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ABSTRACT

Investigates the possible link between the rise (beyond inflation) in tuition and the increased use of computers within the public two-year institutions (a.k.a. community colleges). Examined in detail one aspect of the data available related to the effect of the costs of computing in community colleges. Utilizes data for tuition (adjusted for inflation) and computers on the campuses of community colleges. The result from this work found the null hypothesis to be false, thus leading to the conclusion that there is a correlation between tuition costs and campus computers. Notes three changes in the slope of the tuition curve between 1980-81 and 1983-84 (when the number of computers in use in the U.S. increased an order of magnitude, from one to ten million units), between 1987 and 1990 (when Microsoft introduced the Windows environment and the federal government passed the American Disabilities Act), and between 1992 and 1995 (when the Internet came out of the research community and Windows '95 was introduced). Describes the difficulties caused by the data used in this study, especially missing data elements. Addresses future data analysis and concerns to be considered and what the future will hold for the computerization of community colleges and their fees. Contains 24 references. (VWC)

Studies on the Correlation between Campus Computing and the Rise in Tuition in Community Colleges

by Harold A. Geller

INTRODUCTION

College tuition has been increasing over the years since the beginning of data collection in 1971, by the College Board and by the Department of Education [16,18]. The preliminary tuition data trend was obtained from the College Board web site [16] and led me to consider the numerous factors that may have played a role in this increase of college costs beyond inflation. Keeping this graph in mind, I decided to investigate further. I initially performed searches on the internet's world wide web and in the open literature. Since this paper is geared to community college education I narrowed my investigation to the possible link between the rise (beyond inflation) in tuition and the increased use of computers within the public two-year institutions, herein called community colleges.

One of my own observations of the changes in the slope of the tuition curve is that there is a noticeable slope change between the 1980-81 and 1983-1984 trends in tuition [16]. I recalled, and later verified, the aforementioned fact with the help of a brief history of computers in the Computer Industry Almanac, that the IBM PC was introduced in 1981 [10]. Between the years 1981 and 1983, the number of computers in use in the United States increased an order of magnitude, from one million to ten million units [10]. There is another apparent change in slope between the 1987 and 1990 tuition data, and I was able to recall that it was in 1990 that Microsoft introduced the Windows environment [10]. The year 1990 is also the year that the federal government passed the American Disabilities Act (ADA), which is another contributing factor to increased tuition costs. There is another change of slope that is apparent between 1992 and 1995. The internet came out of the research community beginning in 1994 and Windows '95 was introduced in 1995 [11]. There is also the matter of the so-called Y2K bug that was first hyped by the media in 1996 and intensified to a frenzy in 1999.

METHODOLOGY

I developed statistics for my data using the JMP statistical software package from the SAS Institute, Inc [20]. The tuition data was derived from data obtained from the U.S. Department of Education related to tuition costs over the years from 1976 to 1997 (these were the latest figures available to the public on the World Wide Web as of 25 April 2000) [18]. The derived statistics for the computer investment by community college campuses was based upon a compilation of data from survey results of the number of computers on community college campuses. These data were acquired from nine surveys, beginning in 1990, published by The Campus Computing Project led by Dr. Kenneth C. Green (prior to 1995, survey data were acquired by Green and Eastman) [1-9,14]. Some two-way statistical analyses on the data were performed once the data were compiled into a common form, in this case an Excel spreadsheet. Correlation coefficients for the data were developed using JMP [20]. If a null hypothesis were to be established according to formal methods, it would be that there is no correlation between the rise in tuition and the increased use of computers at community college campuses.

RESULTS

Preliminary Results

When I first compiled my data, the tuition data were not the most recent. These data only went up to the year 1991. Since there was a time constraint, on some presentation of data, I decided to see how the data would look. JMP [20] is capable of handling missing data, so I continued with a preliminary analysis. A plot of the preliminary data is depicted in Figure 1. The plot in Figure 1 highlights the missing data as there are gaps in both the tuition data and the campus computing data. These data, as depicted, were then examined for the correlation coefficient matrix [20]. Results are displayed in Figure 2.

The results as depicted in Figure 2 yielded a correlation coefficient of 0.94. A power spectrum was then developed utilizing a Fast Fourier Transform algorithm within the Chaos Data Analyzer [15]. The result is displayed in Figure 3 for the tuition data.

