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Where Have All the Civil Engineering Students Gone? A Study of Student Choice of Engineering Department

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WHERE HAVE ALL THE CIVIL ENGINEERING STUDENTS GONE?

- A STUDY OF STUDENT CHOICE OF ENGINEERING DEPARTMENT -

Economics Honors Paper

written by Dan Bernhardt

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Introduction

The problem: students in General Engineering at the University of Waterloo are not choosing as often as before to enter Civil Engineering. Increasing numbers of students are choosing Mechanical or Electrical Engineering, creating a large imbalance in the three class sizes. There is tremendous concern about whether this is a long or short run trend, why this imbalance exists, and about what, if anything, should and can be done to correct this imbalance. In this paper, I will construct a logit model* of student choice and apply it directly to those students who have been in General Engineering at the University of Waterloo. I will attempt to discover the answer to the question - Why are students no longer choosing as frequently to enter Civil Engineering?

This paper is unique in that it attempts to build a relatively sophisticated model of undergraduate choice of major and to test it empirically. Very few studies have focused on the choice of major (or department) even briefly. Choice of major is an important topic because it helps to determine the future distribution of high level skills among labor; it certainly ought not to be neglected. Those studies which have looked at choice of department, have given the subject cursory glances at best. The studies have not attempted to include factors unique to the student (e.g. aptitude, interests), nor have they looked at non-salary market characteristics such as numbers of jobs. We shall find that these factors are the most important ones in explaining choice of department and should be considered. We shall find that the large fluctuations in proportions of students entering each department are caused primarily by the cyclical fluctuations in the job markets.

Review of Literature

There have been a plethora of articles concerning education as an investment, and on rates of return on investment in different levels of education, but there have been almost NO articles written on the topic of choice of major. There have been but one theoretical and a few relatively simple, cursory empirical works in the area. Michael Seeborg[1] has

* See Boskin[10] for an application of a logit model to occupational choice.

built a basic theoretical model of student choice of major - actually, he attempted to determine the 'necessary' requisites of a good model. However, he did not attempt to test his model empirically. Indeed, his model, in its rarified theoretical state, is not particularly amenable to testing. Seeborg did little in addition to stating that students should choose the major which maximizes their utility - or choose the major k such that

$$(1)\quad U_k = \max_j U(E_j, A_j, I_j, R_j)$$

where U = utility

E = a vector of anticipated economic and social trends

A = a vector of abilities and aptitudes

I = a vector of interests

R = a vector of attitudes toward risk and uncertainty

over all majors j

- and expounding upon why each parameter is necessary.

There has been some simple empirical work in the area. James Koch[2] has tested a simple disequilibrium (although he did not label it as such) model of student choice of major:

$$(2)\quad \%M = a + bIRR$$

where %M = percentage change in undergraduate students majors

IRR = internal rates of return

and obtained good ($t = 2.71$ ($n=17$), $R^2 = .31$) results. However, significant results were not obtained when the same model and calculated IRR's were used in a study[3] dealing with a different school. Koch's model is relatively incomplete, and there are no solid theoretical justifications for the specification of the disequilibrium model (or at least he presents none). When one considers that the majors (speech to mathematics) - and thus other factors are much more likely to be determinants of choice, one finds it amazing that his results were as good as they were.

Weiss[4], while looking at investment in graduate education to try to find the optimal level of education by field, incidentally noted that there was a "tendency toward equalization of the rates of entry in the different fields." However, after noting that some fields tended to draw more able students (and thus salary estimates for those fields would be biased upwards), he observed no relationship between rates of entry and estimated expected lifetime earnings.

Richard Freeman (and co-authors) has analyzed the supply and demand for various undergraduate majors - engineering, social sciences, etc.[5] In IRRAS Dec., 1977, he found that "the flow of students to bachelor's and first-degree professional fields is affected by market factors..." (e.g. R & D spending, alternative incomes, etc.) He has been especially thorough in his analysis of the (US) engineering market.[5a] In <u>The Over-Educated American</u>(pp. 112-117) he summarizes the results of his extensive studies of the engineering market. He has determined that a classic cobweb model of supply of, and demand for engineering graduates bests describes the (US) market. He also notes that choice of field in engineering is important "in determining labor market success" (salary, etc.)

Theoretical Model of Student Choice of Department

The theory of student choice of major is relatively straightforward; a student choosing among possible majors will weigh the benefits - potential earnings, social atmosphere, quality of lectures - and costs - level of work required, tuition,etc. - of the anticipated outcomes of choosing a particular major. The student will choose the major whose derived utility (derived from the expected outcomes of choosing that major) is the greatest. The student is choosing from a set of anticipated outcomes resulting from choosing a particular department; the department itself is not the object of choice. A student y will choose department i if

(3) $V_{iy}(DC_i, IC_{iy}) > V_{jy}(DC_j, IC_{jy})$ for all $j \neq i$.

where V_{ky} is the utility derived from entering the kth department

DC_k is a vector of characteristics of the kth department common to all students ("Characteristics of a department common to all students" will be assumed to refer to characteristics common to the expected outcomes of choosing the department unless otherwise stated)

IC_{iy} is a vector of student characteristics unique to the individual y and department i.

Let us examine these vectors DC_i and IC_{iy} to see what their components might include. What are the pertinent characteristics common to a department? One basic characteristic common to all students is the market demand for students who enter the department. Actually, students are not directly interested in the demand for those who choose a particular department, but the results of the demand: common salary schedules, common employment probabilities and fluctuations therein. A choice of a particular department will lead to certain common types of jobs with similar job attributes: working hours, working conditions, job situation (rural/ urban), etc. One department may lead to jobs which require interaction with people, a second may lead to isolated field work in the north. Students hoping to enter a particular department may face common admissions requirements and tuition scales. Department and field reputation will be common to all students who choose the same department. For instance, all students in a department which is looked upon as attracting second rate students, will be burdened with that stigma. Students in the same department face the same uncertainty and lack of information about future demand schedules, changes in curriculum, or professors.

Even though these characteristics are common to all students who choose a particular department, the value attached to each attribute may vary from student to student. Consider, for example, two potential Physics students, one a math-whiz, the other a pre-Calc drop-out. Both face some common demand curve for Physics majors, but the math-whiz has a much higher expected salary than the drop-out because of aptitude differences unique to each individual. However, it may be that personal interest parameters unique to the individuals will mean that the pre-Calc drop-out will attach a very different value to expected salary than the math-whiz. Even after the individual parameter of expected salary is taken into account, the math-whiz may end up in French, the drop-out in Physics because of different weightings of individual interest characteristics.

Let us examine more thoroughly the individual student to see how the characteristics unique to that individual affect choice. Among other things, students will wish to maximize net present value of lifetime earnings. However, because of individual traits, the discount rate used to discount future earnings may be different for each student. Some students may have, for example, a greater need for money NOW than do others (they may have little wealth, be supporting families, buying houses, etc.). Differing attitudes towards risk can affect the discount rate. Consequently, students will have differing fears of employment and salary fluctuations. The quality of information a student can obtain about future employment conditions will vary from student to student. Depending on the degree of risk aversion, which in turn is partially a function of information, students will discount future earnings to a different degree.

Ability or aptitude is another factor, unique to the individual, which will affect choice. Ability can be both an absolute barrier - a student cannot meet the admissions standard - or a conditional barrier. Ability or aptitude will affect expected earnings and variance in earnings and employment. An able student can expect to command a high salary even if the demand drops drastically in his field. A less able student will tend to be the last hired, the first fired, etc. and he will have a low expected salary. A poorer student must also consider the fact that he may be unable to get a degree - a tremendous waste of investment in time and money. Also, a less able student may have to put more effort and time into his studies, leaving less time for other activities such as supporting a family.

