Engineering Cooperative Education Participation

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Abstract

Cooperative education (co-op) is a program in which participating students typically alternate between full-time study and paid full-time employment. Choosing to participate in a co-op program usually delays the student's graduation by one year, but may increase the student's job market prospects. This paper estimates the response of co-op participation to the engineering field-specific average wage for recent graduates. We find that a \$10,000 real increase in the average initial wage causes a 5.4 percent decrease in the co-op program participation. In addition, there is heterogeneity in the response by student ability. Though high-ability students are more likely to participate in a co-op program than students of lower ability, we find no evidence that high-ability student's participation choice is influenced by job market conditions. This is consistent with a model where students choose to participate in a co-op program primarily to increase employment prospects after graduation and where high-ability students in engineering face little risk of lower job market prospects due to a worse labor market.

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1. Introduction

A cooperative education (co-op) program is a partnership between an academic institution and firms in which participating students typically alternate between periods of full-time study and paid full-time employment. In engineering, it is most common for a co-op program to involve three non-sequential semesters of paid employment off campus with the same firm. The firm pays the participating students a field-specific fixed rate that is usually set by the university for all participating students. Students may apply for a co-op position once they have completed all the core/introductory engineering courses and selected the engineering field in which they will major. Most institutions do not offer academic credit for employment semesters and do not reduce any requirements for graduation. Thus, choosing to participate in a co-op program usually extends the standard four-year undergraduate degree by one additional year.

Even though it delays graduation by a year, co-op programs are popular in engineering schools with about one quarter of students choosing to participate. Wages during the alternating semesters of employment are in the \$12 to \$20/hour range, depending on the field and university, and provide an important incentive for participation. In addition, Students anticipate that co-op participation will provide them with practical on-the-job engineering experience during the periods of paid full-time employment that may be valued by potential employers and increase their likelihood of finding a good job after graduation. There is evidence that co-op participants are more likely to be employed soon after graduation and have higher initial wages than other engineering graduates (Somers, 1995).

The fraction of students that choose to participate in a co-op differs substantially over time and across fields. Figure 1 illustrates this by plotting the rate of co-op participation from 1989 to 2003 in four selected engineering fields at the seven academic institutions considered in this study. The participation rates for chemical and electrical engineers are much higher than those for civil engineers though they seem to be trending downward during the late 1990s and early 200s while participation rates for civil engineers remain steady. Understanding why co-op participation rates change over time is important to the academic institutions and employers who use co-op programs. Many firms make a large fraction of their hires each year directly from the co-op program, so changes in the number of participating students can influence the labor market for new engineers.

Most important to economists is that participation in a co-op program is an important within-major human capital investment made during college. Documenting the characteristics of students who choose to make this additional human capital investment and analyzing how economic factors influence that choice leads to a better understanding of the link between educational choices and labor market outcomes. In this paper we focus on understanding how engineering co-op program participation responds to field-specific job market conditions and document heterogeneity in this response by students of different ability.

We use data from the Multiple-Institution Database for Investigating Engineering Longitudinal Development (MIDFIELD). This data gives complete transcripts for all students who

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¹ The academic institutions are Clemson, Florida A&M, Florida State, North Carolina State, Purdue, Florida, and Virginia Tech. Students with less than a 2.5 freshman-year GPA are excluded from the figure because academic institutions generally set a minimum GPA requirement for participation in a co-op program. From the data it is clear that while exceptions to the policy are sometimes granted, there is little participation by students with less than a 2.5 freshman-year GPA.

declared a major in one of the engineering fields at the seven academic institutions used in this study: Clemson, Florida A&M, Florida State, North Carolina State, Purdue, Florida, and Virginia Tech. The data identifies which students participate in a co-op program and includes basic demographic information.

We use the field-specific wage for recent graduates as our measure of job market conditions. The wage data is obtained from an annual survey of more than 100,000 engineers conducted by the American Association of Engineering Societies. We find that a \$10,000 real increase in the field-specific average wage for new hires causes a 5.4 percentage point decline in co-op participation. This implies an elasticity of -1.25 which suggests a high degree of student sensitivity to field-specific wage changes. We find that though high-ability students (those with a freshman-year GPA in the top quartile) are more likely to participate in a co-op program, their participation decision is less responsive to changes in the field-specific wage. The co-op participation response is concentrated in lower-ability students.

