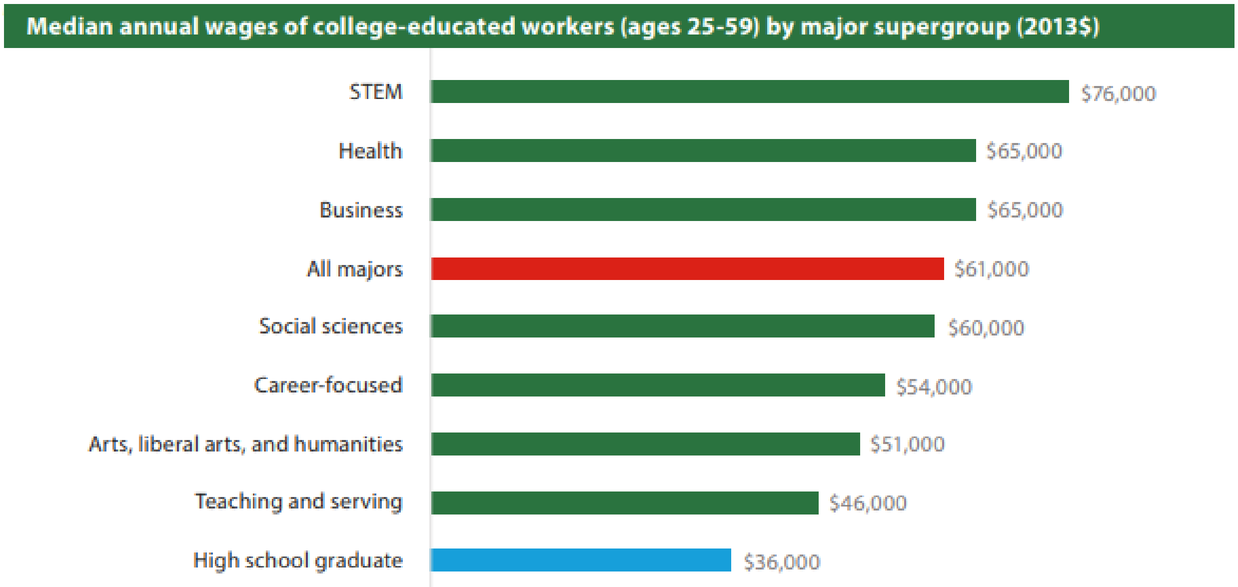

Figure 1: The second figure (1.2) in "The Economic Value of College Majors", a report of Georgetown University's Center on Education and the Workforce

That difference in earnings is even larger than the gap between the average earnings of college graduates and non-graduates, suggesting that students' major choice could be even more impactful on their future employment than the choice to go to college in the first place.

Figure 1 summarizes the main findings of the CEW report. It shows that full-time mid-career American workers with Bachelor's degrees in Science, Technology, Engineering, and Mathematics (STEM) fields had average incomes of $76,000 per year in the early 2010s, more than double the average incomes of high school graduates who never attended college.[1] This is far higher than the average income of college graduates as a whole, which was $61,000. While college graduates with majors in business or health-oriented fields like pharmacy and nursing also earned above-average wages, those with "career-focused" majors like agriculture and communications as well as students with degrees in art and the humanities earned below-average wages, even including students who ended up earning graduate degrees in different fields after graduating college (who are included by their undergraduate major). Graduates with majors in "teaching and serving" fields earned the lowest average salaries, with average annual incomes of $46,000, 40 percent lower than the average wages of STEM majors.

The stated motivation for publishing the average wages earned by workers with different college majors is to help college students (and their families) make decisions about their own field of study. In the words of Andrew Carnevale, the main author of the Georgetown report: "We don't want to take away Shakespeare. We're just talking about helping people make good decisions" (Cohen, 2016). The *New York Times* 'Your Money' columnist Ron Lieber is even more explicit:

> In my ideal world, every parent and potential student would be able to search program by program, school by school, to see who dropped out, who finished with how much debt, how much progress they were making on repaying the debt and how much the graduates from each program earned years later, on average. Full transparency. (Lieber, 2017)

Many politicians and university administrators agree. The agencies that manage the major public university systems of California and Texas have built interactive websites that allow prospective and current students to see average postgraduate wages by major for each of their campuses.[2] The American Institutes for Research created a new research group, *College Matters*, to exclusively produce wage-by-major reports and online tools for universities; Colorado, Minnesota, Tennessee, and Virginia were among the states that hired *College Matters* to estimate and publicize wage-by-major statistics for their public university systems.[3] The commissioner of the Minnesota Office of Higher Education explained: "As the cost of higher education increases, so does the pressure on students to choose a major that will lead to a good-paying job. This website offers data-based trends specific to Minnesota that can help students and families make informed decisions" (AIR, 2016).

As a testament to the political potency of their reports, the president of *College Matters* left his position in early 2018 following US Senate confirmation to join the Trump administration as Director of the Department of Education's Institute of Education Sciences and continue the Obama administration's policy of expanding public access to wage-by-major statistics for most colleges and universities.[4]

However, wage-by-major statistics are challenging to interpret from the perspective of undergraduate students as they choose a major. Take, for example, the fact that Anthropology majors earn lower median wages than History majors by about 10 percent ($5,000), according to the CEW report. One interpretation of this difference would suggest that an education in History increases a student's labor market value, enabling them to earn higher wages when they seek employment after graduation. According to this interpretation, if a student intending to major in Anthropology decided to switch and major in History instead, she could expect to increase her future earnings by around 10 percent, a meaningful difference that could be enough to convince her to switch fields.

But there are many alternative explanations for the differences in postgraduate wages faced by students with different college majors. Maybe the kind of students who would earn high wages *no matter their major* tend to choose certain majors, making those majors appear higher-earning than they would be as a result of educational quality or skill formation alone. Maybe universities themselves push high-achieving students into those same majors, similarly upwardly biasing those majors' observed wages. Maybe poor data quality systematically biases the observed wages of students in certain majors relative to others. Or maybe different majors simply have differential effects on different students, with students earning higher wages after studying fields that they enjoy rather than those in which others earn high wages.

