A Labor Economist's Perspective on College Educated Women in the Information Technology Workforce

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INTRODUCTION

As a labor economist, my usual role in a discussion of women in the information technology (IT) workforce would be to establish the prevalence of gender differentials in outcomes. To what extent are women who invest time and money to acquire education and training in IT fields able to use their skills, and receive commensurate compensation, in the labor market? Because the answer to this question is quite brief, I also address a second question in this article: Given that women with computer science and engineering college majors earn far more (on average) than other college educated women, why do so few choose to pursue this career path? The answer to this question matters both because we continue to puzzle about why women tend to earn less than men, and because (as argued so eloquently by Jane Margolis, 2002) the kinds of technologies that will be developed will depend on the life experiences and interests of our highly-trained IT professionals.

I approach this research by focusing on the college major choices of young women. While it is possible to enter IT careers through many different avenues, both occupational assignments and provision of on-the-job training result from complex interactions between individual workers and employers. In contrast, college major choices are typically far more unilateral, and tend to precede labor market entry. In my research, comparisons are made between women who choose to major in computer science or engineering, and those who make other college major choices.

While it is true that women in computer science or engineering fields tend to earn less than men with the same college major, gender differentials in earnings are a fact of life along other career paths as well. For example, in the most recent year for which detailed information is available, the gender differential in earnings among college graduates in their 30's ranged from 15 to 20 percent in each of 4 other broad college major categories[1], compared to only 5 percent among both computer science and engineering majors (Weinberger and Joy, 2005).[2] The information most relevant to women making their career choices is how the earnings of women in IT careers compare to the earnings of other women. On this measure, college training in computer science or engineering appears to be a sound investment. Data provided in Table 1 shows that, at mid-life, women with computer science or engineering majors earn 30-50 percent more than the average female college graduate.[3] The combination of high average pay and low gender pay gaps in technical fields translates to particularly strong financial incentives for young women to enter these fields.

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[1] The categories were Business, Social Science/Humanities, Math/Science, and Education. These earnings regressions controlled for differences in hours worked per week, full- and part-time work experience, geographic region, parents' educational attainment, and detailed college major within each category. Sample sizes ranged from 700 to 3500.

[2] To read more about gender differentials in pay among the highly educated, see Brown and Corcoran (1997), Weinberger (1998, 1999, 2001, 2005).

[3] Based on annual earnings of representative samples of full-time, year-round, white women workers, aged 33-52. (This group includes many women who did not work full-time continuously). Younger women (age 23-32) enjoy a similar advantage, with 1989 earnings $37,000 for computer science/engineering majors (n=804) compared to $28,000 for the typical college graduate. Young women of color also enjoy this advantage, with 1989 average earnings of computer science/engineering majors $37,000 for Asian women (n=59), $35,000 for Hispanic women (n=39), and $33,000 for black women (n=115). This brief piece cannot adequately address interactions between college major choices, race/ethnicity and labor market outcomes. For a thorough analysis of this question, see Weinberger and Joy (2005).

Regression analysis shows that the large earnings advantage enjoyed by women with computer science or engineering degrees is robust to including controls for other observable variables. In a nationally representative sample of 1992 high school seniors followed until the year 1999, women who majored in computer science or engineering earned 48 percent more than other female college graduates (Table 2, Column 1).[4] After controlling for 12th grade math scores, the estimated advantage is still high (41 percent) (Table 2, Column 2).[5] The very small difference between the Column 1 and Column 2 results demonstrates that very little of the economic advantage to graduates with these majors is "explained" by this measure of pre-college academic preparation or ability that might be valued by the labor market regardless of the college major chosen. The estimated advantage barely changes (still 41 percent) when controls are added for higher degrees earned, the number of hours worked per week, and parents' educational attainment (Table 2, Column 3).[6] These regression results strongly suggest a causal relationship between women's college major choices and later earnings. The economic incentive for women to pursue these careers appears to be quite large. Based on this evidence, the barrier to women's entry is evidently not a lack of lucrative career opportunities.

