IS GRADUATE SCHOOL WORTH IT?

A Cost-Benefit Analysis with Some Second-Order Twists

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LAST SUMMER WHILE sitting on a bench on the Plaza in Santa Fe, New Mexico, I noticed someone wearing a tee-shirt with the interesting slogan, "Whoever has the most stuff when he dies wins" [1]. This is a rather crass statement of a philosophy of life, but it clearly and cleverly expresses the economic aspects of our culture. Not all decisions are made primarily for economic reasons, but the economics of any major decision should be considered. Let's take a look at the economics of a chemical engineer getting an advanced degree. Specifically, what is the benefit, or loss, to a BS chemical engineer for staying in school to earn a master's or doctor's degree?

A QUANTITATIVE ANALYSIS

Each year AIChE publishes an economic survey which includes, among other things, data on median salaries of AIChE members, tabulated by highest degree earned and years since obtaining the BS degree [2]. These data are based on a well-planned survey with over 4,500 responses, a good representative sample. There is some scatter in the data due to small numbers of chemical engineers in some categories (*e.g.*, PhD chemical engineers who obtained their BS degree in 1946). I have smoothed out the data to obtain median salary curves. I have also included typical graduate assistant stipends for chemical engineers in graduate school. The results are plotted in Fig. 1. Without question, the higher the degree the higher the median salary for engineers on the job.

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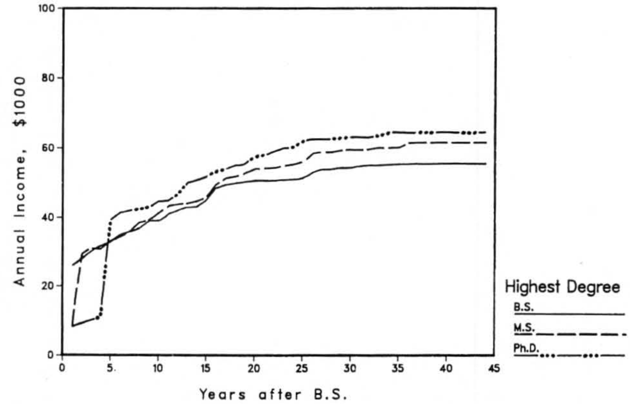


FIGURE 1. Median chemical engineering salaries for three degree-levels.

But how meaningful are median values? Is the difference among degrees really significant? The AIChE survey doesn't publish salary distributions for each year and degree. A survey published by the American Chemical Society in 1982, however, does include such data [3]. This survey gives 90th, 75th, 50th and 25th percentile data for salaries of non-academic chemists and chemical engineers, lumped together, by degree level and years since receiving the BS degree. In general, chemical engineers' salaries are higher than chemists' salaries. It is reasonable to assume, however, that

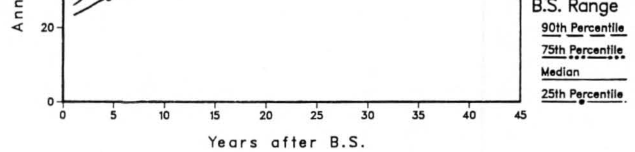
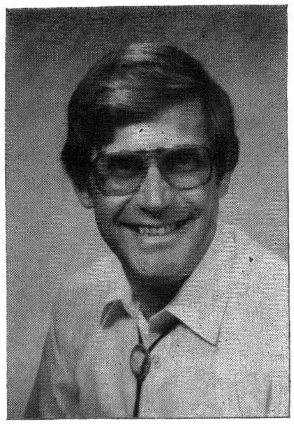


FIGURE 2. Distribution of BS chemical engineering salaries.



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the distribution curves are similar; *i.e.,* in any year and at any degree level, the ratio of the 90th percentile to the median should be the same for chemists and chemical engineers. I calculated the distributions from the ACS data and applied them to the 1984 AIChE medians. Results are plotted in Figs. 2, 3 and 4 for bachelor's, master's and doctor's degrees. (Note that the master's degree data combine MS and MBA figures. The AIChE data indicate that these two degrees have almost identical median curves.)

There is a wide range of variation within each degree. The 90th percentile group at any degree level is likely populated by chief executive officers, general managers, and those who have been successful in building their own businesses. Individual achievement makes a lot of difference.

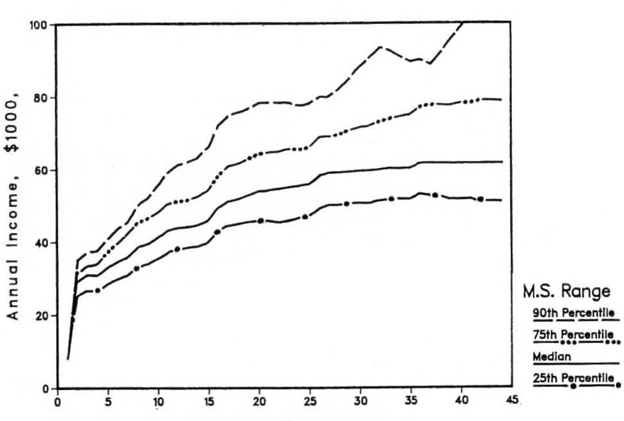

FIGURE 3. Distribution of MS/MBA chemical engineering salaries.