Each of these alternative explanations challenges the natural inference from wage-by-major statistics that if you or your child or your friend's child switched from a lower-earning major to a higher-earning major, then that student's expected future earnings would increase. But before we turn to a more detailed discussion of the challenges of interpreting wage-by-major statistics, let's take a look at how those statistics actually change students' college major decisions.

Children Will Listen

In a seminal 2010 study, Matthew Wiswall and Basit Zafar (2015a) examine the impact of average wage by major statistics on the educational choices of college students. The economists were interested in how students' beliefs—about the average expected wages of their peers by major, their own expected wages in those majors, and their likelihood of pursuing each major—were changed when they were presented with statistics like those currently being rolled out across the United States. Do students care about average wage statistics when they're choosing what to study in college?

To answer this question, Wiswall and Zafar provided a detailed survey to 500 paid undergraduate participants at New York University, collecting information about students' beliefs about average postgraduate wages by major as well as the students' expectations about what their own postgraduate wages *would be* if they earned each majors. Then the students were provided actual average wage statistics for male and female workers by major. Re-eliciting students' beliefs about their own future wages and their likely major choices, the economists could estimate how wage-by-major statistics changed students' expectations about their own futures.

Wiswall and Zafar begin by showing that NYU students performed poorly in guessing average postgraduate wages by major. Students' average guess about the average wage for a given major was wrong by about 40 percent. Students' errors were also systematically related to certain fields of study; on average, the students overestimated postgraduate wages for business and humanities majors while underestimating wages for engineering majors.

After being provided objective information by the researchers, some students drastically updated their expectations of their own future earnings in different majors, and those students also became more likely to choose majors that they thought would lead to higher earnings. For every 1 percent of additional annual income that a freshman or sophomore thought they could earn if they majored in a certain field, that student's expected likelihood of majoring in that field increased by about 2.6 percent. The researchers conclude, perhaps unsurprisingly, that "beliefs about future relative self-earnings are strongly associated with beliefs about future relative major choices: individuals appear to select into majors that they believe will provide them with the highest earnings" (813). As a result, students who participated in the information experiment reported being 4 percentage points less likely to earn a degree in the Humanities and 2.5 percentage points more likely to earn degrees in engineering and computer science, on average.[5]

Interestingly, Wiswall and Zafar found that students were surprisingly resistant to using the provided average wage-by-major statistics—which reported national averages across all working ages—when they updated their beliefs about their own future incomes.[6] Consider a freshman male student planning on being a business major and expecting to earn an $80,000 annual wage a few years after graduating, and say that he thinks that if he switched to being an engineering major, he would earn $75,000 instead. Let's assume that the student had a roughly accurate perception of the earnings of business majors but thought that engineering majors earned 20 percent less than their actual average. After receiving accurate information about average engineering wages, how much should we expect the student revise his original guess about how much *he* would earn if he were an engineering major? The researchers find that his revision is small: on average, he would upwardly-revise his estimate by just 1.6 percent, to $76,200. Despite his large underestimation of engineering majors' average wages, being provided that information would only makes him about 4 percent more likely to expect to major in engineering. As I'll discuss in detail in the next section, students are right to treat this information with caution.

Wiswall and Zafar ran their experiment a few years before organizations across the country began to popularize wage-by-major information. In the 'treatment' phase of their study, they provided their survey respondents with a simple table showing average wages by discipline for a few major categories, along with unemployment rates and a few other statistics (Wiswall and Zafar, 2015b). But in the past 10 years, significant improvements in visualization, quality, and specificity have likely increased the degree to which students pay attention to, and choose their fields of study using, wage by major statistics.

Figure 2 shows the online "Alumni at Work" tool built by the University of California to display the average wages of its alumni. For any campus, graduation year, and major, students can see the 25th, 50th, and 75th percentiles of wages of alumni in that group 2, 5, and 10 years after graduating college.