Yet some kind of barrier clearly exists. Statistics available from the National Center for Education Statistics reveal that, while the representation of women is now substantial among new college graduates in many previously male dominated fields, this is not true in either computer science or engineering fields.[7] In 1970, fewer than 10 percent of new bachelor's degree graduates in business, computer science, engineering, or newly graduating doctors and lawyers, were women. Today, women and men are nearly equally represented among new graduates in business, law and medicine. In contrast, fewer than one-third of new computer science graduates, and an even smaller proportion of new engineers, are women. And there has been no obvious trend towards increasing representation of women in these fields in recent years. The research presented in the remainder of this article describes a survey of academically talented young women, asking questions designed to reveal what the operative barriers might be.

BACKGROUND

Opinions on the reasons for women's underrepresentation in science and engineering fields are varied. At one extreme, Gelernter (1999, pp. 11-12)) opines that "The real explanation is obvious: Women are less drawn to science and engineering than men are. . .Women are *choosing* not to enter, presumably because they don't *want* to; presumably because (by and large) they don't like these fields or (on average) don't tend to excel in them, which is nearly the same thing." This perspective is not universal. Referring to the already highly selected population of M.I.T. science students she teaches, Hopkins (1999, p. 5) observes that "…although scientific talent and brilliance are equally distributed between the sexes, the career prospects for men and women are not equal." The contribution of social scientists to this debate is to take a step back from conclusions based on the people we happen to meet or presume to

[4] These data are from the National Center of Education Statistics National Education Longitudinal Study of 1988. The regression sample is restricted to white women college graduates employed full-time, full-year in 1999. The earnings advantage is computed as the exponential of the estimated coefficient minus 1.

[5] When this specification is estimated separately for Asian, Hispanic, or black women, the estimated advantage to computer science/engineering majors is even higher for each of the three groups, ranging from 50-65 percent.

[6] Coefficient .33, standard error .12, sample size 1100.

[7] See: http://nces.ed.gov/edstats/

understand, and examine relationships between gender and career outcomes in randomly selected samples of well-defined populations.

Research based on representative samples of high school students followed to adulthood establish that, conditional on observable measures of academic talent and preparation, young women are only half as likely as young men to pursue science or engineering careers (Xie and Shauman, 2003).

Possible explanations for this difference abound. A growing body of evidence suggests that many women who intend to pursue higher education or careers in science, engineering or information technology fields find a less than welcoming atmosphere in both the university and the workplace (Keller 1977, Tobias 1978, 1990, Hall and Sandler 1982, Gornick 1983, Zuckerman 1992, McIlwee and Robinson 1992, Seymour and Hewitt 1997, Schiebinger 1999, Wyer 2001). Economists tend to focus on explanations based on gender differences in the allocation of time between the labor market and childrearing, hypothesizing that women might prefer to prepare for careers in which labor force interruptions or reduced hours of work per week are less costly (Blakemore & Low 1984, Polachek 1978, 1981). A more recent economic analysis focuses on the possibility that women who make gender-atypical career choices might face social sanctions (Badgett and Folbre, 2003).

WHY DO WOMEN AVOID IT COLLEGE MAJORS?

Despite the proliferation of opinions and possible explanations, there is very little evidence on the actual tradeoffs considered by young women as they make their career choices. In a recent mail survey, I asked representative samples of college students at two very different institutions about their reasons for avoiding computer science, computer engineering, and electrical engineering, and other courses and careers. The format of the survey was a list of statements ("I would not choose the majors I have checked below because …" or "I would not choose the career paths I have checked below because …"), where each statement was followed by an alphabetical list of possible college majors or occupations. The results from the first institution are published elsewhere (Weinberger 2004), while the very similar results for a group of surveyed students at the second institution are presented here, in Tables 3 and 4.

The sample of 195 women described here is representative of all female seniors at the University of Minnesota who were enrolled in a school other than the Institute of Technology and had enough credits to graduate at the time of the survey (Spring 2004).[8] While we focus here on reasons given for avoiding IT courses and careers, the survey was constructed to give no special emphasis to any particular career path. All choices were presented in a neutral way (alphabetically) and no reference was made to IT careers within the survey, cover letter, or instructions.