TABLE 1
Present Values of Career-Long ChE Salaries
Thousands of Dollars

Highest Degree		Discount Rate 0%	5%	10%
BS	90th Percentile	3015	1037	505
	75th Percentile	2515	881	436
	Median	2099	750	377
	25th Percentale	1757	634	322
MS or MBA	90th Percentile	3239	1073	502
	75th Percentile	2682	909	433
	Median	2227	770	374
	25th Percentile	1898	660	322
PhD	90th Percentile	3170	1020	453
	75th Percentile	2699	882	397
	Median	2324	778	358
	25th Percentile	2013	688	322

What are the total lifetime earnings for the various degree levels, however, and is there a payoff for advanced degrees? I summed the yearly salaries for the various categories, applying discount factors of 0, 5 and 10 percent, assuming the chemical engineer has 44 years of work or school after receiving his or her BS degree. Results are summarized in Table 1. If we look at median salary levels, advanced degrees pay off at 0 and 5 percent, but not at 10 percent. The actual rate of return, again based on medians, for investing in a master's degree is 8.6 percent. For getting a doctorate, it is 7.1 percent. The incremental rate for going from a master's to a doctor's degree is 6.1 percent. These are not spectacular rates of return, but they are certainly reasonable, and they are most certainly non-negative.

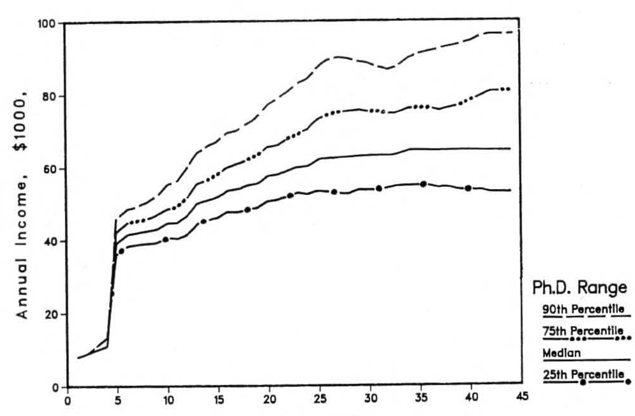

FIGURE 4. Distribution of PhD chemical engineering salaries.

First, there is the ego factor. The advanced degree is an other challenge to meet, and many of us enjoy meeting challenges. The graduate degree is like the proverbial mountain—it's there! And the person who conquers it has a rightful claim to a major accomplishment.

To see whether these results applied to 1984 data only or were more generally valid, I repeated the analysis using 1983 data [4]. The results were qualitatively similar. The rates of return were 11.0 percent for a master's degree, 6.8 percent for a doctorate, and 5.3 percent incremental, doctor's over master's degree. The numbers are a little different but the conclusion remains valid.

But what about taxes? Anyone who has had a good chemical engineering economics course knows that taxes can have a significant impact on an economic analysis. Taxes depend on a great many factors: number of dependents, lifestyle, location, etc. In general, though, the rates are higher for higher salaries. Let's look at just one typical case. Use the 1984 income tax rates and social security rates. Assume the chemical engineer has two dependents, including himself or herself, in years 1, 2 and 30 through 44; three dependents in years 3, 4, 28 and 29; and four dependents in years 5 through 27. Assume that various other tax deductions amount to 10 percent of total salary, and that state income tax is 5 percent of federal income tax. Having made all these assumptions, we can now calculate after-tax income. I did this just for the median values and plotted the results in Fig. 5. Qualitatively, trends are the same. Naturally, all the curves are shifted downward from those in Fig. 1. Summed after-tax present values are given in Table 2 for median incomes at the three degree levels. Calculated rates of return are now slightly lower, as expected: 8.3 percent for a master's degree, 6.9 percent for a doctorate, and 5.9 percent incremental, doctor's over master's degree. The values are still quite reasonable, however, for after-tax income, and they are obviously non-negative.

This is by no means a complete economic analysis. There are other questions which could be considered: What is the proper interest rate to use? What about those who go back to graduate school after working in industry several years? Would it be fairer to compare 75th percentile BS salaries to median PhD salaries? What about those getting advanced degrees in chemical engineering who have undergraduate degrees in other fields? Or *vice versa*? I'll leave these questions to others. What is shown here, however, is that there is a reasonable, positive rate of return for a chemical engineer obtaining an advanced degree.