Tastes and preferences will vary from student to student. Students will wish to choose programmes which interest them and which are relevant to them. Therefore, student background will influence choice; students may choose a department because of various hobbies they have pursued, classes they have taken, relatives they have in a particular field, etc. Each student will prefer different future job conditions. A student may choose a major because it can lead to jobs in which he can work with and can interact with others - or he may choose a major because it leads to the solitude of designing machine tools.

It is obvious that many of the characteristics influencing student choice of major which I have just mentioned are impossible to measure. Therefore, the student's choice criteria should be rewritten as

(3b) $V_{iy}(MDC_i, MIC_{iy}, NMC_{iy}) > V_{jy}(MDC_j, MIC_{jy}, NMC_{jy})$ for all $j \neq y$

where MDC_k is a vector of measurable characteristics common to department k

MIC_{ky} is a vector of measurable characteristics unique to the yth student and department k.

NMC_{ky} is a vector of all non-measurable characteristics.

A student will choose department i if (3b) holds. (3b) can be rewritten as:

(3c) $V_{iy}(MDC_i, MIC_{iy}) - V_{jy}(MDC_j, MIC_{jy}) > E^*_{jy}$ for all $j \neq i$

Where E^*_{jy} is an error term for the jth major and the yth individual, representing non-measurability, and errors in the data.

If one looks at the left side of the equation (3d), one can see the greater the (positive) difference inutility due to measured attributes, the greater the probability an individual will choose major i. The probability a student will choose department i is

(4) $P(V_{iy} - V_{jy} > E_{jy} \text{ for all } j \neq i) = P_i$

If we assume that the E_{jy} are independently distributed with the Weibull distribution then (see McFadden[6])

(5) $P(E_{jy} \leq n) = e^{-e^{-n}}$

If we assume that V is linear in the unknown market parameters then (see McFadden)

(6) $\log(P_i/P_j) = W_k MIC_{ijk} + W_2(MDC_i - MDC_j)$ ⟵ are the W's the weights or the estimated

where P_k is the probability that major k is chosen

W_k is a vector of weightings that the student places on each individual attribute.

MIC_{ijk} reflects the relative difference in individual attributes between departments i and j. For example, a high math grade may reflect a relative aptitude for physics (compared to Speech).

W_2 is a vector of weightings that the student places on each field attribute.

Let us consider that the data are generated by trial of drawing a student randomly from the population of all students, recording his attributes, and his actual choice of department. A sample is obtained by performing this trial N independent times. Further suppose that the number of replications is large - the number of students drawn with the same individual attributes is large. Let S_k be the number of students with the same characteristics who choose major k. When S_i and S_j are large (rule of thumb $S_k \geq 5$). $\log(S_i/S_j)$ is a close approximation of the left-hand side of (6) and estimates of W_k and W_2 can be obtained by applying weighted least squares to the model

(7) $\log(S_i/S_j) = W_k MIC_{ijk} + W_2 (MDC_i - MDC_j) + E_j$

where E_j is an error term (see McFadden).

Assuming a Weibull distribution makes computational problems relatively easy. However, an important corollary to this assumption about the distribution of the error terms is that it implies (see McFadden) independence of irrelevant alternatives. Formally, this means that

$$(8) \qquad \frac{P(i \mid c, \{i,j\})}{P(j \mid c, \{i,j\})} = \frac{P(i \mid c, \{i,j,k\})}{P(j \mid c, \{i,j,k\})}$$

where c = set of measured attributes

$\{a, b, c\}$ = set of alternatives

To give an example where this assumption is implausible, consider individuals who have the choice between taking cars to work or taking a yellow cab. Suppose 2/3 of them choose to take cars. Now suppose there were the additional alternative of taking a red cab. The independence of irrelevant alternatives would imply that they would only choose to take their cars 1/2 of the time - hardly plausible. One would expect that the individuals would still take cars 2/3 of the time and split the other 1/3 between the two cabs. The individuals should lump the cab options together in making the car-cab choice. The individuals will not distinguish between the two cab options. It is clear that this logit model should only be used where the alternatives are distinct and can be plausibly weighed independently by all students.

General Engineering at the University of Waterloo

I am specifically interested in the department choices of General Engineering students at the University of Waterloo over the years 1970-1979.

General Engineering is an elite, highly competitive, 4 2/3 year co-operative programme; only the best students are accepted into this programme. Over the years, the quality of the students in the programme has skyrocketed. About 500 students enter General Engineering each year (fewer in earlier years).

The co-operative system is a programme where students go to school for one term, then work a term in the field which they are most interested in. There are three semesters a year: to graduate a student must successfully pass eight semesters of classes and receive satisfactory work-term reports in each of his six work-terms. The quality of work-term jobs that a student can choose from and the wage rate he receives are extremely high. A fifth year student can expect to receive about $300/week[14] from his job. Industry recognizes that these students are the best engineering students coming onto the market. Since most of the students will end up working for one of their co-op employers for their first jobs, to get good students, industry must recruit the students while they are still in school. There are about three times as many jobs offered as there are students to fill them; a firm must make attractive job and salary offers if it wants to obtain any of these students.

This programme attracts the best students in Ontario, partially because the professors and instruction are known to be excellent, but primarily because the students know they will receive good high paying jobs when they graduate. The LOWEST salary a 1980 received was $16000/year, and the involuntary unemployment rate for graduates has been essentially 0% for years. Students also receive their high work-term wages and tuition is very low(($561.70 + $88.00/course)/semester); students live fairly comfortably while going to school. Furthermore, worries such as where to find summer and post-graduate employment,etc., are almost completely taken care of by others; the co-op system acts as a highly efficient low cost market for the students.

Students in General Engineering face a very structured, very difficult, unbelievably heavy, time-consuming workload. In their second semester of classes, students take a technical elective - either concents of Civil, Electrical or Mechanical engineering. Most of the students choose to go into the department that they took the technical elective from; students choose the technical elective they are the most interested in (most students have made firm choices by this time - see Appendix 2). There are also some slight costs in time of making up lost information if a student does decide to switch. To ensure that students have a solid basis on which to make their choice of department, students do not have to make a firm choice until they register for their second year of classes. Later a student can still switch departments, (it is also possible, theoretically, for a student to transfer from Chemical or System Design engineering) but it will take more than five years to complete the programme. Virtually NO students do this; the make-up requirements are too severe, and the financial benefits tend to be minimal.

Canadian School and Engineering System

Canada's education and engineering market are unique. Many students study engineering even though they eventually wish to enter business or management. This is because business and management recognize an engineering degree as a sign that the possessor is very bright and industrious. Business and industry tend to discount the 3-year (typically) general sciences degree as indicating little of a student's ability.

Partially as a result of this view, engineering students tend not to remain in the fields which they graduate from (and in which they almost always take their first job). About 2/3 of all engineering graduates in Canada were no longer in their field of last university training 15 years after graduation[7] (see Table 1).

Empirical Work*

To elicit the factors which students found to be the most important determinants of choice of department, a questionnaire was given to all first year General Engineering classes (see Appendix for a summary of the responses). The questionnaire was also designed to determine the degree of knowledge students had about the various market conditions.

Another survey of General Engineering students was made in 1979. From this study the attribute profiles of the prototypical Civil, Electrical and Mechanical students can be drawn. Unfortunately, it was not possible, particularly, to take advantage of this study. This is because it was not possible to obtain many measures of the individual characteristics of the student. Only grade 13 course and grade information, and university course, grade and rank information were available. Other information was unavailable because confidentiality laws restricted access and because much of the data have never been systematically collected. Still some attributes - relative interest and aptitude for a field - can be measured.

