STEM and other Fields of Study

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Abstract: Since the 2008 stock market crash in the United States of America (USA), with the multinational effects around most of the world, there has been job losses and financial insecurity felt by most working people. The lack luster recovery and the drop of oil prices in the last year (which has stabilized in recent months), have not improved much this sense and need for financial security. Financial security is largely obtained if one helps one's young adult offspring select a well-paying profession. The paper by the authors in 2007, compared the financial wisdom of selecting STEM jobs as opposed to other fields of study. Their hypothesis that "science, technology, engineering, and mathematics (STEM) related fields will have higher monthly income on average than communication, education, arts, and social science fields", was demonstrated to be true. The monthly income based on specialty field was forecasted using 4 methods. Half of the methods were moving averages and exponential smoothing, and these were stationary series models. The other half was trend-based methods; regression analysis, and double exponential smoothing or Holt's method. The authors showed that the moving averages forecast a difference in favor of STEM fields of $973.79 per month; exponential smoothing predicted a disparity of $934.18 per month. Further, a $1058.84 disparity in monthly income was foretold with linear regression analysis; a $1060.3 in monthly salary was forecast *via* Holt's method. More recent data by Forbes shows that the top paying jobs are No. 1 Drilling Engineer with median pay of $113,900, No. 2 Petroleum Engineer with median pay of $97,300 and No.3 Mining Engineer with median pay $71,300 a year. These STEM jobs do lead to the same conclusion today that jobs outside the STEM fields do not pay as well.

Keywords: Science, technology, engineering, mathematics, medicine, health, careers.

1. INTRODUCTION

The objective of the current work is to review the status of the job fields with regards to monthly earnings, as a function of the field of study at the tertiary or university level. The authors wrote about this topic in their paper [1]. "A Comparative Analysis of the Economic Viability of STEM and Other Fields of Study" in 2007 *via* the International Mechanical Engineering Congress and Exhibition that was held in Seattle, Washington State, USA. Much has happened in the world to rock the world economic boat, including the US stock market crash and bank illiquidity problems of 2008 which produced reverberations around the world, and 'Arab Spring' which started December 2010 with the Trunisian revolution. The sense of financial security in the average US household has been shaken to the core. One of the ways to a secure financial future is to help one's offspring to get a good-paying job *via* a suitable college education. Through careful selection of a suitable major at an appropriate college, a university student can lay his/her path or climb the ladder of financial success.

In [2], Forbes magazine article listed the top four paying jobs in 2014. The top three are engineering jobs, and the fourth is a technological analyst, with a median pay of $67,500 a year. The top three salaried positions are Drilling Engineer with median compensation of $113,900, Petroleum Engineer with median payment of $97,300 and Mining Engineer with salary at the median point of $71,300 a year. In these top 4 paying jobs, the maximum difference is $3867 a month, much more than any of the differences calculated in [1]. There are no non-STEM jobs in sight amongst the top four. The top three occupations are in the oil and gas industry; a branch of industry where recent graduates in mechanical engineering and chemical engineering can easily adapt into and thrive. The importance of these hydrocarbon energy sources in today's postmodern society cannot be overstated.

2. METHODS

In [1], the monthly salaries based on field of training were forecasted employing 4 statistical methods/ models. Two of the methods were stationary series models. They are the moving averages and the exponential smoothing models. The third and fourth are trend-based methods. These were the regression analysis method, and the double exponential smoothing or Holt's method.

The data used were obtained from the US. Census Bureau, from the specific branch of "Survey of Income and Program Participation" [3]. The years studied included 1995, 2001 and 2006.

Moving averages was used to predict values for one-step-ahead forecasts, that is F_t, from the period t-1, provided by Nahmias [4]:

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$$Ft = \left(\frac{1}{N}\right)\sum_{i=t-N}^{t-1} D_i \quad (1)$$

The equation states that the mean of the N most current sets of data is employed to project the succeeding period. D_i is the i^{th} set of data.

Exponential smoothing was employed to predict demand for one-step-ahead in a stationary time series. It is provided by Nahmias [4]:

$$Ft = \alpha D_{i-1} + (1-\alpha)F_{t-1} \quad (2)$$

This equation states that New forecast = alpha (Current observation of demand) + (1-alpha)(Last forecast). Alpha is called the smoothing constant with value between one and zero, which is the relative weight put on the current observation of demand. One difference between Equation (1) and Equation (2) is that only the last prediction is required for Equation (2), whereas Equation (1) needs N past data points or observations.

In regression analysis, it is assumed that there is a straight line relationship between two variables. Nahmias [4] gives the equations as:

$$Y = a + bX \quad (3)$$

And $a = \overline{\overline{D}} - b(n+1)/2$ (4)

$$b = \frac{S_{xy}}{S_{xx}} \quad (5)$$

Where $S_{xy} = n\sum_{i=1}^{n} iD_i - \frac{n(n+1)}{2}\sum_{i=1}^{n} D_i$ (6)

$$S_{xx} = \frac{n^2(n+1)(2n+1)}{6} - \frac{n^2(n+1)^2}{4} \quad (7)$$

The fourth method used by the authors to predict future monthly income was following Holt's method [4], by using double exponential smoothing. Holt's method is different from the single exponential smoothing in that two instead of one smoothing constant, and two smoothing equations are used. One of the equations is for the series, and the other equation is for the trend. Nahmias [4] gives the equations. The equations are all listed and cited in [1].