Our identification of the student co-op participation response to a change in the field-specific wage depends on the assumption that student participation is not constrained by changes to the number of co-op positions available. If, for example, firms reduce the number of co-op positions during periods of slow wage growth, our estimates may be biased. Several university co-op offices have reported to us that some employers complain that they cannot find enough students to fill all their open co-op slots, but we were unable to obtain annual data on the number of open co-op positions or the number of students who applied for the program

from the institutions in our study. So to address this concern, we conduct interviews with 3 large co-op employers and find evidence that supports our identification assumption.

This paper is organized as follows: Section 2 provides a brief summary of the literature on co-op participation and describes the characteristics of co-op programs. Section 3 describes the MIDFIELD student data and the engineering wage data. Section 4 presents the theoretical and empirical models of co-op participation. Section 5 describes the interviews conducted with co-op employers and the implications for identification. Section 6 describes the estimation results and Section 7 concludes.

2. Cooperative Education in Engineering

Cooperative education is the general name used to describe a paid, full-time, temporary, career-related employment associated with college-level education.² A co-op program in engineering is a partnership between an academic institution and an employer designed to combine practical engineering experience during the periods of paid full-time employment with traditional classroom training during the periods of full-time study. The concept was first developed in 1901 by Herman Schneider, an engineering professor at Lehigh University (Smollins, 1999; Stockbridge, 1911). He surveyed the engineering graduates from Lehigh University and noted that those individuals who had practical experience prior to graduation were more successful in their careers than their peers with no pre-graduation experience. He

² The term cooperative education, or co-op, is often used interchangeably with work integrated learning, experiential learning, and professional practice.

started the first co-op program at the University of Cincinnati in 1906. Other academic institutions created similar programs and by 1962 there were 150 co-op programs in the United States (Stockbridge, 1911). As of 1996, the Directory of College Cooperative Education (DCCE) reports that the number of co-op programs had grown to 460 across a wide variety of institutions and academic majors. The DCCE estimates that approximately 50,000 employers participate in co-op programs, include 85% of the top 100 companies on the Fortune 500 List.

The most common path into an engineering co-op program is for an interested student to apply for a co-op position during the sophomore year after having selected a major and completed the core/introductory engineering courses. In addition to course requirements, many universities also require a minimum GPA for co-op participation. Employers advertise co-op position openings through the university co-op office, which facilitates the matching process. Co-op program administrators work to maintain or enlarge their pool of students and employers.

Commonly, students are provided with a list of co-op positions and then decide which listing(s) to respond to with a resume. Program administrators pre-screen the student resumes to ensure eligibility before providing them to the perspective employer. Employers identify students they are interested in meeting with. Interviews are generally performed on-campus in space provided by the co-op program. If acceptable students are not identified, the employer is not obligated to hire any students. Students are also free to pursue co-op employment with

³ Eligibility requirements are specific to the academic institution and in some cases are left to the discretion of individual academic departments. For example, Clemson currently requires a minimum 2.45 grade-point average and completion of at least 27 credit hours while Virginia Tech currently allows each engineering department to define eligibility (Clemson University, 2011; Virginia Tech, 2010).

companies not officially listed with the program office though the agreement must be officially registered with the co-op program office to ensure that the student receives credit towards program completion. Once enrolled in a co-op program, students are obligated to complete the required number of semesters of co-op employment to earn their degree.

Though most co-op placement occurs within the region immediately surrounding the academic institution, the universities in our sample routinely place student throughout the United States and Europe. For example, Purdue University places 40% of their co-op students outside mid-western United States (Purdue University, 2011). Once matched with a co-op employer, students will generally alternate between semester-long periods of on-campus academic study and three semester-long periods of off-campus full-time employment. These non-sequential semesters of full-time employment are generally with the same firm and are distributed across the spring, summer, and fall terms. Inevitably, choosing to engage in a co-op program extends the standard four-year undergraduate degree, one additional year.

The co-op employer pays the participating students a field-specific hourly wage that is set by the university. There is no wage negotiation between the student and the firm, and participating firms are not allowed to offer a wage other than the wage set by the university. Because the hourly wage is better than most available on-campus employment, participating in a co-op program may be the way that many participating students choose to finance their

⁴ Formal engineering co-op programs must require at least 52 weeks of full-time practical experience in order to be accredited (ABET Inc., 2010).

college education as they can use the income from full-time paid employment semesters to pay expenses during full-time study semesters.