[8] Mail surveys were sent to 20 percent of all second semester seniors. The response rate for women was just over 40%. The women described here were enrolled in the Colleges of Liberal Arts (n=108), Biological Sciences (n=12), Management (n=13), Education (n=17), Nursing (n=24), and the college formerly known as Home Economics (n=21). Seniors were sampled because this survey is part of the larger College and Career Choices Study, designed to follow these students into the labor market.

Nonetheless, the women in this group were likely to say that they would avoid IT courses and careers for each of several reasons. The patterns of responses are very similar to those obtained in all three samples examined previously: women in majors chosen by more women than men, women with very high math SAT scores in the same set of majors, and women in the Business Economics major, all of whom were seniors at UC Santa Barbara (Weinberger, 2004). The sample described here is different because it is larger, and is representative of the entire graduating class of young women at an institution with nearly every possible college major available.

As in the previous samples, almost none of the women in this sample were concerned that they would not be able to find a job that paid well if they choose an IT college major or occupation. These students correctly perceive that computer and electrical engineering jobs are remunerative. There is also little support for other explanations suggested by economic models: Very few women are concerned with social sanctions for choosing IT majors, or express concern that IT careers would require working long hours per week or be difficult to combine with raising a family. In fact, the career paths that were perceived as difficult for mothers (lawyer and doctor) are exactly those in which women have become increasingly well-represented in recent years. This is clearly not the barrier to women's entry into IT careers. There was some support for the notion that IT careers are incompatible with taking time out of the labor market altogether (as opposed to working, at least part-time, while parenting), but the surveyed students evidently did not expect this to make IT careers difficult to combine with parenting.

In contrast to the low levels of concern about these economic factors, 30-40 percent of the women indicated an expectation that the classroom and workplace atmosphere in IT would not be welcoming to women, or to them personally. Similar levels of concern were reported for each of the three samples in Weinberger (2004), including the sample of women with very high math SAT scores. Concern about climate was not highly correlated with lack of interest in IT careers in any of the samples. Although not the majority of women, it is striking to find higher levels of concern about climate in IT than in medicine, law or finance.

Previous results that IT courses are considered to be both more time-consuming and more difficult than other college courses were also replicated here. One of the most surprising earlier findings is that young women were more likely to indicate that "the coursework required would be too difficult" when asked about IT careers than when asked about a career as a Surgeon. Finding it incredible that a bachelor's degree in Computer Science could be perceived as more difficult than training to be a surgeon, I rephrased the question for the new survey. The question (and responses) were similar in the first section of the survey. As before, 50-60 percent of students checked computer engineering, computer science, and electrical engineering when prompted with: "I would not choose the majors I have checked below because the courses are too difficult." In the second section of the survey, the prompt: "I would not choose the career paths I have checked below because the coursework required would be too difficult" was replaced in this version by "…because I could not pass the courses." This change in wording was chosen to eliminate those who simply believed the courses were too difficult to bother with, given their level of interest. As expected, students tended to be less likely to believe they would fail than to think the courses were too difficult. However, the surprising result persisted. Fourty percent of the women at this selective university believed that they could not pass the courses

required for careers in computer engineering, computer programming or electrical engineering. Again, this coursework was perceived as more difficult than that required to become a surgeon.[9]

The question for which the change of venue seems to have had the largest effect is "I would not choose the majors I have checked below because I would not be prepared to do socially useful work after graduation." More women were concerned about this in the Minnesota sample, with 20-30 percent indicating this concern about IT college majors. For this version of the survey, the question "I would not choose the career paths I have checked below because the work would not be meaningful or socially useful" was divided into two separate questions ("…would not be meaningful to me" and "…would not be socially useful"). Again 20-30 percent were concerned about the social usefulness of IT careers, but fully 70-80 percent indicated that this work would not be personally meaningful.

FUTURE TRENDS

It seems that a vast majority of the women in the sample (90 percent) would agree with Professor Gelernter that they would not be interested in the courses and would not enjoy the work associated with courses or careers in computer engineering, computer science or electrical engineering. This finding suggests it is vital that we try to understand the mechanisms underlying interest formation if we are to understand the processes leading to this self-selected segregation.[10] It is also important to learn whether it is something intrinsic to these technical subjects, or only the evolved culture surrounding them, that young women find uninviting.[11] This line of inquiry is, in fact, particularly important if it is the case that women have different interests and life experiences than men. For this is exactly the circumstance in which it is important that women's voices be heard when decisions are made about which potential technologies can be developed to best serve the public good.