Various measures of relative aptitude for a field were considered. Among those originally examined were: grade 13 final average, math average, math-science average and first year General Engineering average, and first year rank. Eventually, math average, year one average and rank were selected for detailed examination. Students were broken down into classes (see Table 3, Table 4). Students were classified, for example, as having a very high, high, medium or low math average. For each of these measures, a high classification would reflect a relative aptitude for the more math-science oriented fields, especially electrical engineering. To put it in another way, a low classification may reflect a lack of aptitude for the more mathematical fields. At this time, it should be noted that a high math average may reflect a completely different aptitude for Electrical (relative to Civil) than for Mechanical (relative to Civil). A high math average will reflect a much higher aptitude for Electrical(over Civil) than for Mechanical (over

*The student data are from the Student Record File. These data contain the records of all students who ever entered engineering at the University of Waterloo. Unfortunately, there are gaps in the data - sometimes grades were not recorded because (for example) the student had already been accepted.

Civil).

Other measures reflecting a relative interest in several areas were constructed. A broad programme of study in high school should reflect a relative interest in Civil Engineering. The measures of breadth of interest constructed were the ratios on non-math-science-tech grades to math-science grades and to only math grades (discarded later). A high ratio, ie. relatively high grades in courses other than math and science, can be viewed as reflecting an interest in areas other than strictly mathematics. A high ratio could reflect a relative interest in and aptitude for Civil Engineering - a field which requires an individual to master a wide variety of very different skills. Conversely, a very low ratio would reflect a high concentration of interests in a few areas which would lead the student to Electrical Engineering. Another measure - a dummy variable which is 1 if a student took only maths, sciences and techs, and which was 0 otherwise was constructed. A 1 would reflect very narrow interests and would reflect a relative lack of interest in Civil Engineering.

There were several problems with the measures. One problem was high school grade inflation. (Please see Appendix 4 for a detailed description of the problem and for attempts to correct for it.) Another problem is grading in General Engineering. There has been grade deflation in this programme; the quality of student has gone up far faster than the grade. The standard (see Table 2) has fluctuated over the years; at least two obvious sharp changes in the grading standard can be discerned. Unfortunately, it was not possible to correct for these problems. For this reason, first year rank may be a more reliable measure of aptitude. Although it does not reflect the increasing quality of the students over the years, rank is still a consistent measure.

A final problem is that the courses high school students have had to take have changed over the years. After 1972, students were no longer required to take English. As time has passed, it has become more acceptable to take only mathematics and sciences in grade 13. To the extent that students with only math-science interests tended to enter one department, bias is introduced in the ratio of non-math-science-tech to math-science. In the later years, the pertinent sample of students - those who took courses other than math and science would be biased toward the other major(s). To use the ratio measure will cause the estimated probability that a student would enter a particular department to be biased toward the department which attracts students who take a variety of courses.* If in these later years, market variables tended to be lower than in earlier years, one would expect the coefficients of these variables to be biased downwards; if they are higher, the coefficients will be biased up. Another problem is that the sample size, in later years, is greatly decreased.

Because of the nature of the Canadian engineering market, the incentives of each engineering field are measured by starting and co-op salary.[6] To be specific, starting salaries of Waterloo engineering graduates, an average of the second to sixth and third to sixth work term salaries were used. There were large fluctuations in the rlative starting and co op saleries over the period 1970-1978: (In 1975 Civil graduates earned over $250 per year more than electrical engineering graduates (1970 dollars), by 1978, they were earning over $330 less.) To use starting salaries as measures of incentive is not unreasonable. If the study by F.E. Burke[7] in 1970 is still valid, it is difficult to see that measures of salary for those with 10-15 years of experience in a field would be meaningful - even if they were available. Since according to this study most (about 2/3 of the) students will not be in the field they graduated from 10-15 years later, why should they worry about salaries for those with 10-15 years of experience? Starting salary is more responsive than other salary measures to changes in supply and demand. A study of the trends in starting salaries can give the student an idea of future salaries. Finally, perhaps most importantly, students have easy access to the salary data. From talking with professors, fellow students - graduating engineers and those who have been on work-terms, and from their own work term experiences - students can get a good idea of salary figures. In addition, the University collects the data and they are available to any student who wishes to see them.** Because rational students should look at trends in salary data, and because almost 55% of the students claimed to have made a firm final choice of department before their first year of engineering began (see Appendix 2, but note that this 55% figure is undoubtably biased upward by the students who had "firm final" choices confirmed by their first few weeks of classes and by exposure

*In the years 1977-79 measured Civil probabilities were raised by an estimated .013 on average.

**Since the students really have no other good salary measures available, it is not unreasonable to expect the students to use starting & co-op salaries as measures of future salries.

to other engineering students), various weighted averages of 1, 2 and 3 years of salary figures were used. That is, if a student entered General Engineering in 1973, weighted averages of salaries for the scholastic years of 1973, 1972, and 1971 were tested.

In addition to the salary measures, two measures of the job markets were also used: numbers of jobs/students up for co-op placement (NJSP), and numbers of students unplaced at time t_i before work-term/students up for placement (NUSP). Numbers of jobs/student reflects employment opportunities, job variety and may be used as an indirect proxy by students for other related factors (salary) which may be difficult for them to measure. NUSP will reflect job availability.

There were tremendous fluctuations (see Graph 1) in the relative values of these two variables. In 1975 for example, Civil students had .2 of a job more to choose from than Mechanical engineering students; in 1972, each Mechanical student had 2.32 more jobs to choose from than the Civil students. There are good reasons for using these data with, or instead of, the salary data. Even though it may be unfounded (in the past few years, at least), there is still a feeling of job scarcity; students, I believe, would react more quickly to the knowledge that IBM is hiring x new electrical engineers than they would to the knowledge that IBM is offering high wages to electrical engineers. This belief is reinforced by the results of the questionnaire given to the first year students (see Appendix 2). Overwhelmingly, they found factors such as numbers of jobs and job security (slightly less so) to be more important to their choices of department than salary. Indeed, salary was a surprisingly unimportant factor in their choices. Not only are these job characteristics more important to the students, but information on them is more easily available to the student than salary data. All students will become aware of the relative job situations. A publication called "Want-Ads" is given to all students. This publication lists all available jobs, with descriptions by field but DOES NOT list starting salary. From these listings a student who is up for co-op placement determines which jobs he is qualified for and interested in, and he signs up for interviews with the prospective employers. Only at the interview, or through the student grapevine, will students get specific salary information. However, the numbers of jobs in a field will hit a student over the head; he must thumb through all those pages of "Want-Ads" which are filled with jobs for a particular field. Students up for placement will almost necessarily get an idea of the numbers of jobs in a field.

Students will also be sensitive to those students who are unplaced in co-op jobs or who are having to settle for relatively poor jobs. Job availability IS important to the students; information about unplaced students spreads quickly. To be unplaced is especially worrisome because most students upon graduation work for one of their work-term employers; to be underemployed may be to lose an option for future employment. Various weighted averages of 1,2, and 3 years of job data were used.

There were a few problems with these data. One problem was that data on numbers of unplaced students were only available for the years 1972-1980 and data on numbers of co-op jobs for the years 1974-1980. A problem with the measure of numbers of co-op jobs is that job recruitment efforts were not the same for all departments for all terms. If several Civil engineering students were, for example, unplaced, the placement office would increase its search for Civil engineering jobs. Similarly, if there were NO mechanical students unplaced, few searches would be made for mechanical engineering jobs. The result of these altered recruitment efforts is to flatten out differences in the data. The measured differences in numbers of jobs would be less than the actual difference.