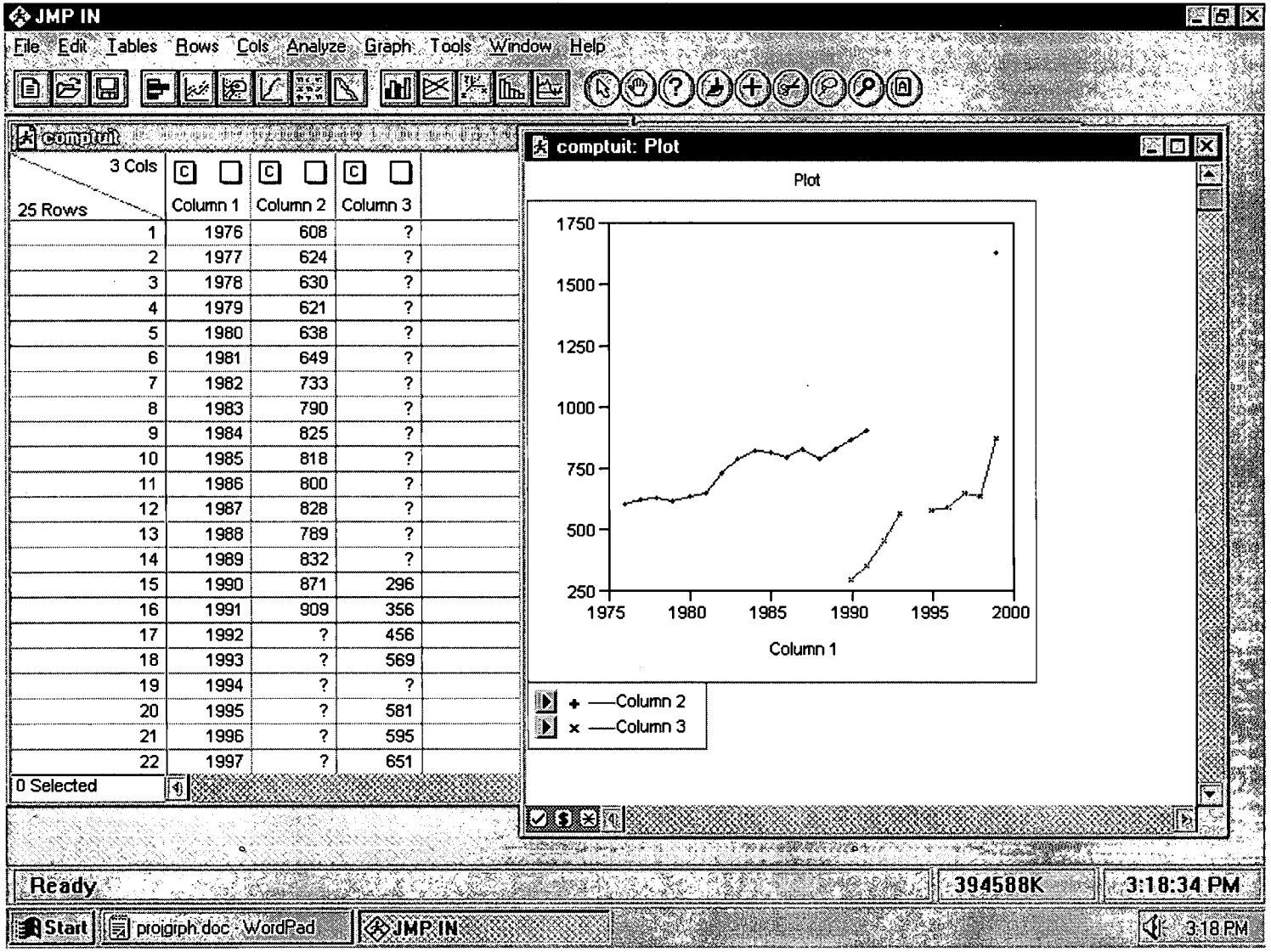

Figure 1 Tuition Costs (1976-1991) (after Adjustment for inflation) vs. Campus Computing (1990-1993, 1995-1999) utilizing the JMP software