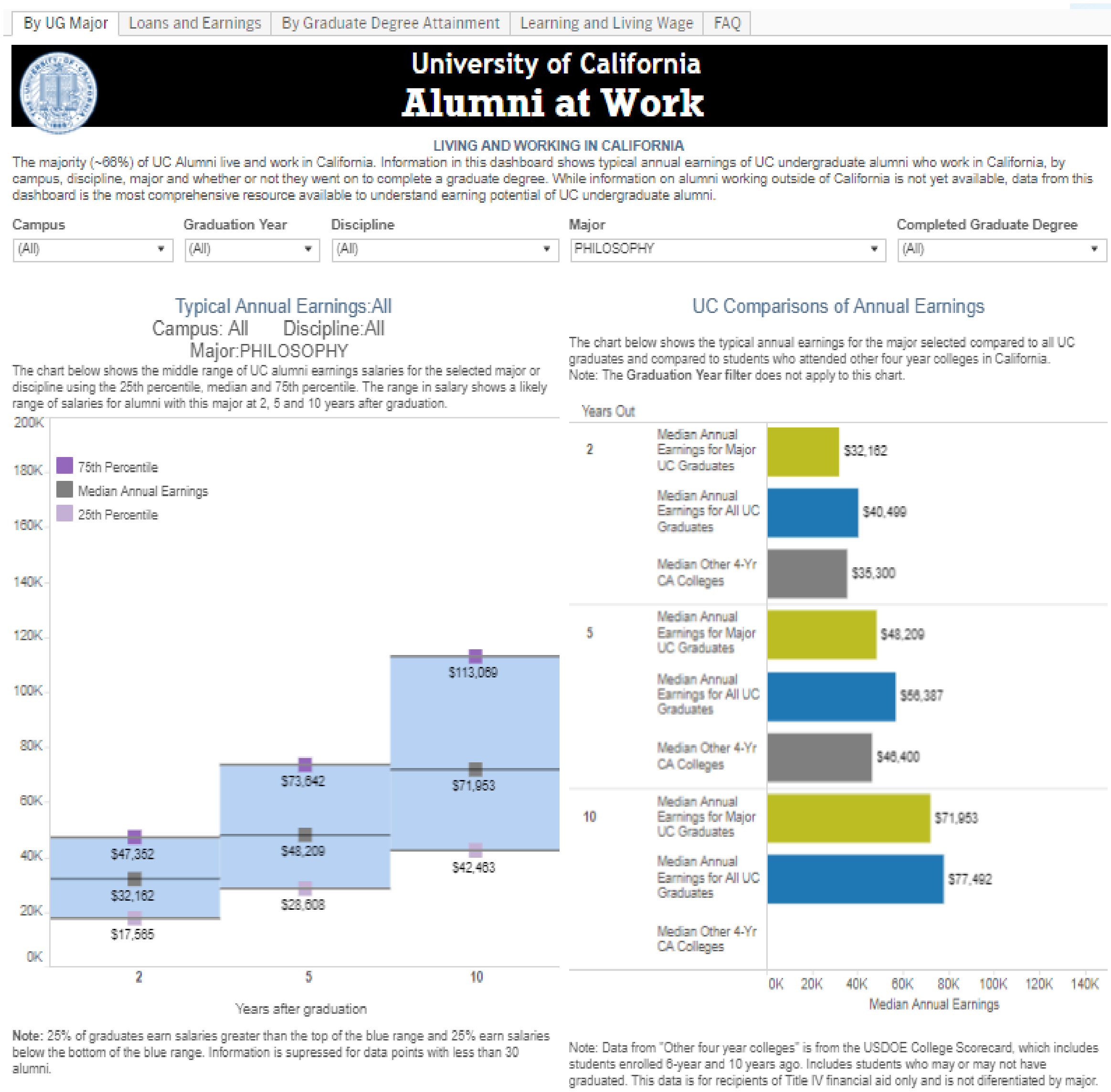

Figure 2: The University of California's Postgraduate Earnings Dashboard, showing median wages for UC graduates working in California by major and number of years after graduation.

Students can compare those wages across campuses and majors. Additional tabs show the distribution of industries in which UC alumni work, as well as a student debt calculator that shows the average amount of time it takes alumni to pay back their loans, all displayed by campus and major. With tools like "Alumni at Work" providing somewhat-`personalized' expected wage statistics for each student, students could more extensively use these statistics to form their own expected wage beliefs across fields of study. Wiswall and Zafar's study implies that these adjustments, in turn, will heavily contribute to students' choice of college major.

Careful the Things You Say

It is a maxim among many economists that, as Wiswall and Zafar (2015a) phrase it in the discussion section of their study, "providing students with accurate information can only be welfare enhancing". However, wage-by-major statistics present inferential challenges that could easily lead many people to distorted beliefs about the likelihood with which certain major choices would lead them to high-earning futures. Some majors might have higher graduate earnings than others because of the skills and experiences gained by choosing those majors, but the differences might also arise for a number of other reasons. This section discusses three varieties of such alternative explanations—and seven alternatives overall—with some posing larger challenges than others to students' successful use of wage-by-major statistics as they choose their field of study:

1. "Selection" concerns, referring to prior differences in the kind of students who select each major in the first place, challenge whether the differences in postgraduate wages are *because* students chose one major or another.
2. "Measurement" concerns deal with the nuts and bolts of how wage-by-major averages are actually calculated, challenging whether these statistics are actually measuring what they claim to be measuring.
3. Finally, "Extrapolation" concerns challenge whether the statistics, even if perfectly-calculated, are relevant to any specific student choosing a major in the first place.

The following discusses a few cases of each.

Selection I: University Requirements

Many universities explicitly limit which students can choose certain fields of study. Some of these limits are implemented as early as students' college application: for example, many universities require that students separately apply to engineering programs, which often require higher standardized test scores or additional high school science training compared to other programs. Other limits are imposed after students have completed one or more semesters of college courses. Freshman students may have to earn certain grades in introductory courses in order to be permitted to major in cognitive science or economics; sophomores might have to apply to a university's business school, perhaps on the basis of their on-campus leadership activities, to earn a degree in business administration. Universities may also impose soft requirements intended to push students out of certain majors: professors may try to discourage students out of engineering majors by assigning low average grades in engineering courses, or by prohibiting chemistry course enrollment for students who didn't complete advanced high school coursework.

Consider, for example, a university where students are required to earn a B+ average in four introductory courses in order to declare a major in computer science. A number of student characteristics could explain why a given student—let's call her Jane—is able to successfully meet this requirement while some of her peers cannot. Jane might have above-average innate academic or mathematic ability relative to her peers, enabling her strong performance in difficult introductory courses. She might have substantial self-motivation to work hard in the course or be unusually willing to spend long hours studying to give her a comparative advantage on exams. If she doesn't have to work a job or satisfy family responsibilities, she may have more time available to dedicate to the course than her peers. If she attended a high school that offered advanced computer science courses or can afford a private tutor to help her along, then she might already know a great deal of the material taught in the introductory courses, giving her a leg up.[7]

No matter which of these reasons explains how Jane is able to satisfy the requirements and major in computer science, that same reason might explain how she ends up earning high wages in the job market, irrespective of whether she had earned the computer science major. Workers with above-average innate abilities or high self-motivation will likely earn high wages no matter their college major. The kind of student who received a high-quality high school education, or who doesn't have to work while in college, or who can afford a tutor, is often a student from a high-income family, providing her with the expectation of high wages and a parental network that could help her find high-wage employment. If the computer science major at this university didn't turn students away, its average postgraduate wages would likely be much lower, because the wages of its stellar students would have to be averaged out with the lower-ability, lower-income students subsequently earning computer science majors but (perhaps) still leaving the university with lower-earning labor market opportunities.