A problem with the measure of students who were unplaced is that, by the time of an actual work-term, almost no students are unplaced. Those who are tend to be unplaced for non-economic reasons such as illness. To obtain an idea of those students who may have had to settle for poor jobs and to avoid the increased recruitment problem, I looked at those students who were unplaced at some point t_i before the ith work term. Unfortunately, t_i was determined by the data which I had - I was using the working records of the co-op placement office. Therefore t_i varies from term to term and sometimes (because records were lost or thrown away) only final data were available. To the extend that final data may not accurately reflect the situation, or that students in one field may tend to be placed earlier than those in the other fields, noise and error may be introduced. The exact nature of the noise and error was impossible to determine.

The Basic Regression Form

Equation (7) was estimated using weight least squares (OLS results were very similar because cell sizes tended to be the same - see Thiel[12] for a justification of weights). The grade and rank data for each student were broken down into ranges. For example, students were classified as having a very high, high, medium or low math grade. Students with the same grade (or rank) characteristics who entered General Engineering in the same year and who made it past the first year (i.e. made a choice of Civil, Electrical or Mechanical) were grouped into the same cell (see Table 3 for a typical classification). The time-series regression models were of the form

$$(11)\quad W_{cji}\log(S_{ci}/S_{ji}) = W_{cji}\beta'(X_i + M_{ci} - M_{ji}) + U_i$$

where S_{ci}/S_{ji} = ratio of number of civil students to the number of electrical engineers (or mechanical engineers) in the ith cell

W_{cji} = the square root of $(S_{ci} + S_{ji})$

X_i is a vector of dummy variables representing individual characteristics for cell i

$M_{ci} - M_{ji}$ is the difference between vectors of market variables for Civil and (either) mechanical or electrical engineering for the ith cell (i.e. for the year of the ith cell - if a student entered General Engineering in year n, market data pertinent to his choice were used - data from year n+1 (and perhaps years n and n-1)).

Note that two regression equations must be estimated. This is because the individual characteristics are essentially scaled in a different fashion. For example, a high rank may reflect a completely different relative aptitude for electrical (compared to Civil), as opposed to mechanical (compared to Civil). If the scales were the same, then the mechanical data could have been combined with the electrical and only one regression equation (with twice as many observations) would have had to have been estimated.

RESULTS

The results (see Table 5) of the analysis were very interesting. To put it bluntly, the fluctuation in the relative job markets explain most of the variation in the probability a student will enter Civil Engineering. The degree of explanation was surprisingly high ($R^2 > .6$ consistently) as were the large sizes of the coefficients. As is reflected in the answers to the questionnaire on factors influencing choice of departmen, students are extremely sensitive to the relative job markets. Students respond very quickly to changes in the market. The best explanation of choice of department occurred when a weighting of 2:1 was used. (If a student entered General Engineering in 1975, a weight of .67 placed on the market data for 1975 and a weight of .33 placed on the data for 1974 best explained his choice.) Three year averages of any sort decreased the degree of explanation.

Students are especially sensitive to the relative numbers of jobs in a field. The more jobs per student in one field relative to a second, the more likely a student will enter the first field. In 1979, there were over two more jobs per student in Mechanical Engineering than in Civil Engineering. The probability was .69 (.70 estimated by regression 2, Table 5) that a student choosing between Civil and Mechanical would choose Mechanical. Given the same distribution of individual student characteristics, if there had been as many jobs per Civil student as Mechanical, approximately 52% of the students would have chosen Civil. Similarly, instead of 69% of the students choosing Electrical (74% predicted) instead of Civil, if the job conditions were equal in the two fields, 48% would have chosen Civil. Grouping the three department options together, instead of 19% choosing Civil, 41% Electrical and 41% Mechanical, 34% would have chosen Civil, 31% Mechanical and 36% Electrical if the market conditions had been equal. The estimated coefficients for the variables measuring the relative numbers of jobs were very large (and consistently significant at the .005 level) and, as expected, similar - $B_{CE,NJSP}=.60$, $B_{CM,NJSP}= .55$. At the means, the elasticity of the probability a student will chose Civil with respect to NJSP is very low. This is not surprising as the means are very close to 0; a doubling in the relative numbers of jobs is trivial - few students would be influenced enough to change their choices of departments. However,

(12) $E_{PC,NJSP}=(1-PC)(B_{NJSP})(NJSP)$

where PC = probability that a student chooses Civil = $(1+e^{-B_iX_i})^{-1}$

B_{NJSP}= estimated coefficient of NJSP

clearly increases quickly as the relative difference in numbers of jobs increases. If there were 1.5 fewer jobs per Civil student than Electrical or Mechanical student, using the means of the other variables, the respective elasticities would be approximately -.47 and -.371. As should be expected $E_{PC,NJSP2:1}$ - the elasticity for the 2:1 weighted average - is even greater; if there were 1.5 fewer jobs/Civil student than for EE or ME, then the elasticities would be -.66 and -.56 respectively.

Relative job security (chances of being unemployed or underemployed) as measured by the difference in fraction of students unplace, was almost as significant as relative numbers of jobs in explaining the changes in the probability a student would choose Civil Engineering. The smaller the fraction of students unplaced in field 1 relative to field 2, the greater the probability a student will choose field 1. The estimated coefficients of NUSP were consistently large and significant at the .005 level - $B_{CE,NUSP}=6.43$, $B_{CM,NUSP}= 6.66$. $E_{PC,NUSP}$, although relatively high, appears to be somewhat lower than $E_{PC,NJSP}$. If there were .06 more Civil students unplaced/Civil student than there were in either Electrical or Mechanical Engineering, then the elasticities would be -.26 and -.24 respectively. As the two job measures reflect almost the same characteristics the two measures are highly correlated. NUSP becomes completely insignificant and its estimated coefficient completely meaningless when it is placed in the same equation as NJSP.

As the answers to the questionnaire on factors influencing choice of department lead us to believe, starting salary is a very unimportant factor in determining which department a student chooses. Students do not appear to be overly concerned with salary. When starting salary is included in any of the equations containing measures of the job market, it is always insignificant and its estimated coefficient is very small. When job measures are not incorporated into the same equation as starting salary, its estimated coefficients are significant (at the .025 level) and positive.

Do correlation between salary & # of jobs?

The estimated coefficient of co-op salary is always insignificant. The most likely reason for this lack of significance is that co-op salary is measured in weekly statistics; the classic numerical analysis problems of subtracting nearly equal numbers and significant digits (rounding can effectively disguise a $100/year salary difference) make this variable a useless measure.

Individual characteristics unique to a student were also very important factors in determining the probability a student would enter Civil Engineering. Students found relative aptitude for a field - as measured by first year rank - to be an extremely important factor in their choice. Students with a high rank - reflecting an aptitude for Electrical Engineering - were much less likely than students with a low rank to choose Civil Engineering. Assuming equal job market conditions in EE and CE, a student with a high rank would enter EE with probability .59; a student with a low rank would choose EE with probability .45. The estimated coefficient of rank is very large in the Electrical equations (around .195) and it is significant at the .005 level. The elasticity of the probability a student will enter Civil with respect to rank is moderate; the elasticity at the means is -.15.