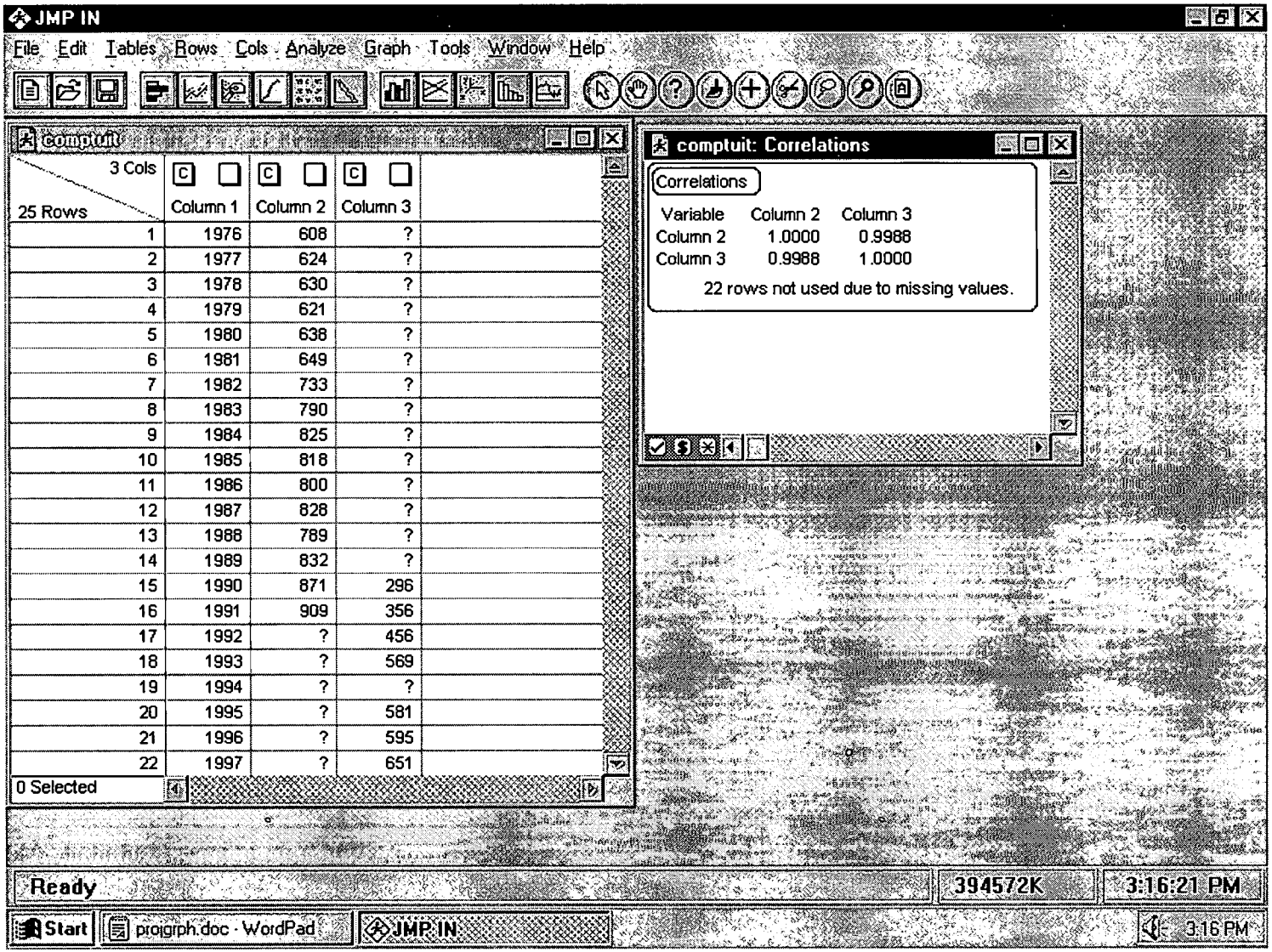

Figure 2: Correlation Matrix using JMP for original data

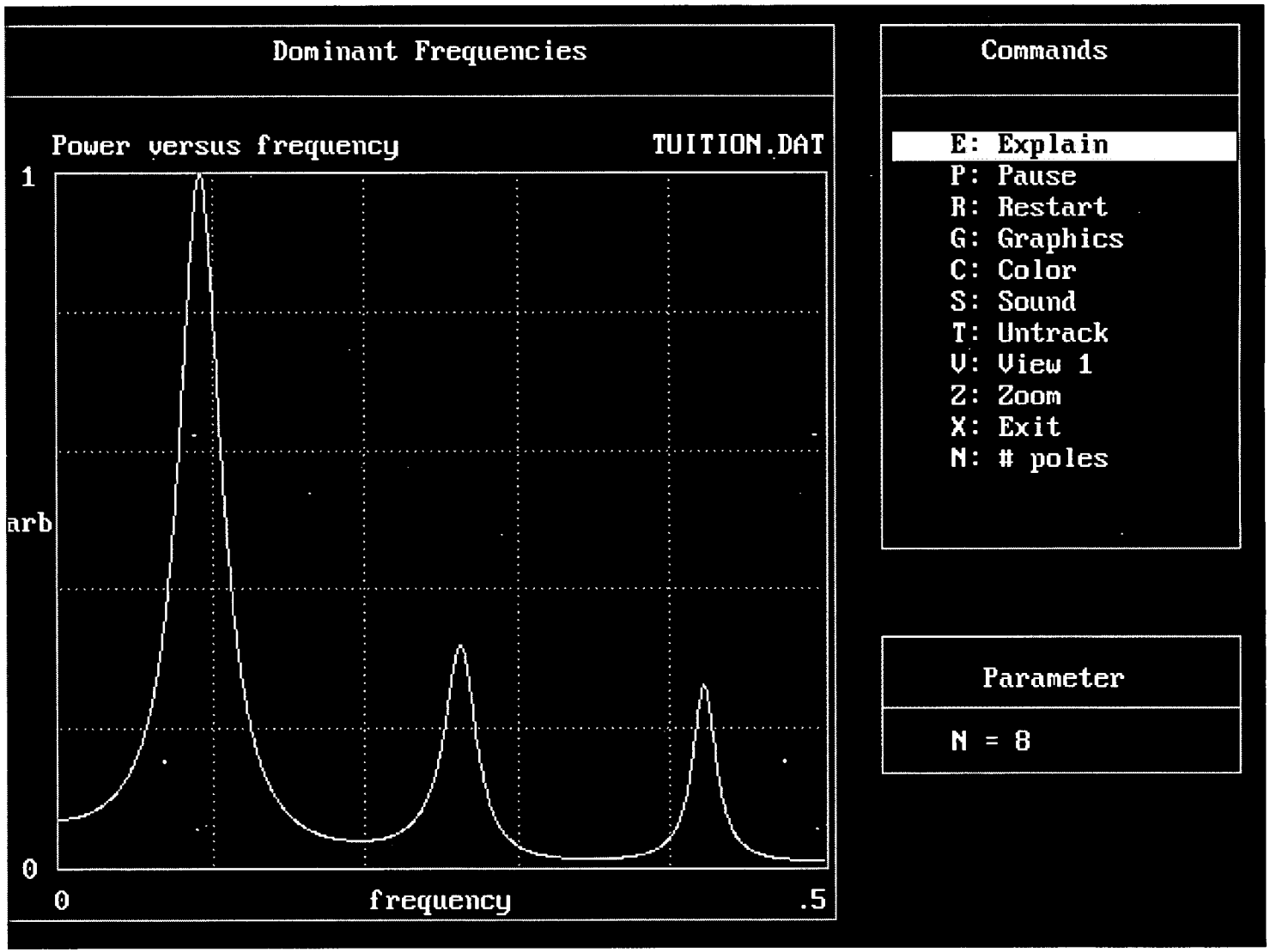

Figure 3: Power Spectrum (FFT) for original Tuition Cost data

As can be seen in Figure 3, there were three dominant frequencies discovered in these data. The periods of the associated frequencies are approximately 2.3 years, 3.8 years and 11 years. Figure 4 depicts the power spectrum for the campus computing data.

As can be seen in Figure 4, the periods associated with the dominant frequencies are at 3.13 years, 8.3 years and 17 years. Again, it must be noted that the data were incomplete and as of 25 April 2000, more recent data for filling the holes in the data from the Department of Education were available online on the World Wide Web [18].

A summary of the results from the initial data analysis is depicted in Table 1 below.

Table 1 – Preliminary Statistical and FFT-derived parameters

Characteristic	**Campus Computing Data**	**Community College Tuition Data**
Dominant period from FFT	17 years	11 years
Second harmonic component period from FFT	8.3 years	3.8 years
Third harmonic component period from FFT	3.1 years	2.5 years
Correlation coefficient	0.94	0.94

Final Results

Once the latest data for tuition costs were available online, I used that data in filling in some of the data "holes." However, there was still a two-year lag in the online data for tuition and the data available from the Campus Computing Project. Since the College Board Online had the tuition data for 1999 available, I used that tuition data, adjusted for 1984 dollars as the other tuition data had been modified similarly based upon the Consumer's Price Index. I used linear interpolation to fill the remaining holes from the tuition data of the Department of Education to the data from the College Board [18]. There was only one missing data point from 1990-1999 Campus Computing Project data [14], which was for the year 1994. I filled that "hole" again by using a linear interpolation from the 1993 data to the 1995 data [5,6]. The final continuous data are displayed using the JMP software [20] in Figure 5.