While not all universities restrict entry to any specific major, the majors most likely to be restricted at any university are also those with high average postgraduate wages (Bleemer and Mehta, 2021). STEM fields in particular are well-known to discourage struggling students from earning those majors; as early as the 1970s, a nationally representative survey of third-year college students showed that 42 percent of students who entered college intending to study the natural sciences had switched out of that discipline, compared to just 23-24 percent of students in every other discipline (calculations from Arcidiacono (2004), Table 12). The difference between these fields suggests that as many as 15-20 percent of students who intended to major in the sciences had been pushed out of their preferred field of study, with the rest switching to another major because of changed preferences (e.g. see Stinebrickner and Stinebrickner, 2013).

Interestingly, despite this increased likelihood of being pushed into a different field of study among students initially intending to study STEM, those students are not more likely to drop out of college completely (Arcidiacono, 2004). As a result, the large number of students pushed out of STEM into other disciplines are likely to bias those other disciplines' average wage statistics as well. Since university major requirements tend to admit students with strong labor market prospects into STEM majors, the students pushed out of those majors are likely to have somewhat poorer prospects, possibly dragging down the average wages of less-restrictive majors.

University major requirements may also exacerbate pre-existing income inequalities by effectively restricting "high-earning" majors to students from high-income families that could afford higher-quality secondary education, tutoring services, and other educational advantages. But the requirements also upwardly-bias average earning statistics in the first place. Without an estimate of the nationwide prevalence and stringency of university major requirement policies, it is difficult to estimate the degree to which they contribute to the high average wages among graduates with majors in computer science, economics, engineering, and other frequently restricted majors, but the selection effect may be substantial.

Selection II: Student Employment Preferences

Let's go back to Jane, our hypothetical student more likely to earn a high-earning major than many of her peers. The last section discussed the possibility that Jane's university might ameliorate her high-earning major selection because of Jane's ability to perform well in difficult courses, but Jane might not need the university's prodding to select such a major. Instead, Jane might just be the kind of student—the kind of adult, really—who has a strong preference for a high-earning job in her future. If Jane believes that certain majors are more likely to lead her to a high-paying job than others—perhaps because those majors are more restricted by the university, or maybe because she's already seen statistics showing that students earning those majors have higher average postgraduate earnings—she might choose to earn those majors herself. This could cause a positive feedback loop, with previously-high-earning majors becoming *even more* high-earning because ambitious wage-driven students choose to study them.

In a follow-up to their study discussed above, economists Matt Wiswall and Basit Zafar studied this question in their cohort of NYU students (Wiswall and Zafar, 2016). They surveyed the students and collected detailed beliefs about the benefits and costs of jobs that students could earn with majors in various fields: which fields led students to high-paying jobs, or jobs where workers were rarely fired, or jobs with greater time-flexibility. They also asked about students' own preferences over these various job attributes and found a lot of variation across students: some students wanted high-paying jobs, but others (especially women) placed far greater value on flexibility and a low probability of being fired.

Wiswall and Zafar found that the stated employment preferences on students' surveys were highly correlated with the actual jobs that the students were working a few years after they graduated college: students who wanted higher wages when they were in college ended up in jobs with higher wages.[8] More interestingly, students' employment preferences were important in their major selection. Students told the researchers that they believed that Business majors would lead them to higher-paying jobs (say, in finance), while majors in the Humanities would lead students to jobs with greater flexibility and stability (in education or public administration). As a result, students sorted themselves across majors in accordance with their beliefs; those who wanted high wages majored in Business and ended up with high wages, while those who wanted flexibility majored in the Humanities and got the flexibility they desired.

So, did majoring in Business actually increase students' postgraduate wages, and by how much? We know that Business majors have higher average wages than Humanities majors, but is this *because* the students studied Business, or instead partly because the kind of student who wants high wages will choose to study Business, even if that student would have been able to obtain a high-earning job if they had majored in the Humanities? To put the question another way: if Jane doesn't want to work as a manager in a large firm, then choosing to study Business may not meaningfully increase her future wages. The primary reason Business majors earn so much money may be that they chose to study Business *because* they wanted to be corporate managers (and earn corporate managers' salaries), not because Business substantially increased their employability as managers at large firms.

Wiswall and Zafar don't estimate the degree to which student employment preferences distort wage-by-major statistics, but this is a second reason to take care in making predictions about a given student's wage (or how their wages could change in different scenarios) using average wage statistics.

Selection III: Student Ability

According to a recent report by *Business Insider*, Economics is the most popular major at six of the seven private Ivy League Universities (with only Finance more popular at the seventh, The University of Pennsylvania). Political Science or Government is the next-most-popular major at five of those seven schools (Jackson, 2018). But neither Economics nor Political Science is anywhere close to the most popular undergraduate major across the country. The CEW Report shows that, among college-educated workers in the US, the two majors are ranked 15th and 16th, behind professional degrees like Business and Nursing as well as liberal arts degrees like Psychology – the country's most popular major – as well as English and Biology (Carnevale *et al*, 2015).

The CEW Report also shows that Economics and Political Science are the social science majors with the highest average postgraduate wages, with economics majors averaging 50% higher earnings than workers with majors in sociology or anthropology. One factor contributing to these high wages is the high ability levels of the students across the country who choose those majors, since those students disproportionately attend Ivy League and other elite universities. These majors likely have particularly high returns for top students—Harvard students, for example, are substantially overrepresented in the senior financial and governmental positions that the University's Economics and Political Science degrees would aptly prepare them for—but that doesn't necessarily mean that switching into those majors at other universities will raise students' expected wages.