3. RESULTS

Some of the data used in [1] are repeated here in Table **1**. The monthly income for Bachelor Degree holders are listed in descending order. Owing to the long processing time, it takes about 5 years for the collected census data to be updated.

It can be seen that the largest difference between STEM fields and non-STEM fields, presented in Table **1**, was $1606 in 1993, and was $2043 in 2001. The divergence in monthly pay is consistent, if not constantly growing at the same rate. It is a given that the 2015 data (yet to be collected) will be showing a greater disparity in remuneration.

4. DISCUSSION AND CONCLUSION

The paper by the authors in [1], differentiated the economic outcomes of selecting STEM jobs as opposed to other fields of study. Their hypothesis that "science, technology, engineering, and mathematics (STEM) related fields will have higher monthly income on average than communication, education, arts, and social science fields", has been shown to be correct. The monthly income based on specialty field was predicted using 4 methods. Two of the models were moving averages and exponential smoothing. The

Table 1: Monthly Income for Bachelor Degree Holders [5]

	Years		
Field	**1993**	**1996**	**2001**
Engineering	$3,645	$4,287	$4,549
Mathematics	$3,008	$3,378	$3,691
Computer	$2,324	$3,814	$4,395
Natural Science	$2,710	$2,753	$3,052
Communications	$2,396	$2,834	$3,390
Social Science	$2,243	$2,310	$2,987
Liberal Arts	$2,103	$2,746	$2,949
Education	$2,039	$2,011	$2,506

other two were trend-based methods; regression analysis, and double exponential smoothing or Holt's method. The authors showed that the moving averages forecast a difference in favor of STEM fields of $973.79 per month; exponential smoothing predicted a disparity of $934.18 per month. Further, a $1058.84 disparity in monthly income was forecast with linear regression analysis; a $1060.3 in monthly salary was predicted following Holt's method. In 2014, Forbes reported that the top paying jobs are No. 1 Drilling Engineer with median pay of $113,900, No. 2 Petroleum Engineer with median pay of $97,300 and No. 3 Mining Engineer with median pay $71,300 a year. These STEM jobs do lead to the same conclusion today that jobs outside the STEM fields are not well-paid ones.

It is interesting that in [6], the interactive map allows one to hover over a college major. One can also hover over an occupation to see which majors the government, public and private sectors are hiring. The information provided by the US. Census Bureau shows that only a minority of STEM majors are employed in STEM. This does not conflict with the findings of the current work. It simply means that the highest paying jobs (in the oil and gas industry) do not need all the engineering graduates produced by our universities. However, the engineering graduates, as an example of the STEM disciplines, are still the preferred ones in entry level jobs of non-STEM fields, e.g. management. They may also be getting higher salaries than non-STEM majors in the exact same entry-level job, leading to brighter futures and thus higher average salaries over the course of their careers.

In [6], the STEM college majors are computers, mathematics and statistics, engineering, physical sciences, biological, environmental and agricultural sciences, psychology, social sciences and multidisciplinary sciences. The STEM jobs are computers, mathematics and statistics, engineers, life sciences, physical scientists, social scientists and architects. The non-STEM jobs are managers (non-STEM), business and financial, social sciences, legal, education, arts and entertainment, service, sales, office support, agriculture and construction and production.

It is interesting to note that the interactive graphics do not list construction and production as STEM jobs, even though these two categories do employ many engineers.

It is clear that STEM jobs from computers to medicine, ensure a promising financial future to fresh first degree graduates of these STEM disciplines. In the last decade, STEM jobs' growth was triple that of non-STEM jobs. STEM professionals are also less inclined to lose their jobs than their non-STEM colleagues [7]. In some papers, it was expressed that not enough effort has been taken to model the dynamics of STEM jobs and to improve data gathering and study [8]. This could partly explain the small discrepancies captured by the interactive map mentioned previously [6].

In [9], the author stated that almost all STEM jobs in the United States are already or possibly in 'competition' with offshore STEM jobs. The historical advantages of advanced industrial nations' science and engineering work will have a short duration. Within ten years science and engineering capabilities internationally will be at par with the US in many areas. "The rising capabilities and experience of offshore workforces, changes in work process and communications, the potential transformation of product and service development and delivery, and innovation advantages in emerging economies are, in combination, creating strong innovation centers offshore," [9].

The forecasts for the U.S. STEM work force, depend greatly on whether there is world increase in demand and the share of that work that companies select to put down in the U.S. There will be some segments that the U.S. has clear lead, and a large amount of work that will still be carried out in the US because of the size of the domestic market and the many levels of means and know-how [9]. This sentiment is also shared in [10]. The computer software industry is one case of globalization that has resulted in steady job levels in the U.S.

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