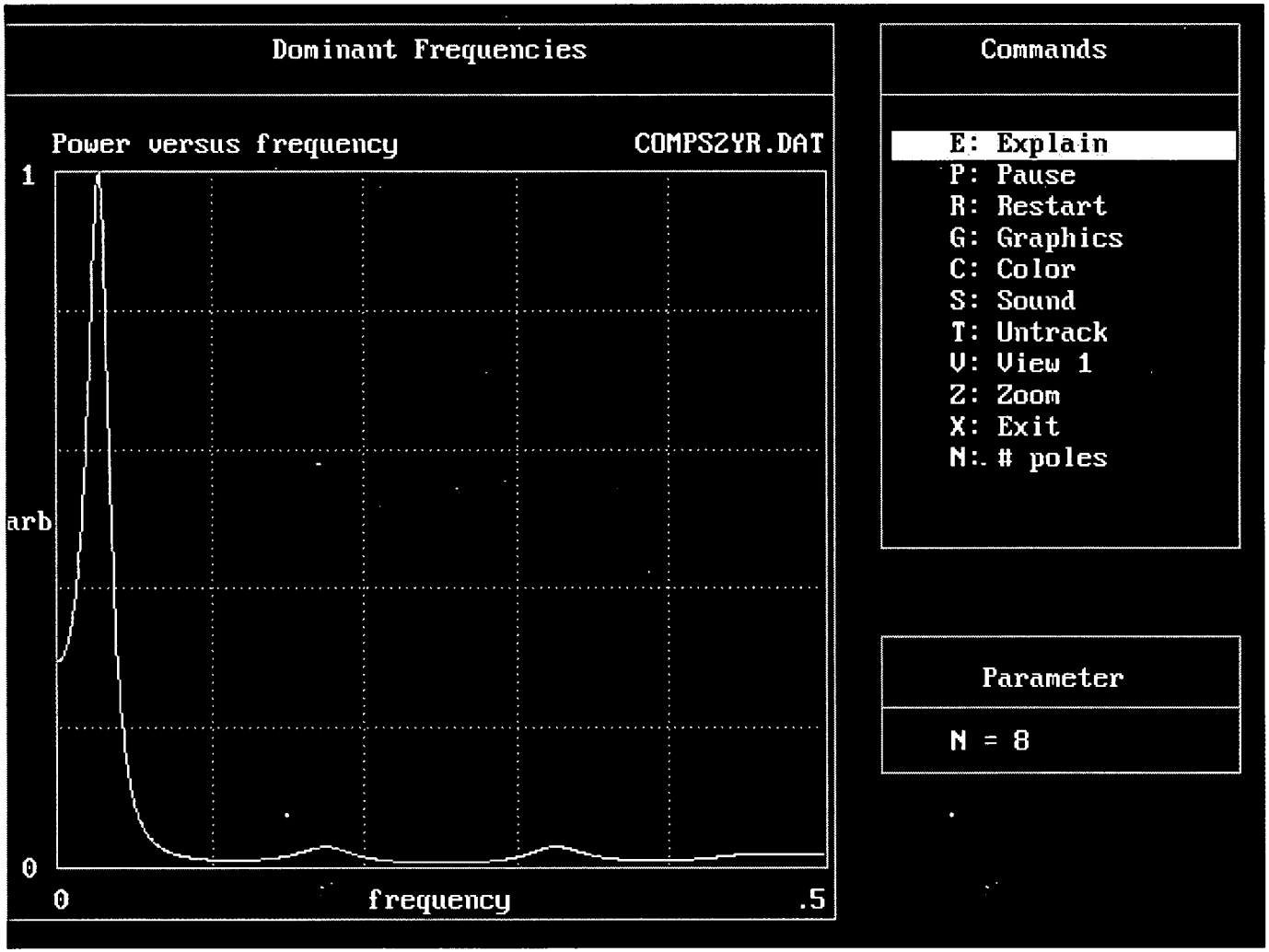

Figure 4: Power Spectrum (FFT) for Campus Computing Data

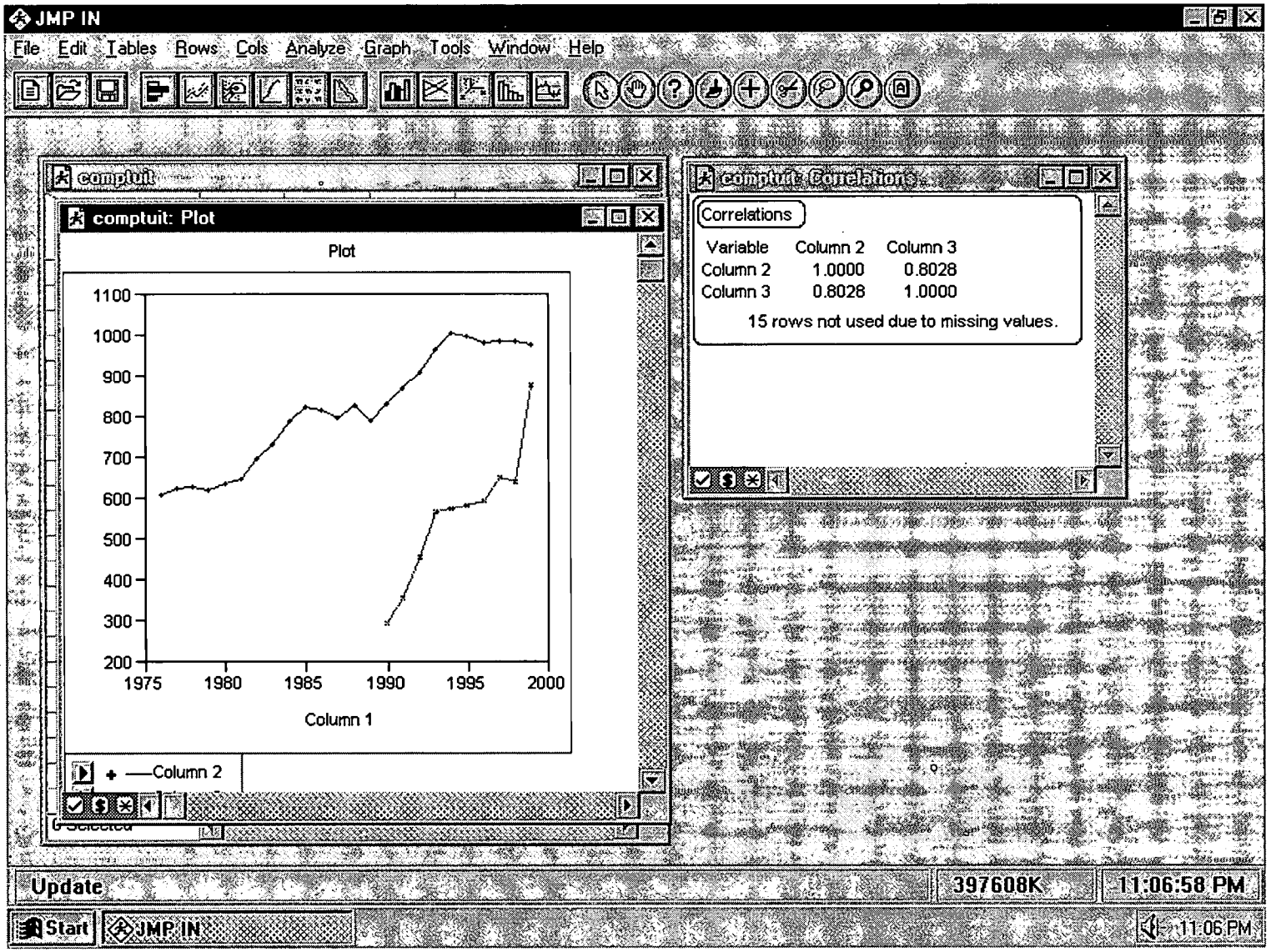

Figure 5: Tuition Costs 1971-1999 (after adjustment for inflation) versus Campus Computing Data with Correlation Matrix using JMP

As can be seen in Figure 5, the tuition data is plotted continuously from 1976 and the Campus Computing data from 1990. The correlation coefficient matrix is also displayed by the JMP software. The correlation coefficient for the tuition versus Campus Computing and Campus Computing versus tuition is a respectable 0.80. This is a high correlation coefficient with a significant magnitude, nullifying the original null hypothesis.