This "ability sorting," with students of different measurable ability levels (as measured by high school grades or exams like the SAT) tending to choose different majors, presents an additional challenge in interpreting wage-by-major statistics. One key dimension of "ability sorting," identified by economist Peter Arcidiacono in his detailed 2004 study of the subject, is students' math ability (Arcidiacono 2004). If Jane is a strong math student, then she will not only be more capable of obtaining a high-earning major as a result of the university selection policies discussed above, but she is also likely to attend a more-selective university and may have a preference for studying majors that let her use her mathematical abilities. When Jane ends up earning high post-graduate wages, those wages might be the result of the selective university she attended or a direct result of her mathematical prowess as much as they are a result of Jane's choice of major.

Estimating a statistical model making strong assumptions about the behavior of the students in his database, Arcidiacono estimates that 32-year-olds with STEM majors in the 1980s earned about 39 percent more than students without college degrees, but that about half of the wage difference (19 percentage points) could be explained by the combination of the three varieties of selection described in the last few subsections: university requirements, student preferences, and student abilities. We will return at the end of this paper to a more robust strategy to generate selection-free estimates of the relative earnings made available from obtaining different majors, but Arcidiacono's estimate gives a sense of the magnitude of the effect of selection in driving differences in earnings across college majors.

Measurement I: Data Quality

Kumar (2018) discussed limitations of the university wage statistics published by the compensation transparency firm PayScale. PayScale's wage data are self-reported by a self-selected sample of American employees. The data may be modified in unknown ways prior to statistical estimation. The sample size of the data in each category—the number of people who attended a given school, majored in a given field, and reported their earnings to PayScale—is often small, leading to noisy estimates of average wages. While each of these problems is specific to PayScale, each also represents the many ways in which low data quality challenges the interpretation of wage-by-major statistics.

Consider, for example, the "UC Alumni at Work" dashboard that provides wage-by-major statistics for University of California campuses (UC, 2019). First, the available data only include workers (1) in the state of California who (2) are not self-employed and (3) do not work for the federal government. This only includes about 50% of UC graduates 10 years after graduation, leaving out a large number of likely-high-paid workers who own small businesses or have emigrated out of the state. Second, the data are "annualized" prior to being averaged, which means UC inflates graduates' observed wages when earnings are not reported in all four quarters of a given year. This process may benefit some majors' averages (like the Arts, where many jobs do not pay wages during the summer but will be 'annualized' to higher pay) at the expense of others. Finally, sample sizes are not listed, but the fact that many listed majors have 0 students (such that clicking on them causes the chart's disappearance) suggests that small samples may plague available estimates.

Some wage-by-major estimates are better than others. The CEW estimates, for example, are generated from a dataset that does not censor any workers and is large enough to remove most statistical noise, but cannot estimate averages for any specific university (since workers' *alma maters* are not in the data). The current effort to add wage-by-major statistics to the federal College Scorecard would use IRS tax records that exclude low-wage workers (who do not file returns). While each of these disparities may have only a small effect on the available statistics, all together they could substantially bias available estimates.

Measurement II: Selective Measurement

In addition to limitations in organizations' ability to measure the wages of a representative group of college graduates, there are also fundamental limitations in using college major and income data to properly measure wage-by-major outcomes in a way that is useful to students choosing between majors.

First, most data used to construct wage-by-major statistics only include individuals who graduate college, but many students choose a major but then drop out before completing their degrees. If some major choices make students more likely than others to drop out of college, then the effect of choosing those majors may not be clear from statistics that only include students who complete the major. For example, in their in-depth study of students at Berea College, a small no-tuition liberal arts college in Kentucky, economists Ralph and Todd Stinebrickner (2014) have shown that students are more likely to drop out if they enter that school intending to study professional fields like education or agriculture.

As a result, freshmen looking at the average wages of Berea graduates should keep in mind that people who choose to study agriculture are likely earning even lower average wages than wage-by-major statistics would suggest, since the statistics would omit non-graduate agriculture majors who will likely earn lower mid-career wages than their degree-earning peers. Estimating wages by *selected* major instead of earned major could ameliorate this gap, which is an idea we'll return to in a few pages.

Similarly, income data usually only include the reported incomes of currently employed workers, excluding the unemployed (who would have wages if they could find a job), homekeepers (who would have wages if they worked for a firm instead of their household), and workers who earn unreported "off-the-book" wages. As a result, majors that lead graduates to low-paying jobs (like the Arts) will be penalized relative to majors that tend to lead graduates to unemployment (like Linguistics, the major with the highest age-40 unemployment rate), since the latter unemployed students are excluded from the estimating sample (Bleemer, 2018).

Finally, because of cost-of-living differences in different geographic regions, wage data may not correspond to college graduates' quality of life. Psychology is the most popular major among workers in about half of US states, and most of the 10 states with the highest proportion of Psychology majors in their workforce are in the Northeast, a region with relatively high prices for food, housing, and energy. Most of the 10 states with the highest proportion of Biology majors in their workforce, on the other hand, are in the Southeast, where prices are much lower. Some proportion of these price differences can likely be explained by differences in quality or "willingness-to-pay"—in return for higher prices, residents of the Northeast may get higher-quality products or better living arrangements—but the rest reflects a real difference in cost between the two regions (See Moretti, 2013). As a result, Biology majors may be better off (relative to Psychology majors) than wage-by-major statistics suggest since they tend to work in places where they can buy more for each dollar than a Psychology major could.[9]

These issues may look negligible, but like problems with data quality, they can add up to substantial biases in the estimates of wage-by-major statistics. None of these problems would be fixed by improving the sample size or coverage of the data underlying current wage-by-major statistics; instead, they would require additional data collection (like the intended majors of college drop-outs), imputation (of off-the-book wages), and adjustment (correcting for cost-of-living differences) in order to produce more helpful statistics for young college students.