Upon graduation, many students that participated in the co-op program are offered full-time employment by their co-op employer. In a survey of co-op students in the North Carolina community college system, Wessels and Pumphrey (1995) report that 40 percent of co-op participants accept permanent employment offers from their co-op employer. In a survey of Texas co-op employers, Friel (1995) reports that 53 percent of co-op participants accept permanent employment offers from their co-op employer. Even if this offer is not ultimately accepted, it may increase the student's bargaining power with other potential employers which could lead to a higher wage.

As mentioned in the introduction, Somers (1995) concludes that co-op participants are more likely to be employed soon after graduation and have higher starting salaries than non-participants, though this may be due to student selection into co-op programs rather than the causal effect of the co-op program. In a subsequent survey of 600 engineering students from a large public university, Gardner and Motschenbacher (1997) confirm that co-op participants have higher starting salaries on average, but find that the salary difference declines over time with no differences in later career outcomes. This suggests that the initial increase in wages and employment probability are not driven by selection, though it does not rule out selection on factors that influence initial wages but have little effect on later career outcomes.

In addition to pay while in college and possible employment advantages after graduation, the literature on engineering co-op programs has identified other benefits including

improved academic performance, confirmation of career choice, and increased networking, that may influence student participation (Calway & A., 2000; Morgan, Brannon, & Bowman, 1999; Worley, 2010). Across all co-op programs, the university makes efforts to ensure that the nature of the work asked of the students is realistic and non-menial. Co-op students engage in real jobs and function as a viable, paid employee of the company.

There is a large literature showing that student occupation choice responds to job market conditions. Focus on the student's decision to study engineering began with work by Arrow and Capron (1959) and Hansen (1961) during a period when there was concern about a shortage of engineers. These and later studies found that student enrollment in engineering is sensitive to wages paid in the engineering profession. More recently, Ryoo and Rosen (2004) estimate a dynamic model of occupational choice and confirm that students enroll in engineering programs in greater numbers when wages for engineers are higher. However, the literature has not addressed if co-op participation in engineering is also influenced by job market conditions. This paper contributes to the literature by showing that students are less likely to participate in an engineering co-op program during periods when wage growth in their field his high.

3. Data

The transcript data for engineering students at the seven universities used in this study was obtained from the Multiple-Institution Database for Investigating Engineering Longitudinal Development (MIDFIELD). The complete MIDFIELD data includes the academic records of all

degree-seeking undergraduate students from eleven public institutions from 1987 through 2009 (Long, 2011).⁵ These institutions have larger enrollment in engineering programs than average compared to the more than 300 colleges with engineering programs. Not all the universities in the MIDFIELD data record co-op participation on the student transcript, so we restrict our data analysis to the seven universities where co-op participation is reported: Clemson University, Florida A&M University and Florida State University (which have a joint College of Engineering), North Carolina State University, Purdue University, University of Florida, and Virginia Polytechnic Institute and State University. Most of these universities are located in the southeast United States and we make no attempt to weight the data to make it more nationally representative.

Each of the universities in our sample has a voluntary co-op program where participation is not required for graduation. Because co-op programs have minimum grade point average (GPA) requirements (which may differ by institution and year and for which complete records are not available), we restrict our sample to students with a 2.5 cumulative GPA or greater in the first semester of the sophomore year. Students who complete their first year of college after 2005 and all transfer students are excluded from the sample. Our sample contains the complete academic records for 29,644 undergraduate students that continued pursuing a degree in engineering after completing their first year of college.

Across all institutions and years, 23 percent of engineering students in our sample decide to participate in a co-op experience. There is a large amount of variation in participation

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⁵ The MIDFIELD database includes student records from fall 1987 to summer 2009, though not all institutions provide data for the entire period.

over time with a high of 33 percent and a low of 13 percent. There is even larger variation across institution with a high of 37 percent participation and a low of 2 percent participation.

Table 1 reports summary statistics for co-op participants and non-participants separately. It shows that students who participate in the co-op program have higher freshman GPA on average than non-participants. This indicates disproportionate selection of high-ability students into co-op programs. The higher average SAT math score for co-op participants is additional evidence of selection of positive selection on ability into the co-op program. The summary statistics also indicate that Black students are much less likely to participate in the co-op program than Hispanic, Asian, or White students. Male and female students participate at rates consistent with their representation in the engineering student population.