Just as the federal government sponsors research to understand the fundamentals of good nutrition, and informational campaigns to encourage people to eat more fresh vegetables, there is a role for government to support research and policy to foster healthy professional development. And just as my grandmother and mother selected recipes from other cultures that made vegetables more appealing and healthier, there is a role for families here as well. As a research community, our role is to provide reliable information to young people who have the capability to contribute to society in ways they might not have imagined for themselves.

CONCLUSION

Economic considerations do not appear to be the operative barrier preventing surveyed women from choosing college majors or careers in computer science, computer engineering or electrical engineering. Instead, female college students express lack of interest, expectations of not being welcome, and seemingly inflated evaluations of the difficulty of college coursework in these fields. These findings point to future research on the process of interest formation, efforts to improve (or change perceptions of) classroom and workplace climates for women, and systematic evaluation of the actual and perceived difficulty of teaching technical subjects to

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[9] As in Weinberger (2004), the corresponding sample of men perceived the coursework required to become a surgeon as more difficult than that required for any of these IT career paths.

[10] Research on this topic by Jaquelynne Eccles is in progress.

[11] See Seymour & Hewitt (1997), and Margolis and Fisher (2002), for thoughtful treatment of this subject.

academically high achieving women. The potential benefits include a future pool of talented, well-trained IT decision makers with a wider range of perspectives than are currently represented.

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Table 1—Average Annual Earnings by Educational Attainment, 1989 and 1999.

	1989 Average Annual Earnings College Graduates Ages 33-52	1989 Average Annual Earnings Bachelor's Level College Graduates Ages 33-52	1999 Average Annual Earnings Bachelor's Level College Graduates Ages 33-52
Women Computer Science Majors	$44,000	$43, 000	$67,000
(standard deviation)	(13,000)	(13,000)	(31,000)
sample size	79	65	118
Women Engineering Majors	$52,000	$48,000	$65,000
(standard deviation)	(23,000)	(14,000)	(30,000)
sample size	87	63	203
All Women College Graduates	$34,000	$31,000	$48,000
(standard deviation)	(19,000)	(17,000)	(28,000)
sample size	22066	13293	23931

All samples restricted to white women working at least 35 hours per week and at least 50 weeks per year.
"All Women" statistics computed from 1990 and 2000 Census 1% samples.
1989 statistics by college major computed from the 1993 NSF Survey of College Graduates.
1999 statistics by college major computed from the 1999 NSF SESTAT Survey, matched with the 1993 Survey of College Graduates.

Table 2--Annual 1999 Earnings of Women with Computer Science or Engineering Majors, Relative to other Female College Graduates (Ordinary Least Squares Earnings Regressions, Dependent Variable is Log 1999 Earnings).

	(1)	(2)	(3)
Computer Science or Engineering Major	0.393	0.344	0.347
	(0.091)**	(0.095)**	(0.106)**
Worked 35-39 Hours per week			-0.104
			(0.056)
Worked 41-48 Hours per week			0.119
			(0.051)*
Worked at least 49 Hours per week			0.158
			(0.040)**
Master's Degree			0.072
			(0.038)
Ph.D. or Professional Degree			0.577
			(0.179)**
12^{th} Grade Math Score (1992)		0.007	0.005
		(0.002)**	(0.002)**
Parent Education Controls?	No	No	Yes
Observations	1100	1100	1100
R-squared	0.02	0.03	0.12

These data are from the National Center for Education Statistics National Education Longitudinal Study of 1988 eighth graders. Sample restricted to white women college graduates working at least 35 hours per week, and at least 50 weeks per year in 1999.