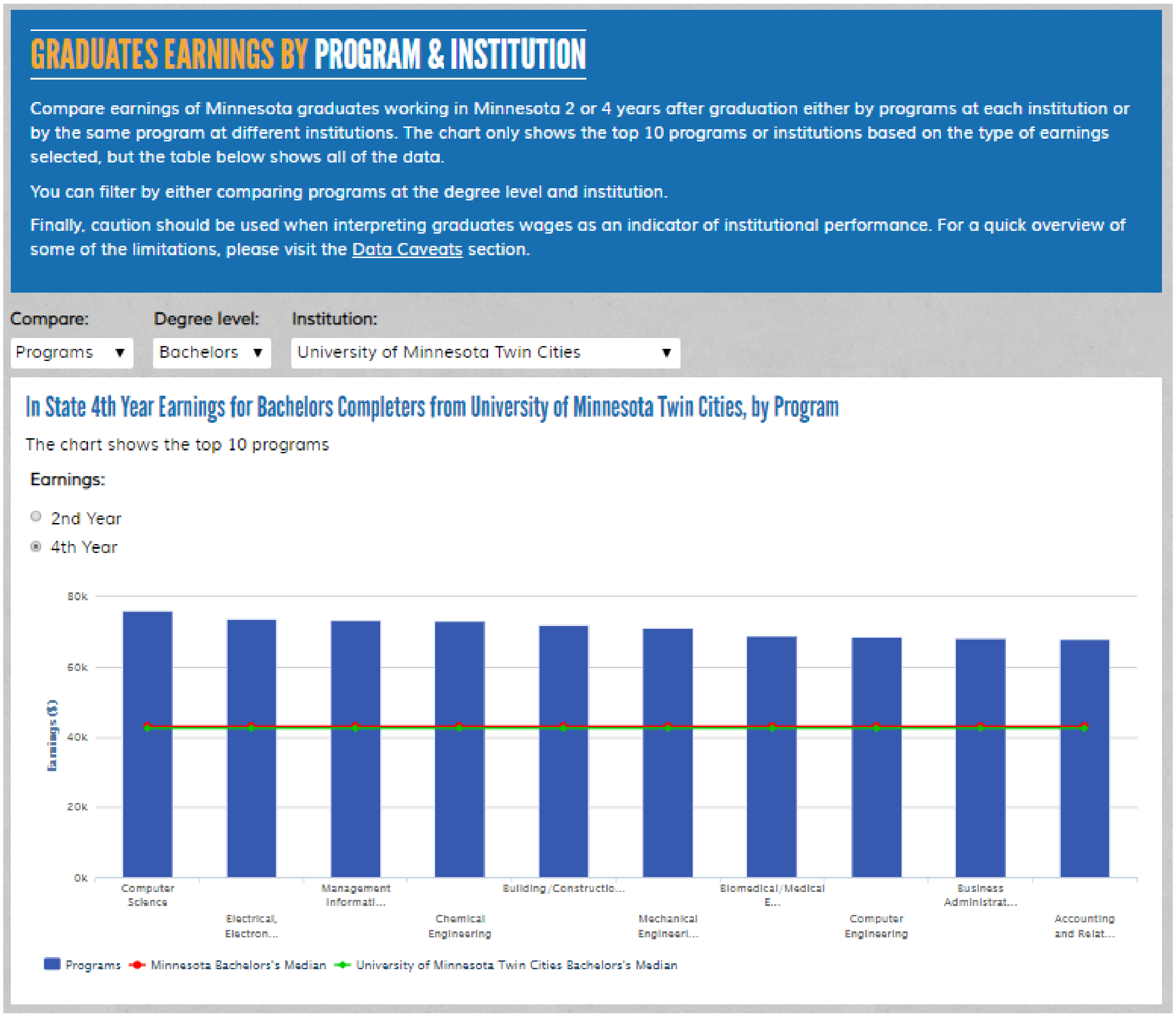

Figure 3: Minnesota's 2018 Postgraduate Earnings Dashboard, showing average wages for recent graduates of Minnesota universities by major.

Extrapolation I: Short-Run Wages

There is a tension in producing wage-by-major statistics between contemporary relevance and early-career wage instability. Consider the wage-by-major statistics available on the website of the Minnesota Office of Higher Education, which were estimated by *College Matters* using wage data collected by Minnesota's unemployment insurance bureau.[10] The tool links a single year of earnings data to the social security numbers of graduates of all Minnesota colleges and universities 2 and 4 years prior. It shows, for example, that Construction Management is in the top 12 most-lucrative majors at the University of Minnesota Twin Cities (two years after graduation), while Neurobiology and Biochemistry are in the bottom 12 most-lucrative majors. Indeed, employed students with Construction Management degrees earn almost four times the average wage of Neurobiology majors two years after graduation.

How should this evidence be interpreted? One explanation is that Construction Management has led students to a far higher-paying career trajectory than Biochemistry, which should incentivize students to select the former major. But a more likely explanation is that many Biochemistry majors attend graduate school after completing their undergraduate degree, earning low wages while preparing for more lucrative future careers. Indeed, the CEW report shows that more than two-thirds of Biochemistry and Neuroscience majors in the workforce have earned graduate degrees, and that Biochemistry majors have average mid-career earnings of $97,000, far higher than the average wages of graduates with degrees in 'Miscellaneous Industrial Arts' like Construction Management.

Of course, the statistics presented by Minnesota and CEW all share the limitations already discussed above, and it is not *a priori* obvious which source provides more-useful information to freshmen selecting their own majors. Nevertheless, wages estimated two or four years after graduation are likely to be additionally biased by graduate school attendance, early-career employment changes, and all of the frictions that delay young peoples' entry into the labor market.