The MIDFIELD data only gives academic records with no information about job placement or wages. We obtain annual field-specific salary data from the American Association of Engineering Societies (AAES) *Annual Report of Engineering Salaries* for each year from 1988 to 2009 (AAES, 1988-2009). The AAES is the umbrella organization for engineering societies in the U.S. and conducts an annual salary survey of more than 100,000 engineers in the private sector and government. The data were not available to us electronically, so the data was hard-coded from printed reports. The average wage as well as the upper decile, upper quartile, median, lower quartile, and lower decile are reported for each year by field and by the number of years since undergraduate graduation.

The AAES survey of engineering wages is nationally representative, but the students in our data are not. Even if location-specific engineering wage data was available, it is not clear

that we would want to use this as many of the graduates are offered from jobs located outside the state and often outside the region.

4. Model and Empirical Specification

We model students as facing a one-shot decision to participate in a co-op. Students that decide to participate in a co-op generally delay graduation by one year, but face improved job prospects. Each student is assumed to have an expectation of her future income path if she chooses not to participate in the co-op program (Y_{ii}^0), and another (assumed higher) expected future income path the student chooses to participate (Y_{ii}^1). We assume that individual student utility in period t is proportional to the log of student consumption in that period and there is no savings so that individuals consume their earnings in each period. Normalizing the price of consumption to one, the expected present discounted value of utility for student t is given by

$$u_i^0 = \sum_{t=1}^N \delta^t E \left[U \left(Y_{it}^0 \right) \right] \tag{1}$$

if the student decides against participating in a co-op. If the student chooses to participate in a co-op, the expected present discounted value of the student's utility is given by

$$u_i^1 = \alpha_i + \sum_{t=2}^N \delta^t E\Big[U\left(Y_{it}^1\right)\Big] \tag{2}$$

where α_i is the utility from the year spent participating in the co-op. The rate of time preference is δ . The individual differences in expected income paths are contained in Y_{ii} which incorporates individual differences in the expected probability of employment in each period. Individuals will chose to participate in a co-op if $u_i^1 > u_i^0$.

The current wages of engineers who recently graduated in the same field likely have a strong influence on the expected future wages for engineering students. An increase in the field-specific average wage signals a good job market for students in that engineering field that diminishes the advantages of co-op participation, driving Y_{ii}^1 and Y_{ii}^0 closer together. A good job market means that students are more likely to find a job and can expect higher wages even without having participated in the co-op program.

We use the AAES salary data to form a year and field specific measure of average wages.

We average the discounted mean wage reported for engineers who received their undergraduate degree within the last five years according to:

Wage_{jt} =
$$\frac{1}{6} \sum_{x=0}^{5} (0.95)^{x-1} W_{jtx}$$
 (3)

where W_{jtx} is the average real wage in field j for experience level x and year t. The assumption that future wages are discounted using a rate of about 5 percent is arbitrary, though the results are robust to alternative assumptions. The resulting variable $Wage_{jt}$ measures the field-specific wage for recently graduated engineers by year and is our primary explanatory variable of interest. Figure 2 displays this five-year average real wage for selected fields from 1989 to 2003.

Because the co-op participation variable $Coop_{ijkt}$ is binary, we specify a latent-variable model of co-op participation that we will estimate using a probit specification:

$$Coop_{ijkt}^* = \alpha + \beta Wage_{jt} + \mathbf{X}\mathbf{y}_{kt} \mathbf{\theta}_{kj} \mathbf{\delta}_{t} + \eta_{ijkt}$$
(4)

where i indicates the individual, j indicates the field, k indicates the university, and t indicates the year. Individual characteristics of student i are given by X. There is potential concern that students differ in unobservable ways that are correlated with which university they attend and

which engineering field they choose to study. We address this by adding field-by-institution fixed effects, denoted in the model as θ_{kj} . Year fixed effects δ_t are also included to control for common shocks including aggregate trends in engineering salaries and co-op participation. There are a total of 17 year indicator variables and 38 field-by-institution indicator variables that we include in the probit model. With the inclusion of these fixed effects, identification comes from field-specific movement in the wage and not wage changes that are common to all fields. Standard errors are clustered at the institution level.

Even with time and institution-by-field fixed effects, there is concern that our measure of the average wage for recent engineering graduates is endogenous. The observed co-op participation variable indicates both that the student desired a co-op position and that a co-op employer hired the student. Employers may respond to a wage increase by hiring more co-op students as substitutes for hiring the more expensive permanent employees, or employers may respond to a wage increase by hiring fewer co-op students because they anticipate being able to make fewer job offers at the completion of the co-op program. If the former is true our estimate of β will be biased upward. If the latter is true our estimate of β will be biased downward. To investigate these possibilities we conducted interviews with co-op employers. Our interviews suggest that the number co-op positions offered is not driven by market conditions which supports our assumption that changes in the number of student participants is driven by student choices rather than employers.