As expected the estimated coefficient of rank in the Mechanical equations is significantly lower than that in the Electrical equations. One can apply the standard Chow test to the coefficients of rank in the two equations to test the hypothesis that they are equal. The null hypothesis that the coefficients in the Mechanical and Electrical equations are equal can be rejected at the .005 level (calculated F = 41.45. This is what one would expect - a high rank indicates less of an aptitude for Mechanical (relative to Civil) than for Electrical (relative to Civil). To eompensate for the different scaling, the coefficient of rank in the Mechanical equations should be smaller. The estimated coefficient of rank in the Mechanical equations is still positive - about .12 - and significant at the .01 level. Rank has a large effect on the probability a student will choose Mechanical Engineering. Given equal job market conditions in the two fields, a student with a high rank will choose ME with probability .53, a student with a low rank will choose Civil with probability .56. The estimated elasticity of the probability a randomly selected student will choose Civil with respect to rank is rather low in the Mechanical equation - hovering around .10.

If the three department options are grouped together, given equal job markets, a randomly selected student with a high rank will choose EE with probability .40, ME with probability .32, and CE with probability .28. An individual with a low rank would be expected to choose CE with probability .38, EE with probability .31 and ME with probability .30.

First year General Engineering average was not as good a measure of relative aptitude as rank. There was too much noise in the measure - grade deflation, changing grade scales, etc. which could not be filtered out.

The high school grade measures were disappointing as well. Although there was an attempt to correct for grade inflation, it appears that it was largely unsuccessful. Especially disappointing was the lack of significance of math grade. It was hypothesized that a high math grade would indicate a relative aptitude for Electrical (as compared to Civil) Engineering. If this <u>were</u> a good measure of relative aptitude, it could be useful in determining admissions policies. Unfortunately, undoubtedly due to the problems with grade inflation, math grade was largely insignificant. The estimated coefficient of math grade was completely insignificant in the mechanical regression equations ($t < .4$) and was only <u>marginally</u> significant in the electrical equations.

The estimated coefficient of the ratio of the non-math-science-tech grades to math-science grades, measuring the relative degree of interest (or lack thereof) in Civil Engineering was highly significant in the Electrical regression equations, but insignificant in the Mechanical equations. The problem of grade inflation is washed out by taking the ratio. Students with high ratios reflecting a relative interest in the field of Civil Engineering - a field which requires students to be skillful in many areas - were much more likely to choose CE than EE - a field which requires tremendous skills in a very few areas. Given equal job markets, a student with a high ratio will choose Civil with probability .56; a student with a low ratio will only choose Civil with probability .37. The coefficient of ratio was large (-.397) and significant at the .005 level. The elasticity at the means was fairly high (-.21).

The coefficient of ratio in the Mechanical equation was negative, as expected, but insignificant. Since ME does not require the same narrow specialization as EE, and thus the relative difference in interest between CE and ME reflected in a high ratio is not as great, this is not surprising. To test the hypothesis that the two coefficients were equal, a standard Chow test was applied. The null hypothesis that the two coefficients of ratio were equal could be rejected at the .005 level (claculated F = 31.9). Given equal market conditions, the probability a student with a high ratio will enter ME is .47; a randomly selected student with a low ratio will choose ME with probability .52. The elasticity at the means was fairly low (-.06). As hypothesized, the estimated coefficients of the job measures appear to be biased downwards in both the Electrical and Mechanical regression equations. They are biased downwards because in the late 1970's the sample of students was weighted toward CE and the relative job market for Civil Engineers was poor.

The results from the other measure of relative interest, ie. the results of the equations with the dummy Z, were at first glance surprising. Z was constructed to be 1 if a student took only math, science and tech courses, 0 otherwise. In both the Mechanical and Electrical equations, the estimated coefficient of Z was negative, as expected. However, the estimated coefficient of Z in the Mechanical regression equation was <u>more</u> significant and larger than the estimated coefficient of Z in the Electrical equation. This result, I believe, occurs because students who tend to enter Mechanical are more likely to branch out into the tech courses for a sixth or seventh grade 13 course. The null hypothesis that the two coefficients were equal could be rejected at the .01 level. A student with a "broad" high school course load, could be expected to choose CE with probability .35, EE with probability .35 and ME with probability .29. Assuming equal market conditions, a student with a "narrow" course load will choose CE with probability .31, ME with probability .32 and EE with probability .37.

From the results of this study, it is clear that the relatively poor market for Civil Engineering graduates has been largely responsible for the decrease in the fraction of students entering Civil Engineering. Students respond very quickly to changes in the job market. As a result, the fraction of students entering a particular department tends to fluctuate wildly. Five years ago the market for electrical engineers was poor and few students chose EE. Today the poor market for Civil graduates has created the paradoxical situation where the fifth year Civil class is the largest of the three classes and the fourth year class is by far the smallest. The answers to the questionnaire on factors influencing choice of department indicate that the situation will not improve much this year. Students in this year's first year class, even those who intend to enter Civil Engineering believe strongly that there are fewer job opportunities, lower salaries, less job security...in Civil than in either EE or ME. Students will not enter CE in much larger numbers until the Civil market improves relative to the other fields.

What possible policy implications could these findings have? What, if anything can be done to dampen the tremendously unsettling oscillations in department choice - oscillations which merely reflect a high degree of sensitivity on the part of the students to the cyclical nature of the relative job markets? The first, most basic, conclusion is that nothing drastic should be done. It is clear that the problem is a short-run phenomenon - it will only last as long as the relatively poor market for Civil Engineers continues. If there were as many jobs in CE as in the other fields, then approximately equal numbers of students would enter each department. Therefore, one strategy which should not be adopted is to have a separate admissions programme for CE. There are (at least) two serious reasons why this strategy should not be adopted. First, many students would be forced to make choices between CE and EE or ME before they had a good idea of what the fields were actually like. To force students to make uninformed decisions can cause problems. Also, if there were separate admissions programmes, by the time the Civil market were to recover, CE could easily attract a second-class label; it might be forced to accept students EE and ME had rejected. This stigma might prove hard to remove.

There are some admissions policies which could be adopted which would increase the fraction of students who choose Civil Engineering without bringing any undesirable side effects (such as a stigma or large class sizes). It should be noted that students who enter CE tend to have broader high school backgrounds. Students who choose Civil Engineering are more likely to take courses in the Arts and Social Sciences than students who choose Electrical or Mechanical Engineering. Grades for these non-math-science courses tend to be only about .92 of the math-science grades; students who take a variety of courses will have lower overall averages (of perhaps 1-2%) as a consequence. It may be that these students should have their lower final grades raised slightly to compensate for their taking these courses which lower thier average.

An alternative policy (see Appendix 3 for a more detailed description) would be to choose more students who have relatively high non-math-science-tech/math-science ratios. If, for example, half the students who entered General Engineering in 1977 had high ratios, 25% medium and 25% low ratios, then (for convenience assume all students took non-math-science-tech courses) about 2% more students would have entered Civil than actually did. That is if the class size was 500, about 10 more students would have chosen Civil.

Another similar option would be to accept more students with broad high school backgrounds. If, for example, 80% of the students accepted in 1978 had broad high schoold backgrounds (took [illegible] than math-science-tech in Grade 13), then approximately an additional one percent of the student body would choose Civil. As is evident, changing the admissions policies would help increase the fraction entering Civil, but the effect would be minor. There are many other possible permutations and combinations of these addmissions options which could be pursued, but none would have large effects on the numbers entering Civil. On the other hand, none of these options, if implemented, would have major undesirable side effects either.

If admissions policies are not a target for policy, but it is desired that the fraction of students entering Civil be increased, then there are a few options which could be considered. Students, as mentioned previously, believe that the market for Civil Engineers is relatively much worse than the markets for the other two fields. When the relative market for Civil engineers finally improves, to speed up the increase in numbers choosing CE, students should be exposed as quickly and as thoroughly as possible to information about the relative market changes. The more students who believe the market for Civil Engineers is good, the more students who will choose to enter CE.