In their seminal study of universities' role in intergenerational mobility, economist Raj Chetty and his coauthors study patterns in wages across universities over fourteen years following students' graduation using detailed IRS tax records (Chetty *et al,* 2017, Figure II). The authors find that as late as age 26, when many students are four years out of college, graduates of elite Ivy League universities have earnings indistinguishable from those of graduates from any other four-year university. Their earnings diverge between ages 27 and 32, such that 32-year-old Ivy League graduates are far higher-earning than graduates of other universities at the same age. The researchers argue that wage comparisons across universities stabilize between ages 32 and 36, but that estimating wages at earlier ages can lead to large miscalculations in the expected wage returns of various universities.

The best available evidence on the stabilization of average wages by major and by age similarly suggests that by graduates' early 30s, the wage-by-major ranking has roughly stabilized. Analysis of University of California records show that the highest-earning major at UC Berkeley 10 years after graduation is Computer Science, with Computer Science majors earning two-and-a-half times the average wage of the lowest-earning majors in the Arts. What was the highest-earning major 30 years after graduation, for graduates of UC Berkeley from the early 1970s? Computer Science, with median earnings just over two-and-a-half the average wage of Art majors. How about 40 years after, for graduates from the late 1960s?

It's Computer Science again, with median earnings almost exactly two-and-a-half times the average wage of Art majors. The rankings look similar all the way down; Business and Economics are high, Nutrition and Agriculture are low, and the Social Sciences and Natural Sciences are in between.[11]

While wage-by-major statistics using age-32 wage data are highly correlated with similar statistics estimated at older ages, they still have many limitations (as we've seen above), and those limitations are compounded for statistics using wages observed for workers younger than 32. Wages estimated just a few years after college education can grossly mislead freshman seeking majors that will lead them toward highly remunerative employment.

Extrapolation II: Match Quality and Preferences

Some wage-by-major statistics might be too outdated to be relevant, while others might rely on wages from too early in college graduates' careers. But they could also not be relevant because any given student has a lot of differences from the 'average' student used to calculate wage-by-major statistics. After all, which major will lead a *specific* student to high postgraduate wages might depend a lot on characteristics of that student, like their mathematical or writing abilities, their preferences for certain subject matter, their study habits, or even their dreams about what they want for themselves in the future. How much can these students learn from what happens to the median employee?

This question brings us to a recent academic study that successfully overcomes many of the challenges described above. The study estimates differences in wages across fields that are adjusted for all of the selection concerns noted above (1, 2, and 3), comparing near-identical students who are almost-randomly assigned different majors and comparing their wages years later, irrespective of their (or their universities') preferences. The wage data are high-quality and cover all workers in the entire country (4). The study even includes students who had selected a major but then dropped out before finishing college (5). And the study focuses on students who are torn between two fields, showing what would happen if they were to select one or the other. This is a group of students whose outcomes are likely of great interest to freshmen trying to decide between two majors that they feel conflicted about.

The study also has limitations. It focuses on wages at age 30 or before, which may not accurately reflect differences in wages across the students' careers. Also, the study was conducted on Norwegian university students, and Norway's universities and labor markets are somewhat different from those in the United States, calling into question its relevance for American university students.

Nevertheless, the statistics estimated by economists Lars Kirkeboen, Edwin Leuven, and Magne Mogstad offer important insight into the sensibility of wage-by-major statistics in the first place, as well as into students' major decisions directly.

Their setup is deceptively simple. Unlike the United States, Norway has a single centralized office that administers the whole country's university admissions. Students take a placement exam and then submit

Preferred Major	Actual Major			
	Humanities	Social Science	Science	Engineering
Humanities	-	21.4*	5.0	-38.5**
		(11.0)	(11.9)	(14.7)
Social Science	18.7**	-	55.5**	-55.4**
	(6.7)		(21.5)	(20.6)
Science	53.7**	69.6**	-	-2.2
	(18.4)	(22.4)		(14.6)
Engineering	59.8	-5.5	52.4**	-
	(50.6)	(58.2)	(21.0)	

*Table 1: Estimated change in earnings ($'000s) if a student had earned the preferred major, compared to their earnings in their actual major. Estimates for late-20s earnings in Norway from Kirkeboen, Leuven, and Mogstad (2016). Asterisks represent statistical significance rejecting a 0 null hypothesis: * 10%, ** 5%.*

a ranked list of university-major pairs that they would like to attend. For example, they might list University of Oslo - Economics first, University of Bergen - Economics second, University of Oslo - Philosophy third, and so on.

An algorithm, not application-readers, determines which students are admitted to which programs. Students with the top exam score are admitted to their first-choice school and major. Then students with the second-best score are admitted. As the algorithm goes down the list, eventually some of the more-popular university-major pairs will fill up; unassigned students who wanted to enroll in those programs are assigned to their second-choice program. The algorithm continues down the list of exam scores, and students are forced into lower and lower preferences as all of their preferred programs fill up. Once all of the program slots or all of the students are exhausted, the admissions process is complete, and students are notified of the (single) program that they will be attending the following year.

The economists compared the postgraduate wages of students who *just barely* made it into their preferred program, taking the last available slots before the program filled up, to those of students who just barely *didn't* make the cut, and had to attend another program instead. For each pair of majors, then, you could estimate two effects: the effect of getting Major 1 compared to people who had to study Major 2 instead, and the opposite effect of getting Major 2 compared to people who had to study Major 1 instead. Because these students were all near the cutoffs between majors, there was no substantial selection between the two: universities couldn't choose which students got which major, students couldn't choose what to major in, and the students who barely made it were very similar on average to those who didn't (the only difference likely being a single point on the placement exam).

You can see a subset of the scholars' findings in Table 1. The units are in thousands of dollars in annual earnings, and each estimate has a standard error in parentheses below it. To help interpret the coefficients in the table, consider a student who majored in Humanities, but would have (slightly) preferred to major in the Social Sciences. If that student had been able to earn a Social Science degree, the first coefficient in the first column of Table 1 shows that the student would have earned an average of $18,700 more per year than they would with their Humanities degree around age 30.