5. Co-op Employer Interviews

University co-op offices have reported to us that employers are able to fill most all of their open co-op positions in some years, but that in other years they complain that they cannot find enough qualified students. We were unable to obtain data documenting the number of open positions by year or the number of students who applied for the program. If employers do not adjust the number of co-op positions very much from year to year, periods of excess demand (with many unfilled co-op positions) and periods of excess supply (with many unmatched students) would be due to the student response alone. To confirm this, we conducted interviews with co-op employers and found some evidence that supports our identification.

We conducted interviews with three company representatives involved in co-op recruiting with the intent to evaluate the demand side of the co-op process and specifically to discuss co-op hiring practices in relation to labor market dynamics. Through coordination with the Cooperative Education Program at Clemson University, we identified three of the companies that have recruited engineering co-op students at Clemson during the period of the study. Representatives at the three companies held positions that coordinated directly with one or more academic institutions and were responsible for determining the number of annual co-op requisitions. Each representative was contacted via email and asked to voluntarily participate in an interview related to the study. Semi-structured interviews were performed with company representatives via phone.

The interview protocol included a series of open-ended questions related to the study. A complete copy of the protocol is included in the appendix. Phone interviews were conducted in September and October 2010 and lasted between 30 and 60 minutes. For consistency, all interviews were conducted by the same author. 6

The representative from Company 1, a regional employer in the energy sector, reported that the number of co-op positions offered had increased from 250 to 400 over the past three year. The representative stated that the co-op program was a "mess" three years before and that it was growing out of a desire to make more full-time hires from the pool of co-op participants. The representative also suggested that they should use the co-op program to smooth out bumps in full-time hiring, though with only three years co-op program data available to the representative it isn't clear that employment smoothing was occurring.

The representative from Company 2, a large international employer in the chemical and manufacturing sectors, reported that co-op hiring had been constant at between 100 and 150 positions each year over the past ten years. The representative reported that they had never experienced any trouble filling all their co-op positions and stated that the decision to hire about the same number of co-op students each year improves their reputation with the students at universities where they do their recruiting.

The representative from Company 3, a large international employer in multiple engineering-related sectors, reported that they hire about 500 co-op students each year and

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⁶ Recorded interviews were transcribed and proofed against the original recordings, and the recordings were subsequently destroyed. The names of companies and company representatives that participated in this study are intentionally not included in reporting.

that they do not deviate by more than 10 percent in the total number of co-op positions in any given year. The representative reported that they have far more co-op applications during periods with a poor engineering job market (low wages), but that they do not adjust the number of co-op positions.

Company 2 and Company 3 draw a significant percentage of their full-time, permanent hires from the co-op population and view their co-op students as the entry point to a pipeline of full-time candidates. Company 3 reported that as much as 80% of their annual full-time hiring comes from prior co-op and internship positions. Accordingly, Company 3 advertises their co-op positions as the preferred path towards full-time employment and they maintain rigorous standards for securing a co-op position. Alternatively, Company 1 may have hired co-op students to help even-out fluctuations in full-time hiring rather than a pipeline towards full-time employment, though Company 1 seemed to be transitioning to a larger co-op program.

These interviews suggest that the number of co-op positions is fairly constant over time. Firms seem hesitant to reduce the number of co-op positions they make available each year because they want to have a good reputation with the university co-op programs and students they are trying to recruit. Though none of the companies we interviewed said they ever had trouble filling their open co-op positions, we know from co-op program offices that this sometimes occurs.

6. Results

We estimate a probit model where equation (4) is the underlying latent variable model. The marginal effects evaluated at the mean are reported in Table 2. We vary the included control variables over the first four columns, though the year and field-by-institution fixed effects are included in every specification. Table 2 indicates that the estimated effect of a change in the average real wage on the probability of co-op participation is robust to the inclusion of gender, race, and GPA controls. The interpretation of the estimate is that a \$10,000 real increase in the field-specific average real wage, as defined by equation (3), causes a 5.4 percentage point decrease in the probability of co-op participation. The baseline probability of co-op participation is 22.6 percent in our sample so a \$10,000 real increase in the wage is estimated to cause a 24 percent decrease in co-op participation.