The final data were also subjected to the same FFT algorithm as the preliminary data, using the Chaos Data Analyzer [15]. These data are displayed in Figure 6.

As can be seen in Figure 6, the dominant frequencies have changed as compared to the original data. There are only two dominant frequencies related to the tuition data now being examined. One is equivalent to a 20-year period and a second harmonic corresponds to a period of approximately 8.3 years. The same was done for the Campus Computing data [1-9] with the one data point filled in using linear interpolation, and is displayed below in Figure 7.

The FFT-derived power spectrum for the Campus Computing Project data [1-9] also displays a shift in frequencies as compared to the first preliminary data. The two most dominant periods appear to be the same as the ones in the previous power spectrum for the tuition data, 17 years and 8.3 approximately. However, there is a small additional component at roughly a period of 2.8 years.

Table 2 – Final Statistical and FFT-derived parameters

Derived Parameter	**Campus Computing Data**	**Community College Tuition Data**
Dominant period from FFT	17	17
Second harmonic component period from FFT	8.3	8.3
Third harmonic component period from FFT	2.8	
Correlation coefficient	0.80	0.80

I also wanted to examine the trends in the return of the surveys themselves, within the Campus Computing Project data across all of the years available [1-9]. This produced the following plot, Figure 8.

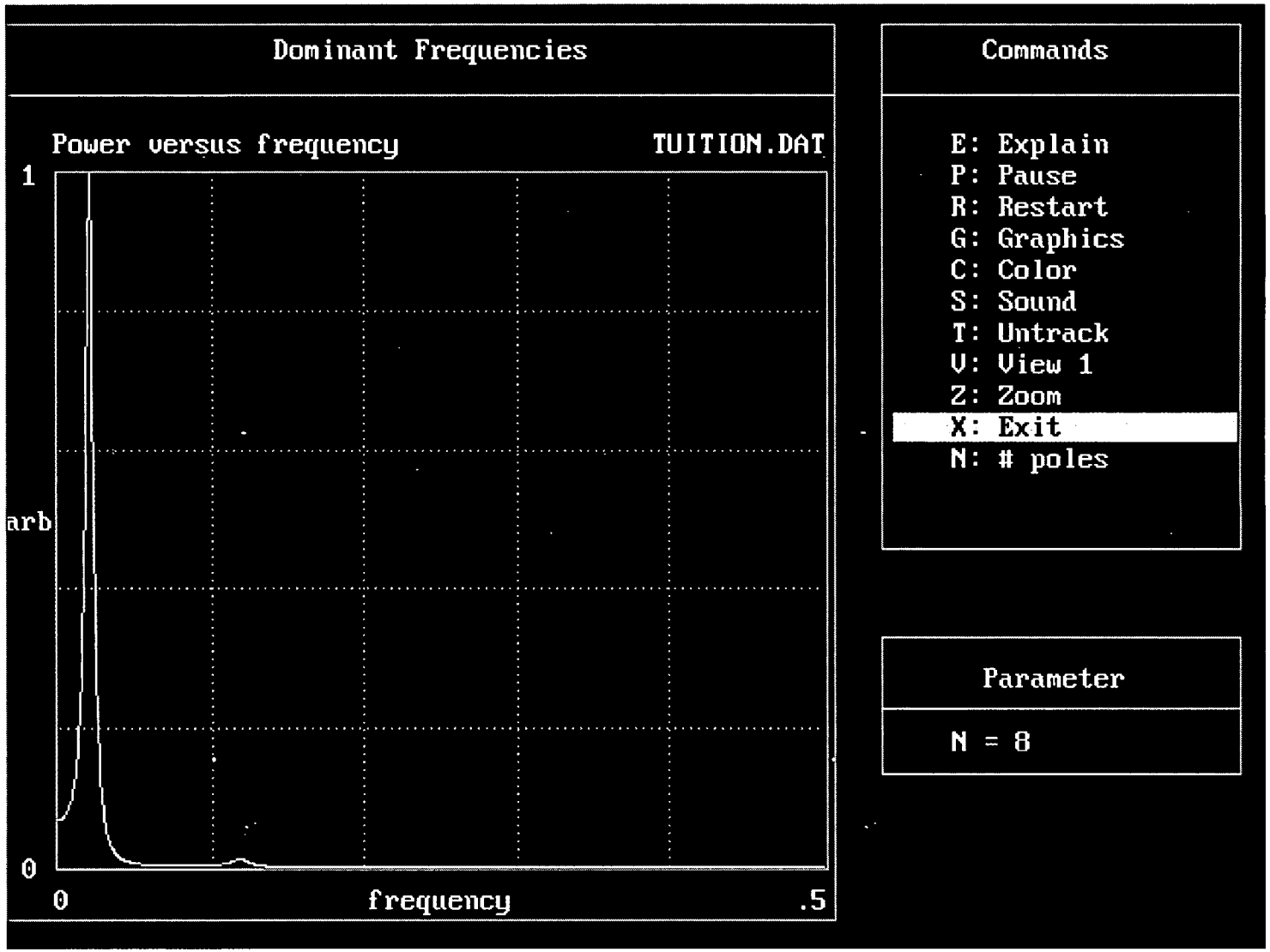

Figure 6: Power Spectrum (FFT) of Tuition Costs 1971-1999 (after adjustment for inflation)