Interestingly, Table 1 shows that switching out of a Social Science degree into a Humanities degree would *also* increase that student's early-career wages, by $21,400. It appears that the wages of Humanities and Social Sciences majors importantly depend on students' preferences; whichever the student prefers, choosing that major will lead them to higher wages. Kirkeboen, Leuven, and Mogstad call this "comparative advantage": students' preferences align with their strengths, and following their preferences can improve their future earnings.[12]

Of course, comparative advantage only goes so far. The last column of Table 1 shows that students considering Engineering as a potential major would be better off majoring in Engineering, whether or not they prefer Humanities or Social Science, in terms of their average future wages. Nevertheless, these statistics simultaneously call into question the purpose of average wage-by-major statistics and point towards a potential (and far more useful) replacement.

Studying students 'on the fence' between two majors, and measuring post-graduate wages for students who made one or another choice for different reasons (estimating, say, the average wages of students whose parents pushed them to major in STEM compared to those who felt less pressure and thus majored in something else) could provide an effective alternative to the currently-available wage-by-major statistics in the United States.

Children Will Look to You for Which Way to Turn

Future wages are one of a number of factors relevant to a college student's choice of major. Imagine the ideal tool that a student would want when considering her future wages. She would want to provide information about herself: her abilities, her preferences, her goals. Then she would want to see what has happened to people like her who made a variety of choices. If she was a high-math-ability student choosing between English and Chemistry majors, for example, then she would want to know the average career paths taken by other high-math-ability students who had made one or the other choice, since that information could help her understand what her life would look like if she chose one or the other major.

The student might derive a small amount of insight from Kirkeboen, Leuven, and Mogstad's study, from which she would learn that Norwegian students who chose to major in English over Chemistry were no worse off (in terms of wages) than they would have been if they'd majored in science. While imperfect, that information could meaningfully help inform the student's decision. Wage-by-major statistics as available in the United States, however, would be substantially less helpful. While English majors earn less than Chemistry majors on average, the discrepancy can be explained in a lot of ways: university selection, student selection, data anomalies and mismeasurement, *et cetera*.

Even in the absence of those discrepancies, extrapolating those statistics to the student's own life would be challenging. With these confounders in mind, it's unclear how our student could legitimately integrate the relevant wage-by-major statistic into her decision, let alone choose one major over another as a result.

Of course, the fact that many current and upcoming wage-by-major statistics are largely unhelpful to—and easily mislead—current college students is not in itself a reason to throw those statistics away. On the one hand, the presentation of such estimates contributes to 'human capital' rhetoric around higher education, implicitly teaching students to value future employment and wages above other considerations and may lead students to make suboptimal major decisions. On the other hand, Wiswall and Zafar show that the likely net result of making students aware of wage-by-major statistics is to make them more likely to earn science and engineering degrees, which may or may not be good for the students or everyone else.

But the challenges discussed in this paper concretize the notion that we should do better, and that better is available. With better data, more careful estimation strategies, and clearer exposition of the strengths and weaknesses of available wage-by-major statistics, such statistics could become far more helpful to major-choosing undergraduate students, millions of whom are presently making this important decision with only low-quality information about the long-run employment ramifications of their choice.

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FOOTNOTES

[1] Indeed, the spread of wages across college majors exceeds the wage gap between high school and college graduates, a phenomenon that has been persistently true for at least 80 years in the US (Bleemer and Quincy 2024).

[2] See https://www.universityofcalifornia.edu/infocenter/uc-alumni-work ; https://discoverdata.utsystem.edu/SASVisualAnalyticsViewer/VisualAnalyticsViewer_guest.jsp?reportName=seekUT&reportPath=/Reports/SeekUT

[3] See https://www.air.org/center/college-measures/ ; For examples of state informational websites, see: http://www.mnedtrends.org/Report/compare-graduate-earnings-programs-and-institutions and http://va.edpays.org/Report/compare-graduate-earnings-programs-and-institutions

4 See https://www2.ed.gov/news/staff/bios/schneider.html. As Blagg and Chingos (2016) note, "Policymakers from both parties agree that prospective students need access to better information on quality when deciding whether and where to attend college and what degree program to pursue."

5 Beffy, Fougere, and Maurel (2012) similarly find that French university students are sensitive to expected earnings by field of study.

[6] This mirrors students' surprisingly limited responsiveness to net cost information in choosing whether or not to attend college, and their relatively muted extensive-margin responsiveness to information about the wage returns to college attendance (Zafar and Bleemer, 2018).

[7] Kokkelenberg and Sinha (2010) show that many of these characteristics are typical of STEM students at Binghamton University.

[8] In a survey of British high school students, Boneva and Rauh (2018) show that students with stronger preferences for high wages also tended to be from higher-income families, perhaps availing them to higher-wage employment.

[9] State-level analysis of annual ACS public-use statistics by the author and Yuri Jeon; Ruggles *et al* (2015).

[10] Formerly available from MNEdTrends.org, these data have been moved to https://mn.gov/deed/data/data-tools/graduate-employment-outcomes/.

[11] Calculations by the author using historical UC Berkeley student transcript records (Bleemer 2018) linked to 2000-2017 California wage records from the CA Employment Development Department by the UC Office of the President; see Bleemer (2021).

[12]See Bleemer and Mehta (2022) for another example of comparative advantage, with regard to undergraduate economics majors. In the case study examined in that study, the causal wage value of earning an economics major for students on the academic margin of the major at UC Santa Cruz is approximately equal to what would have been predicted by comparing the average wages earned by economics majors with the average wages earned by recipients of the majors that those students would have earned if they were prohibited from studying economics. This is because the average causal effect is estimated to be somewhat smaller than the average wage statistics would have suggested, but students on the academic margin of the major derived above-average wage returns from being permitted to declare the major, highlighting several challenges in the straightforward interpretation of average-wage-by-major statistics.