While we use a large wage change in reporting the regression results, the AAES wage data shows that annual real wage changes in engineering fields are much smaller. The median annual change in our wage measure as defined in equation (3) for all fields from 1988 to 2009 is only \$430. Our estimates imply that a real wage change of this size would cause a 0.23 percentage point decrease in the probability of co-op participation, a 1 percent reduction.

The results reported in Table 2 indicates that female students are not significantly more likely to participate in a co-op program than male students. However, Black students are much less likely to participate than White students. This is true even with institution fixed effects and after controlling for GPA. The representative from Company 3 mentioned that they often had

trouble meeting their diversity goals in their co-op recruiting, suggesting that fewer Black students apply for co-op positions.

The results also indicate that high ability students (those with higher GPA) are more likely to participate in a co-op program. The disproportionate selection of high-ability students into co-op programs suggests that estimates, like those from Somers (1995), showing that co-op participates are more likely to find employment and receive higher wages are likely biased upwards. Our view is that the co-op program improves (but delays) the labor market outcome on average for participating students, though likely to a smaller magnitude than is estimated in the literature in light of this positive selection.

The model presented in Section 4 suggests that student heterogeneity in future wage expectations accounts for the variation in co-op participation. However, the effect of co-op participation on future wages may itself depend on student ability. This could cause heterogeneity in the effect that a change in the average wage has on the co-op participation decision. When the average wage increases, is it high- or low-ability students that primarily turn down co-op participation in favor of earlier graduation?

In Table 3, we use GPA as our measure of student ability and estimate the model for each quartile of the GPA distribution. The 25th GPA percentile is 2.91, the median GPA is 3.26, and the 75th percentile is 3.63. Recall that we have restricted the sample to students with at least a 2.5 GPA at the time they make the co-op decision. Our estimates suggest that high-ability students (likely students with the highest future income paths) are least likely to reduce co-op participation in response to an increase in the average real wage.

As reported in Tale 3, the estimated effect of a change in the average wage is similar for students in the lower 75 percent of the GPA distribution, but much smaller in magnitude and not statistically different than zero for those in the highest GPA quartile. This suggests that high-ability students do not change their co-op participation decision in response to job market conditions. We predict that a large increase in the real wage would decrease the number of low-ability students who choose to participate in a co-op program, but would leave the number of high-ability participants unchanged.

In terms of the model, if non-participating high-ability students face little risk of lower job market prospects due to a worse labor market, they would not be induced to participate if the average real wage were to decrease. However, if lower-ability students believe they are able to improve their job market outcome by participating in a co-op program their participation should increase when the average real wage decreases. The results from Table 3 are consistent with this interpretation, though we have no direct evidence that job market outcomes are affected by co-op participation.

7. Conclusions

This paper estimates the response of co-op participation to the engineering field-specific average wage for recent graduates. We find no evidence that high-ability student participation in the engineering co-op program is influenced by the engineering job market. However, we find strong evidence that at times when average wage growth is low (or even negative) and it is likely more difficult to secure a job after graduation, the co-op participation

rate of lower-ability students increases dramatically. Interviews with employers of co-op students suggest that this is primarily a student-driven response.

Our findings have implications for engineering education and the management of co-op programs. The significant sensitivity of co-op participation to wage changes implies that co-op program administrators and co-op employers will find current job market conditions useful in forecasting co-op participation. Though the identification comes from field-specific wage variation, our findings suggest that an important explanation for the decline in the overall popularity of co-op programs in the late 1990s through the end of our data in 2005 is the good job market conditions for engineers during that period.

Our finding that the participation of high-ability students is not affected by job market conditions suggests a puzzle. That high-ability students do not respond to changes in the average wage could suggest that their co-op participation decision is not heavily influenced by the expected difference in future wages. If this is the case, then what explains the high rate of participation by high-ability students? About 29 percent of students in the top 25 percent of the GPA distribution at the time they make the co-op participation decision choose to participate while only about 20 percent of students in the lower 75 percent of the GPA distribution choose to participate.

Another puzzle is our finding that Black students are under-represented among co-op students. Because co-op participation involves semesters of full-time employment at wages that are higher than average student wages, we would think that students from low-income backgrounds would be more likely not less likely to participate in a co-op program. For low-

income students, a co-op program could be a way to pay for college. For a subset of our data, we observe the zip code of the student find that the Black students live in zip codes with nearly \$10,000 lower median household income than all other students in the data. If Black students come from lower-income families, why are they less likely to participate in a co-op? Whatever the explanation, our results suggest that companies that recruit through co-op programs will have a more difficultly in achieving their diversity goals than companies that do not recruit through co-op programs.