Another point which should be noted is that Electrical Engineering students tend overwhelmingly to be least interested in CE and vice versa (see Appendix 2). Civil and Electrical students tend to have very different interests and aptitudes which keep them out of each other's fields; probably relatively few EE students would switch to CE if the relative markets changed (some Electricals may switch to ME and some ME students to CE). Therefore, it probably makes more sense to look at those students who are now interested in ME and to try to increase these students' interest in Civil Engineering.

Summary and Conclusions

The decrease in the fraction of students entering Civil Engineering is a direct response by the students to a cyclical downturn in the market for Civil Engineers. When the market for Civil Engineers improves RELATIVE to the markets for Electrical and Mechanical Engineers, then more students will enter Civil Engineering. Because of the bad market for Civil graduates, students who would have chosen CE are now entering the other two departments. This is reflected, I believe, in the profiles of the prototypical students (see Appendix 1); one is struck by the similarity between the profiles of those who wanted to enter Civil Engineering and those who were unsure which department they would choose. Were most of these students who were undecided, students who would have entered CE but for the job market for Civil Engineers? Are they undecided because their interests and aptitudes lead them toward Civil Engineering - but they are turned away by the market and therefore are unsure of which department they want to enter? When the market for Civil Engineers improves, these and other students will shift quickly back into Civil; engineering students react very quickly and strongly to changes in the market.

Students appear to be most responsive to numbers of jobs per student in a field. Both the answers to the questionnaire on factors influencing choice of department and the regression analysis support the conclusion that this is the most important market factor affecting choice. The greater the relative number of jobs in a field, the greater the probability a randomly selected student will enter that field. Students are only slightly less sensitive to relative job security. The greater the relative job security, ie. the smaller the relative fraction of students unplaced, the greater the probability a student will enter that field. Engineering students are not nearly as concerned about relative salary as they are about the relative job market. Students stated that salary was not an important factor influencing their choice of department, and the regression analysis bears this out. After the effect of the job market is taken into account salary becomes completely insignificant.

Civil and Electrical Engineering tend to draw two very different types of students. The large majority of students who want to enter Electrical, are very uninterested in Civil; similarly, most Civil students are not interested in EE. Mechanical Engineering, it appears, draws both those students who are also interested in Civil and those who are interested in Electrical Engineering. Students who intend to enter either CE or EE, overwhelmingly would choose ME as their second choice. This pattern is seen elsewhere. Students who choose Civil, for example, have high school averages which are about five points lower than those interested in Electrical; Mechanical grades are spread over the two ranges. A high first year rank indicates a much greater aptitude for Electrical (compared to Civil) than it does for Mechanical (relative to Civil). Similarly, a high ratio of non-math-science-tech grades to math-science grades, ie., a demonstration of a command of several fields, indicates a much greater relative interest and aptitude for Civil (compared to Electrical) than it does for CE (compared to ME).

In the past few years, the characteristics of the average student who enters General Engineering has changed somewhat. The student today, tends to have a narrower high school background consisting more strictly of maths and sciences than he used to. More students are taking these courses and a few others (electronics and computer courses) which may especially stimulate an interest in Electrical Engineering. Fewer students who enter General Engineering are taking a wide variety of courses which would develop an interest in Civil Engineering. These students also have higher high school grades. To some extent these students may be crowding out students who used to enter Civil Engineering, but who, because they wish to master a wider variety of courses in high school, have lower grades and are no longer being accepted into the programme. However, the magnitude of the effects of this demographic shift in student population upon the fraction which chooses Civil, is almost certainly insignificant. The market is primarily responsible.

While waiting for the market for Civil Engineers to improve, it is still possible to increase somewhat the fraction who choose Civil. Since in addition to the market conditions, these various individual characteristics do affect choice of department, it is possible to increase the fraction of students who choose Civil Engineering by changing the admissions policies. It is possible to reverse the trend in the type of student being accepted. A number of possible changes have been mentioned which would increase the fraction who choose Civil. It might be possible, for example, to increase the numbers of students admitted with broad backgrounds of high school study, or to compensate students for the lower grades they receive in courses other than math or science (grades in these courses are only .92 the math-science grades). Students might be encouraged to take a greater variety of high school courses. Any of these suggestions, if implemented, would increase the fraction of students which chooses Civil. Unfortunately, the increase would almost certainly not be very great - perhaps 10-20 students. Save for the implementation of some of these policies, there is little to do except sit back and wait and hope for an improvement in the market for Civil Engineers.

APPENDIX 1

In the fall of 1979, a survey was given to all engineering freshmen by the engineering counselling services at the University of Waterloo. From the summary of the results of the survey (the survey was confidential and only the summary was available) profiles of the prototypical Civil, Electrical, and Mechanical engineering students can be drawn.

Students interested in entering Civil engineering typically did less well in high school (grade 13 average mark between 75-79%) than electrical (80-84%) or mechanical (75-89%) or Undicided (80-84%), and also felt they would do less well in engineering (about 5% lower than either electrical or mechanical students, but about the same as those students who were undecided.)

Civil students had more general reasons for choosing Civil engineering ("It suits me") and 33% had the goal of using their education as a "'job ticket'". More Civil students wanted to be generalists - 48% - than specialists - 29%, and a few wanted to go into pure research-5%. Electrical students had specific computer/electronics interests; 24% wanted to go into electrical engineering so they could design computers. They had much more specialized interests (20% wanted to do pure research, 53% wanted to be specialists, 20% generalists). One third of the mechanical students had specific machine/tool/auto design interests and 32% had the goal of using mechanical engineering as a "'job ticket'". Mechanicals preferred specialization - 39% - to generalization -35%. Students who were undecided about which field to enter were interested in using their degrees as a job ticket -27%. They typically had more Civil interests - 20% - than electrical - 5% or mechanical interests - 3% (72% did not know where their interests lay). More of the undecided students were interested in generalization than specialization.

The high school background of Civil students reflected their broader interests. Their best subjects (which correlated highly with the ones they were most interested in) were mathematics and the non-math-science-tech courses: geography, languages, etc. They were very active in sports/school activities (82%) and had general hobbies. 70% had no experience with computers and almost none had computer or electronics hobbies.

Electrical students were best in the math-science-computer-electronics areas. They had more narrow interests--only 67% were involved in sports/school activities. They had specific computer (8%) and electronics (30%) hobbies and 50% of the electrical students had some computer background.

Mechanical students were best in the maths and sciences. 72% were active in sports/school activities and they had general hobbies.

Those students who were undecided about which department to choose were best in the maths and non-math-science-tech-courses. They had "medium sports/activities interests", had general hobbies and had "very low computer/electronics interests."

Appendix 2

The questionnaire on factors influencing choice of department was given to each first year General Engineering k-section in early November, 1980 (about six weeks into the semester). The responses of those students who completely filled out the questionnaire and met various validity and consistency checks and whose answer sheet were read correctly by the OPSCAN reading machine were considered. A total sample of 343 responses were used. The following is a partial summary of the responses.

Of the 343 students whose responses were used, 70 of them intended to enter Civil (15 had switched to Civil from another field), 129 intended to enter Electrical (11 had switched from another field), 112 intended to enter Mechanical (28 switched from another field) and 32 students were unsure which field they intended to enter (21 had initially preferred another field). It is interesting to note that there has been a flow of students who initially preferred Electrical into other fields (-10 net). Mechanical (+15) had the greatest inflow of students, Civil (+2), and Undecided (-7).