Table 3 --Proportion indicating "I would not choose the majors I have checked below because …"
Random sample of 195 female graduating seniors enrolled in UofM schools other than the Institute of Technology

	Biology	Comp. Engin.	Comp. Sci.	Economics	Elem.Ed.	electrical Engin.	English	Finance	Nursing	Psychology	Sociology
"…the coursework is too time-consuming"	0.3	**0.4**	**0.3**	0.1	0.0	**0.4**	0.1	0.1	0.2	0.0	0.0
"…the courses are too difficult"	0.3	**0.6**	**0.5**	0.2	0.0	**0.6**	0.0	0.2	0.1	0.0	0.0
"…the courses are not interesting to me"	0.4	**0.9**	**0.9**	0.6	0.2	**0.9**	0.3	0.6	0.3	0.1	0.2
"…I would not develop my full potential"	0.3	**0.4**	**0.4**	0.3	0.3	**0.4**	0.3	0.4	0.2	0.2	0.3
"…the subject matter will be quickly outdated"	0.0	**0.3**	**0.3**	0.1	0.0	**0.1**	0.0	0.0	0.0	0.0	0.0
"…I would be considered too serious, nerdy, or strange"	0.1	**0.1**	**0.2**	0.0	0.0	**0.1**	0.0	0.0	0.0	0.0	0.0
"…I could not find a job that paid well after graduation"	0.1	**0.0**	**0.0**	0.0	0.3	**0.0**	0.4	0.0	0.0	0.3	0.4
"…I would not be prepared to do socially useful work after graduation"	0.1	**0.3**	**0.2**	0.1	0.0	**0.2**	0.2	0.1	0.0	0.0	0.1
"…employers would assume I was not capable of completing a more challenging major"	0.0	**0.0**	**0.0**	0.0	0.1	**0.0**	0.2	0.0	0.0	0.1	0.2
"…I wouldn't expect the classroom atmosphere to be welcoming to me"	0.0	**0.4**	**0.3**	0.1	0.0	**0.4**	0.0	0.1	0.0	0.0	0.0

Table 4-- Proportion indicating “I would not choose the career paths I have checked below because …”
Random sample of 195 female graduating seniors enrolled in UofM schools other than the Institute of Technology

	Accountant	Comp. Engineer	Comp. Prog.	Electrical Engineer	Lawyer	Nurse	Pediatrician	Psychologist	Social Worker	Surgeon	Teacher	Tech Support
"…the pay would be too low"	0.0	**0.0**	**0.0**	**0.0**	0.0	0.1	0.0	0.1	0.4	0.0	0.4	0.3
"…I would not enjoy the work"	0.8	**0.9**	**0.9**	**0.9**	0.4	0.3	0.2	0.2	0.2	0.4	0.1	0.8
"…these careers would require too many years of schooling"	0.0	**0.1**	**0.1**	**0.1**	0.4	0.1	0.5	0.2	0.0	0.6	0.0	0.0
"…I could not pass the courses"	0.1	**0.4**	**0.4**	**0.4**	0.2	0.1	0.2	0.0	0.0	0.3	0.0	0.1
"…these jobs require working long hours per week"	0.1	**0.1**	**0.1**	**0.0**	0.5	0.2	0.3	0.0	0.1	0.5	0.1	0.1
"…the work would not be meaningful to me"	0.7	**0.8**	**0.8**	**0.7**	0.2	0.1	0.0	0.0	0.0	0.1	0.0	0.7
"…if I took time off to care for young children, my skills would be out of date"	0.1	**0.4**	**0.5**	**0.2**	0.1	0.1	0.1	0.0	0.0	0.2	0.0	0.3
"…it would be hard for me to 'fit in' with my co-workers"	0.2	**0.4**	**0.4**	**0.4**	0.1	0.1	0.1	0.1	0.0	0.1	0.0	0.3
"…the work would not be socially useful"	0.2	**0.3**	**0.3**	**0.2**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
"…it would be difficult to combine these careers with raising a family"	0.1	**0.1**	**0.1**	**0.1**	0.4	0.1	0.2	0.1	0.1	0.5	0.0	0.1
"…I wouldn't expect the workplace atmosphere to be welcoming to me"	0.1	**0.4**	**0.3**	**0.4**	0.1	0.0	0.0	0.0	0.0	0.2	0.0	0.2