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Appendix

Phone Interview

Overview of Research:

We are performing research related to engineering cooperative education hiring practices in relation to labor market dynamics. It is our understanding that your company regularly hires cooperative education engineering students. You have been identified as the appropriate person at your company to speak with regarding this subject. However, if you cannot answer some of these questions, please let me know and we can discuss who might be a better contact for your company. Of course, if you wish to not answer a particular question or wish to end the interview at anytime, please let me know.

answer a particular question of wish to end the interview at anythine, please let me know.
Are you ready to begin?
Name,
Company:
Title:
Length of time in that position:
Please describe your involvement (both currently and proviously) in the process of identifying and hiring

Please describe your involvement (both currently and previously) in the process of identifying and hiring engineering cooperative education students for your company?

At which academic institutions do you have personal experience in recruiting from?

Are you aware of your company's active recruiting of other academic institutions? If yes, which academic institutions?

During your interaction with engineering cooperative education students, have you noted any trends in the level of personal and professional preparation of the students?

Have you noted any trends in the number of students applying for engineering cooperative education positions at your company?

Typically, what is the total number of engineering cooperative education positions at your company and what is the common length of employment for those positions?

Have you noted any trends in the number of engineering cooperative education positions available at your company?

Have you noted any relationship between unemployment/economic conditions and the number of engineering cooperative education positions available at your company?

Have you noted any relationships between unemployment/economic conditions and the number of engineering cooperative education students applying for positions at your company?

If you perceive that there has been a decline in the number of engineering cooperative education positions and/or applicants for those positions, what do you attribute that to?

How could cooperative education programs do a better job of ensuring that there are a sufficient number of qualified applicants applying for engineering cooperative education positions?

Are there any further thoughts you have related to engineering cooperative education that you would like to share?

Thank you for your time and willingness to participate in this study.

END OF PHONE INTERVIEW

Figures and Tables

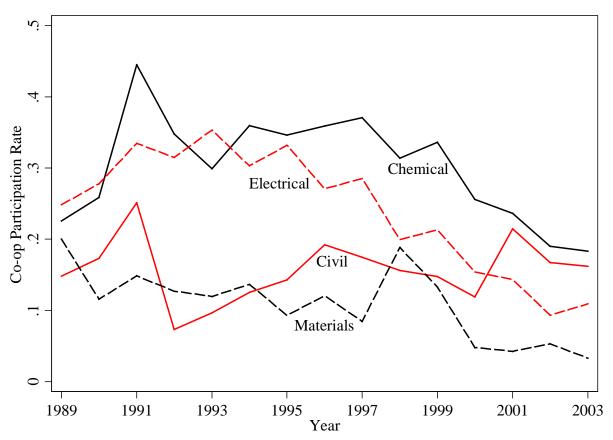


Figure 1: Selected Co-op Participation Rates by Year

Note: The data includes students with a 2.5 freshman-year GPA or higher that have declared a major in chemical, electrical, civil, or materials engineering by the first semester of their sophomore year at Clemson, Florida A&M, Florida State, North Carolina State, Purdue, Florida, and Virginia Tech.

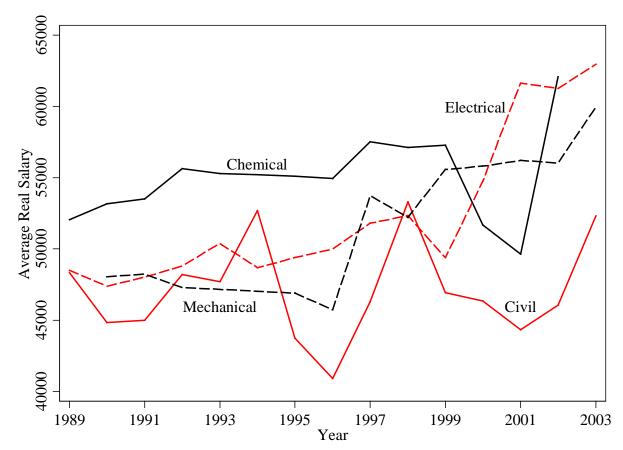


Figure 2: 5-Year Real Average Salary by Year

Note: The five-year average salary is computed as described in the text using data from the American Association of Engineering Societies (AAES) *Annual Report of Engineering Salaries* from each year (American Society for Engineering Societies (ASES), 1988-2009). The CPI-U is used to convert reported salaries into 2010 dollars.