Students who intended to enter EE tended to make their firm final choices much earlier than the other students. About 70% had made the firm decision to enter EE at least one year before they answered the questionnaire. Only 35% of the students who intended to enter Civil, and 34% of those interested in Mechanical Engineering had made firm choices (or claimed to have made firm choices) by that time. This is partially the result of the net inflow/outflow of students who had switched department interests; those who switched to Mechanical or Civil could hardly have made firm final choices more than one year ago. It is interesting to speculate why students interested in EE made their choices so much earlier - in Ian Smart's study, ME students made their choices far before EE or CE students. Is it because the financial conditions for EE were relatively better a year ago (as they were for ME two years ago)? Is it more of a long term phenomena - students are being attracted to EE during high school because of the courses (computer/electronics) they are taking? In light of the study which I have just completed, I believe that the first explanation is correct; the

Appendix 3

relatively good financial conditions for Electrical engineers probably explains most of the observed difference in time of final department choice.

Students generally did not consider differences in starting or co-op salary to be an important factor in their choice of department. Only 3% of the CE students, 5% of the EE students, 11% of the Mechanical students and 3% of those who were undecided considered starting salary to be more than slightly important. The students DID know that Civil Engineering did not have the highest starting salary - only 3% of the students and NOT one student who intended to enter Civil believed that Civil Engineering had the highest starting salaries; those who were not unsure believed about 4:1 that Civil had the lowest starting salaries. A few more students felt that the highest starting salaries were to be found in EE than in ME. However, about half of the students were unsure which field had the highest salary.

Students found the relative numbers of job opportunities to be much more important. About 75% found the relative numbers of job opportunities in each field to be at least a "rather important" factor when considering their choice of department. 17% of the Civils, 5% of the Electricals, 7% of the Mechanicals and 6% of the Undecideds felt CE had the most opportunities; 34% of the Civils, 61% of the Electricals, 24% of the ME students and 22% of the Undecideds felt EE had the most; 26% of the Civils, 11% of the EE students, 47% of the ME students felt ME had the greatest number of opportunities. More than 50% of the students felt Civil had the fewest number of job opportunities (33% of the CE students felt so) - and only 26 students felt either ME or EE had the fewest number of opportunities. Students were rather confident of their ratings.

A slightly smaller number of students, about 60%, found job security (risk of unemployment) to be at least a "rather important" factor when considering their choice of department. Students tended to feel their field was the most secure (Civil students to a lesser degree), although almost 45% were unsure which field was the most secure. Most students (even Civil students) who had an idea which field was least secure, felt that CE was the least secure.

About 80% of the students found relative chances for advancement to be at least a "relatively important" factor when making their choice of department. This is interesting because students also indicated high levels of uncertainty about which fields had the best (40%) and worst (60%) chances for advancement. Students may use numbers of job opportunities as a proxy for this factor.

As expected, relative interest in each field was a vital factor for students when making choices of department; 88% of the Civils, 82% of the EE students, 81% of the Mechanicals and 85% of those who were undecided found that relative interest was a vital factor in their choice of department. As expected, students were most interested in the fields they were in (5 EE or ME exceptions). Undecideds were evenly split in their interests. What was most interesting were the fields students were least interested in. Overwhelmingly, those interested in CE were not interested in EE and vice versa; 63% of the Civils were least interested in EE (19% unsure), and 62% of the electricals were least interested in CE (26% unsure). Mechanical and Undecided students were split evenly- 37% of the ME students and 28% of the undecideds were least interested in CE, and 45% of the ME students and 25% of those who were undecided were least interested in EE. Only 19% of the Civils, 13% of the Electricals and 13% of the Undecideds were least interested in ME.

Students did not find either relative course load or class size to be important factors in their choices of departments.

Appendix 3

These probabilities were obtained by solving for

$$(1)\ P(C) = \sum_{D=1}^{n} P(MC;IC=D)P(IC=D)$$

where $P(MC;IC=D)$ is the probability a student with individual characteristic D will enter Civil Engineering given the market conditions MC

$P(IC=D)$ is the probability a student will have characteristic D.

Note that $\sum_{D=1}^{n} P(IC=D) = 1$.

$P(IC=D)$ can be arbitrarily controlled through various admissions policies - thus partially determining the probability a student will choose Civil Engineering.

Appendix 4

High school grade inflation has been a serious problem for about 10 years. In 1969, province-wide exams in all grade 13 courses were dropped. This left no common standard for comparison of students; there are no admissions exams. As a result, many high schools inflated their students' grades--to get more of their students scholarships, to get more into universities, etc. This is a recognized problem. The University of Waterloo now uses the following correction factor:

(9) $G_i \equiv G_{hi} + (UW_h - G_h)$

where G_i is the corrected grade for the ith student
G_{hi} is the raw grade for the ith student from the hth high school
UW_h is the average first year grade of a student from high school h who enters engineering at the University of Waterloo
G_h is the average high school grade of a student from high school h who enters engineering at the University of Waterloo

This measure is fine for the University of Waterloo. Unfortunately, their corrected factor is biased downward in the later years. This is because the engineering faculty has had grade deflation; the quality of student has gone up faster than the grade. Therefore, the correction factor used was:

(10) $HSG_{1j} = HS_{ij} + (UWCG_{i+1,j} - HSCG_{ij}) - (UWWC_{i+1,j} - WCG_{ij}) - I_i$

where HSG_{ij} is the corrected grade of the jth county, ith year

HS_{ij} is the raw high school grade of the jth county, ith year

$UWCG_{i+1,j}$ is the average county grade in first year engineering

$HSCG_{ij}$ is the average high school grade for students from the jth county in the ith year

UWWC = UWCG for Waterloo County

$WCG_{ij} = HSCG_{ij}$ for Waterloo County

I_i is the percent of students in Waterloo County who had an an average greater than 80% in year--the percent greater than 80% in 1969.

The assumption is made that grade inflation is constant within a county board of education, but can vary from county to county. Since there is considerable movement of teachers from school to school within the county, and that county boards may, to some extent, set grading standards, this is not an unreasonable assumption. County grade was used instead of high school grade because school sample sizes were not large enough. The unfortunate feature of this correction factor is that it limits the sample to students from Ontario whose county was recorded of the SRF tapes.

TABLE 1

1967	Graduates	Graduates working in field	All engineers working in field
Civil Engineers	9742	4277	5426
Electrical Eng.	8138	4257	6316
Mechanical Eng.	7920	1739	2656

TABLE 2

Year	high first year average	low first year average
1970	106	165
1971	116	154
1972	126	220
1973	139	174
1974	137	250
1975	137	239
1976	160	207
1977	170	192
1978	198	164
1969	124	107

TABLE 3

	I=7	very high rank	high rank	medium rank	low rank
	Civil	32	27	40	53
1976	Electrical	45	29	32	23
	Mechanical	32	34	35	25
	Civil	21	36	33	48
1977	Electrical	39	23	30	44
	Mechanical	37	37	34	40