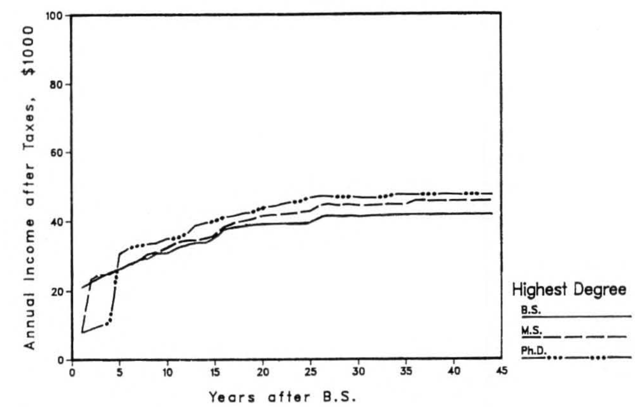

FIGURE 5. Median after-tax chemical engineering salaries for three degree-levels.

TABLE 2
After-Tax Present Values of Median ChE Salaries
Thousands of Dollars

	Discount Rate		
Highest Degree	0%	5%	10%
BS	1616	586	297
MS or MBA	1699	598	294
PhD	1762	602	283

A QUALITATIVE ADDITION

Graduate degrees for chemical engineers have a 5 to 10 percent rate of return for lifetime earnings. Is that sufficient reason for pursuing graduate studies? Not really. It's one factor, but not an overwhelming one, and the choice has to include other factors. There are five principal ones that I have observed over the years.

First, there is the ego factor. The advanced degree is another challenge to meet, and many of us enjoy meeting challenges. The graduate degree is like the proverbial mountain—it's there! And the person who conquers it has a rightful claim to a major accomplishment. The same factor probably influenced most of us in choosing chemical engineering as an undergraduate major; it's recognized as a tough challenge.

Second, there is the job market. Some jobs, research and teaching in particular, require advanced degrees in today's market. The advanced degree—MS, MBA, or PhD—will open up some new doors. John Mulroney, a vice president of Rohm and Haas, said it very well recently [5]. "The PhD degree in chemical engineering seems much more relevant to the current needs of specialty chemical companies than it did ten or fifteen years ago. Probably the greater scientific content of the doctoral education is more valuable today."

Third is the opportunity to change fields easily. Some chemical engineers find their first job isn't as satisfactory as they had hoped. They want to get into a new, growing, area or shift to a new location. Going back to graduate school is a good way to make a clean break from one job and start fresh elsewhere.

Fourth is the experience of graduate school and graduate level education itself. It's a great life, much different from undergraduate education. J. L. Duda described it very well [6]. There are unlimited opportunities for pursuing knowledge at the very edge of what is known. The work can be tough, but it is also exciting and challenging.

Last, there are a number of extraneous factors, ones which apply to one or a few people due to special circumstances. For instance, the spouse, or spouse-to-be, is still in school. The company is willing to pay the bill, plus pay full or part salary. The kids are in school and it's boring sitting at home; it's time for a refresher course before getting back into the job market. It's a good place to look for a girlfriend or boyfriend. It sure beats 8:00 to 5:00 hours—or shift work.

There are many things to consider in deciding whether to go to graduate school. Consider them all. Contrary to popular belief, the economics of getting advanced degrees in chemical engineering are favorable.

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4. Forman, J. C., G. M. Lambson, and L. C. Bell, "AIChE Economic Survey Report—1983," American Institute of Chemical Engineers, New York, August 1983.
5. Mulroney, J. P., "Divergent Pathways: Chemical Engineering and the Industry," *Chemical Engineering Progress*, Vol. 80, No. 12, p. 29, 1984.
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In Memoriam

CHARLES PEIFFER

Charles Calvin Peiffer, 55, associate professor of chemical engineering at the Pennsylvania State University, passed away on June 18, 1985. He conducted research in the Penn State Petroleum Laboratory and was well known for his studies on co-current absorption and vapor-liquid equilibrium. For many years he was an outstanding advisor to the Student Chapter of AIChE at Penn State and in 1980 he received the Outstanding Advising Award for AIChE. He was an exceptional instructor and received several teaching awards. The unit operations laboratory in chemical engineering at Penn State will be modernized and renamed the Charles C. Peiffer Unit Operations Laboratory. He is survived by his wife, Norma, and two children, Charles and Elizabeth.

REVIEW: Molecular Fluids

Continued from page 203.

rived. While the vast majority of existing books on statistical mechanics is limited to atomic fluids, this comprehensive monograph treats molecular fluids with an emphasis on anisotropic forces. It requires an undergraduate knowledge of statistical mechanics, thermodynamics, electromagnetic theory, vector analysis, and quantum mechanics, and is aimed at graduate students and researchers in chemistry, physics, and engineering.

The chapter on intermolecular forces reviews thoroughly many advances that have occurred since 1970, especially for small relatively rigid molecules, for example N_2, HCl, CO_2, CH_4 and H_2O. Given the complicated nature of anisotropic intermolecular interactions, it is not surprising that the appendices account for over one-third of the book. The fourth chapter develops statistical mechanical perturbation theories which are powerful tools in chemical engineering thermodynamics. The effects of various short and long range forces are included conveniently in an expansion about a spherical reference fluid. The theories are tested systematically using computer simulation data. Throughout the book, symmetry and invariance

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