Table 1: Student Summary Statistics

Panel A: Engineering Students who are Co-op Participants

Variables	Obs	Mean	Std. Dev.	Min	Max
Average Wage (\$10,000)	6,713	5.206	0.470	4.089	7.009
Freshman-Year GPA	6,708	3.371	0.408	2.5	4
High School GPA Percentile	5,299	76.51	20.26	1	99
SAT Math Score	4,916	654.0	64.9	410	800
Female	6,713	0.211	0.408	0	1
White	6,713	0.858	0.349	0	1
Black	6,713	0.032	0.177	0	1
Hispanic	6,713	0.022	0.147	0	1
Asian	6,713	0.059	0.235	0	1

Panel B: Engineering Students who are Co-op Non-Participants

	. 0		- p p		
Variables	Obs	Mean	Std. Dev.	Min	Max
Average Wage (\$10,000)	22,931	5.295	0.542	4.089	7.009
Freshman-Year GPA	22,902	3.236	0.430	2.5	4
High School GPA Percentile	13,056	79.46	18.73	1	99
SAT Math Score	16,901	646.7	71.8	290	800
Female	22,931	0.214	0.410	0	1
White	22,931	0.749	0.434	0	1
Black	22,931	0.101	0.301	0	1
Hispanic	22,931	0.034	0.180	0	1
Asian	22,931	0.061	0.239	0	1

Note: The data includes students with a 2.5 freshman-year GPA or higher that have declared a major in chemical, electrical, civil, or materials engineering by the first semester of their sophomore year at Clemson, Florida A&M, Florida State, North Carolina State, Purdue, Florida, and Virginia Tech.

Table 2: Estimated Marginal Effects from a Probit Model of Co-op Participation

VARIABLES	(1)	(2)	(3)	(4)
Average Wage (\$10,000)	-0.056***	-0.056***	-0.054***	-0.054***
	(0.020)	(0.020)	(0.020)	(0.020)
Female		0.008	0.012	0.010
		(0.023)	(0.020)	(0.020)
International Student			-0.021	-0.023
			(0.018)	(0.020)
Asian			-0.002	-0.004
			(0.022)	(0.021)
Black			-0.083***	-0.070***
			(0.021)	(0.022)
Hispanic			0.020	0.023
•			(0.022)	(0.022)
Other Race			-0.050***	-0.053**
			(0.019)	(0.025)
Freshman GPA			,	0.098***
				(0.027)
Observations	29,625	29,625	29,625	29,591
Pseudo R-squared	0.1211	0.1212	0.1237	0.1342

Notes: All specifications include year fixed effects and university-by-major fixed effects. Standard errors clustered at the institution level are given in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Table 3: Estimated Marginal Effects from a Probit Model of Co-op Participation by Ability Level

	(1)	(2)	(3)	(4)
VARIABLES	GPA<2.91	GPA [2.91-3.25]	GPA [3.26-3.63]	GPA>3.63
Average Wage (\$10,000)	-0.069***	-0.071***	-0.066***	-0.019
	(0.014)	(0.026)	(0.024)	(0.027)
Female	0.009	0.035*	0.009	-0.008
	(0.018)	(0.019)	(0.022)	(0.028)
International Student	-0.014	-0.006	-0.032***	-0.034*
	(0.022)	(0.031)	(0.007)	(0.020)
Asian	0.019	-0.005	-0.002	-0.032**
	(0.033)	(0.029)	(0.016)	(0.015)
Black	-0.037***	-0.091***	-0.089***	-0.090*
	(0.009)	(0.034)	(0.020)	(0.050)
Hispanic	0.095**	0.005	-0.014	0.006
	(0.044)	(0.063)	(0.011)	(0.050)
Other Race	-0.011	-0.061	-0.044**	-0.079***
	(0.017)	(0.058)	(0.022)	(0.015)
Observations	7,119	7,107	7,433	7,339
Pseudo R-squared	0.1089	0.1235	0.1400	0.1228

Notes: All specifications include year and university-by-major fixed effects. Standard errors clustered at the institution level are given in parentheses: *** p<0.01, ** p<0.05, * p<0.1