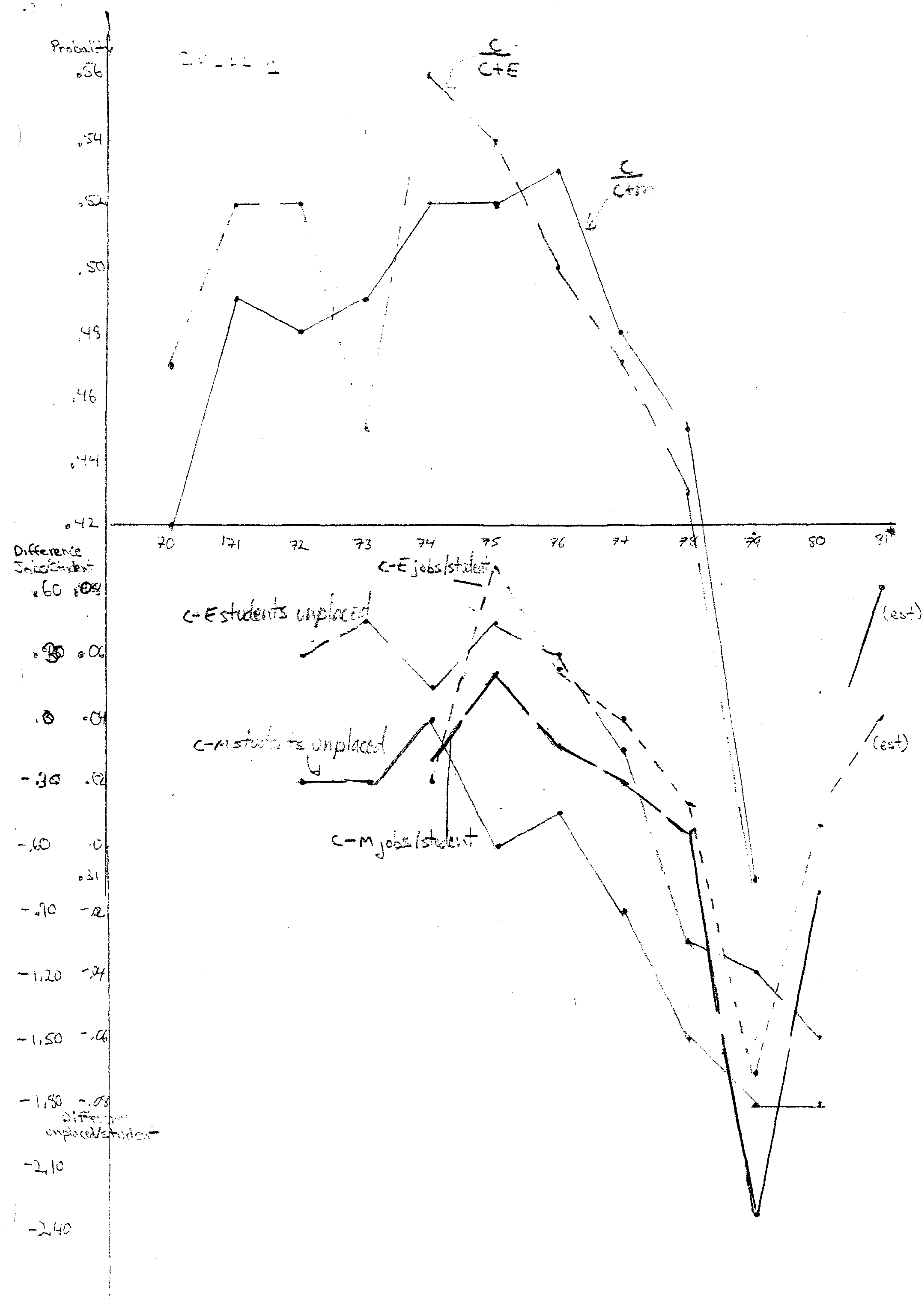
TABLE 4

	very high	high	medium	low
Rank	>80	>62	>45	<45
Math	>85.1	>79.1	>72.1	<72.1
Ratio	> .965	> .865	< 0.865	
Dummy	0	1	2	3

TABLE 6

Summary Statistics

	Civil-Electrical		Civil-Mechanical	
	Mean	Standard Deviation	Mean	Standard Dev.
SJDR	-.2375	.7446	-.5497	.8403
SJDR2:1	-.1191	.6369	-.4648	.6505
NUSP	.0308	.0425	-.0102	.0396
NUSP2:1	.0314	.0397	-.0095	.0367
SDR	-11.30	18.92	-12.6	17.05
SDR2:1	-11.00	15.27	-12.07	11.06
WEIGHT-RANK	7.93		8.00	
WEIGHT-RATIO	6.72		6.76	



Probality
.56
.54
.52
.50
.48
.46
.44
.42
C/C+E
C/C+M
70
71
72
73
74
75
76
77
78
79
80
81*
Difference jobs/student
.60
.30
-.30
-.60
-.90
-1.20
-1.50
-1.80
-2.10
-2.40
.08
.06
.04
.02
-.02
-.04
-.06
-.08
Difference unplaced/student
C-E jobs/student
C-E students unplaced
C-M students unplaced
C-M jobs/student
(est)
(est)

TABLE 5 (cont.)

* significant at .01 level
** significant at .025 level
**** significant at .10 level

1. F for regression
2. individual t
3. standard error of B
4. elasticity at mean
5. elasticity at NJSP=-1.0 (other variables at means)
6. elasticity at NJSP=-1.5
7. elasticity at NUSP=-.06

NJSP - # of jobs (coops) per student

TABLE 3

CIVIL-ELECTRICAL | CIVIL-MECHANICAL

1

C	RANK	SJDR	N	C	RANK	SJDR
-2.68	.196	.464	24	-.77	.113	.397
28.65*[1]	4.38*[2]	6.14*		20.00*	2.60*	5.99*
R^2=.73	.045[3]	.075		R^2=.66	.043	.066
		-.058[4] -.290[5] -.471[6]				.098[3] .23 .374

2.

C	RANK	SJDR2:1	N	C	RANK	SJDR2:1
-2.99	.192	.602	20	-.945	.12	.550
27.17*	4.04*	6.14*		18.11*	2.55*	5.66*
R^2=.76	.047	.098		R^2=.68	.047	.098
	.15[4]	-.04[4]-.40[5]-.66[6]			.10	-.14-.34-.56

3.

C	RANK	NUSP	N	C	RANK	NUSP
-5.01	.214	6.43	32	-1.77	.113	6.66
23.50*	4.78*	5.14*		14.20*	2.66*	4.94*
R^2=.62	.045	1.25		R^2=.49	.043	1.35
		-.10[4]-.26[7]				-.036 -.24

4.

C	RANK	NUSP2:1	N	C	RANK	NUSP2:1
-5.43	.209	7.12	28	-1.82	.119	8.06
24.10*	4.66*	5.23*		18.08*	2.87*	5.61*
R^2=.66	.045	1.36		R^2=.59	.042	1.436
		-.12 -.295				-.041 -.293

5. Civil-Electrical

C	RANK	SAL2:1	SJDR2:1	N
-2.90	.193	.0039	.524	20
17.55*	4.00*	.60	3.17*	
R^2=.77	.048	.0064	.165	

6. Civil-Mechanical

C	RANK	SAL2:1	SJDR2:1	N
-.792	.122	.0042	.507	20
12.03*	2.55**	.80	4.40*	
R^2=.69	.0478	.0052	.115	

7.

C	RANK	SAL2:1	N	C	RANK	SAL2:1
-2.71	.236	.0094	40	-1.09	.103	.013
13.55*	4.56*	2.33**		6.24*	2.31**	2.79*
R^2=.42	.052	.0040		R^2=.25	.045	.0046
		.054[4]				.087[4]

8.

C	MATH	NUSP	N	C	MATH	NUSP
-2.86	.072	5.80	32	-.0794	-.0073	5.35
11.89*	1.48****	4.28*		9.65*	-.190	4.38*
R^2=.45	.049	1.35		R^2=.40	.039	1.22

9.

C	RATIO	SJDR	N	C	RATIO	SJDR
1.933	-.397	.431	18	.996	-.103	.322
17.25*	-4.28*	3.76*		3.95***	-.91	2.68*
R^2=.70	.093	.115		R^2=.35	.114	.120
	.21[4]				.06[4]	

10.

C	Z	SJDR2:1	N	C	Z	SJDR2:1
-.15	-.156	.629	20	1.52	-.220	.558
18.63*	1.03	6.00*		15.44*	1.48****	5.46*
.69	.151	.105		.64	.148	.102
	(.02)[4]					