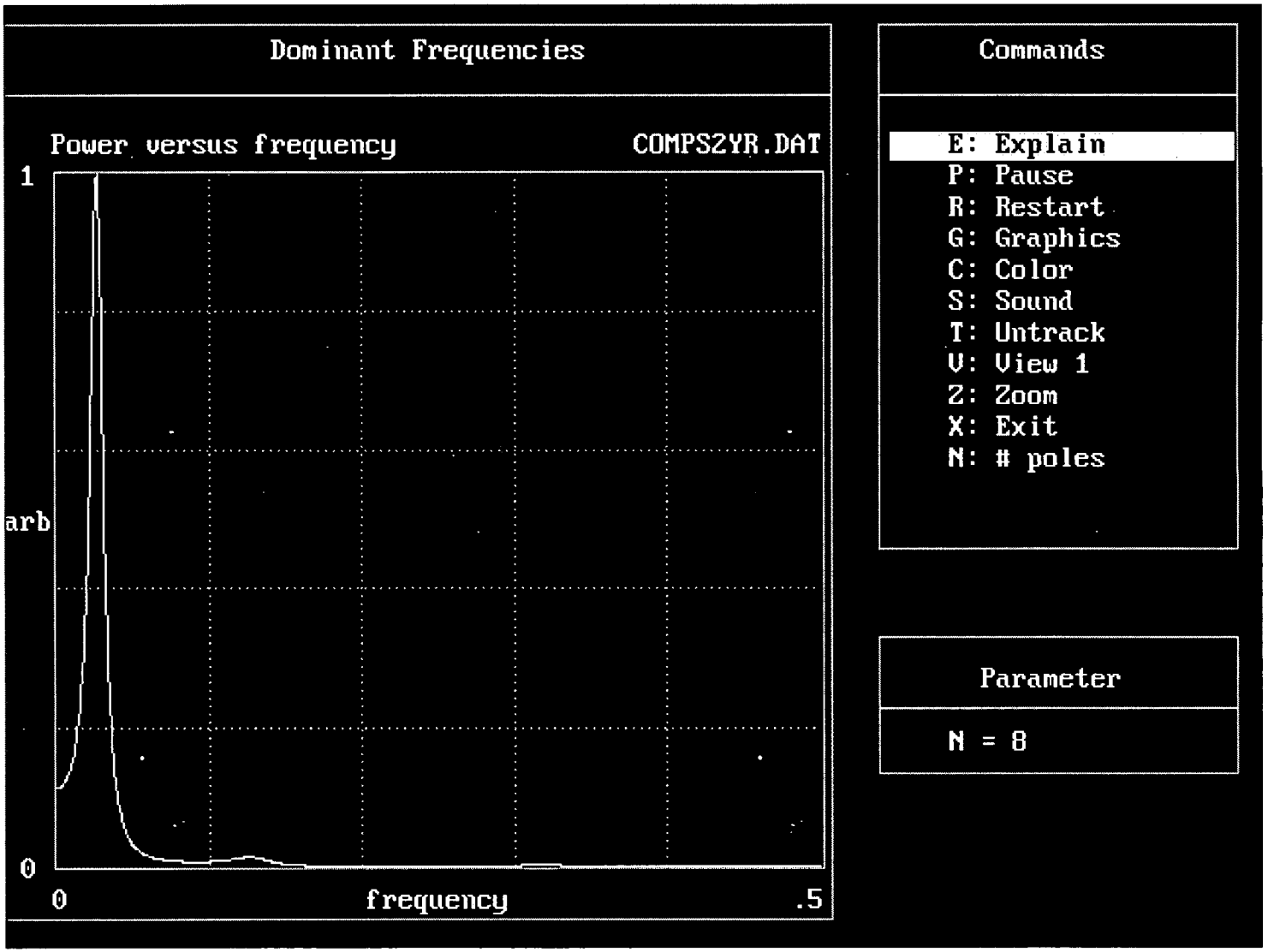

Figure 7: Power Spectrum (FFT) for Campus Computing Data for Community Colleges

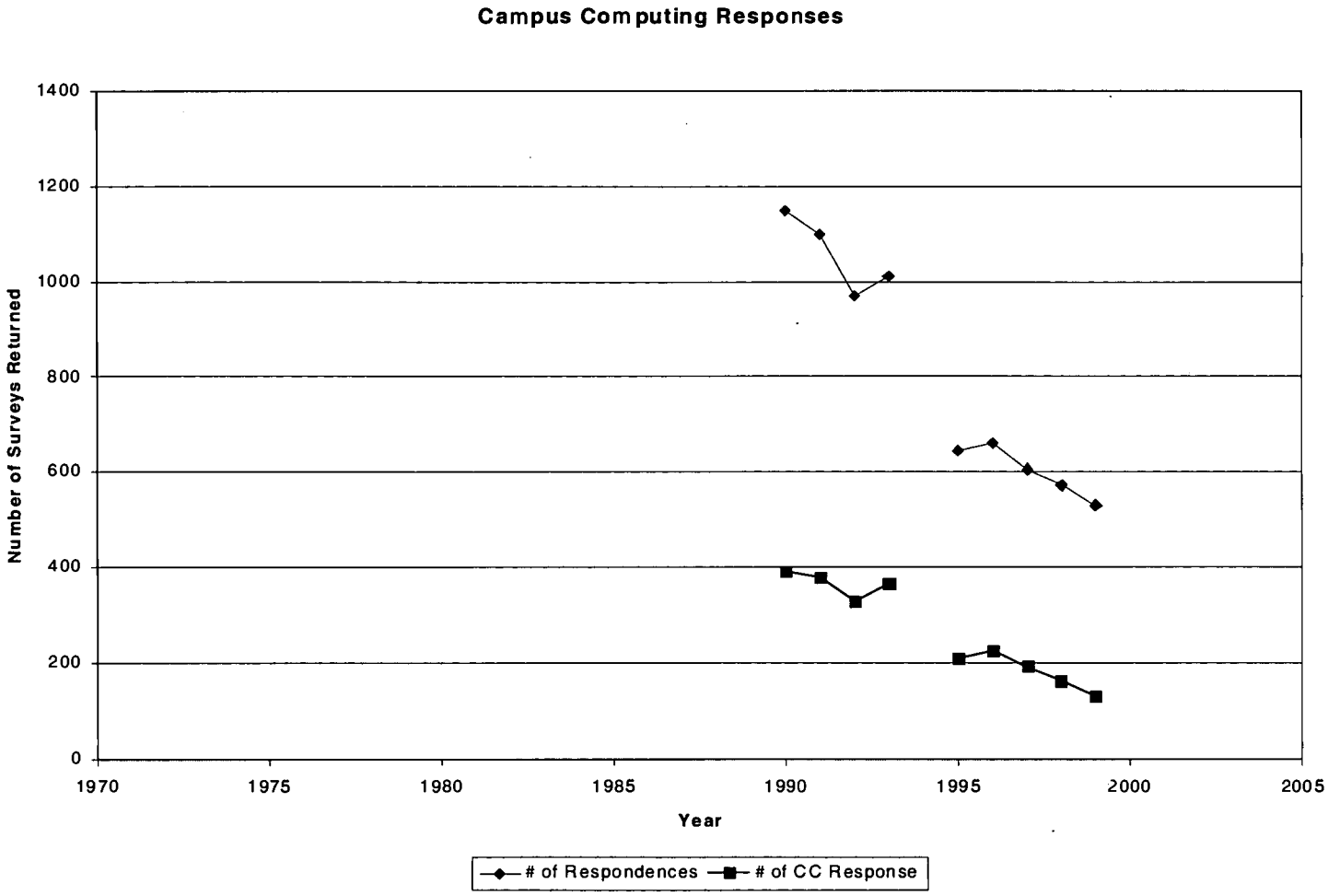

Figure 8: Change in the Number of Responses to the Campus Computing Survey

CONCLUSION

The Data Presented

I have examined in detail one aspect of the data available related to the effect of the costs of computing in community colleges. I utilized data for tuition (adjusted for inflation) and computers on the campuses of community colleges. The result from this work found the null hypothesis to be false, thus leading to the conclusion that THERE IS A CORRELATION BETWEEN TUITION COSTS AND CAMPUS COMPUTERS. In fact, the correlation coefficient is a very respectable 0.80.

The data used in this study has its own difficulties. First, it must be recalled that the data used in this study suffered from missing data. In the use of the Campus Computing data [1-9], a linear interpolation was utilized to bridge the data gap. In the tuition data from the Department of Education [15], a linear interpolation was also used to bridge the data gap (from 1996 to 1999) and a figure from a second source (College Board OnLine [16]) was used as the end data point (i.e. 1999 college tuition). Furthermore, the Campus Computing data did not extend over the same period of time as did the tuition data. There are approaches that have been utilized in the remote sensing arena that were considered for use in this study. As an example, I considered using data from another source to take the campus computing data back further in time. This was done utilizing data from Quality Education Data, Inc. of Boulder Colorado [12].

As can be seen in Figure 9, the Quality Education Data, Inc. data [12] available on the number of students per computer at public institutions has a three year overlap with the Campus Computing Project data. If an algorithmic adjustment is made, the data may allow for the extension of the Campus Computing Project data beyond its starting year of 1990.

The results displayed in Figure 8 previously, related to the number of responses obtained by the Campus Computing Project demonstrate a general decline in the number of responses over the years [1-9]. This is an unfortunate circumstance as it would be most instructive for the entire college community to monitor the college community's use of computers and the possible effects it may have on other campus aspects, both financially and academically.

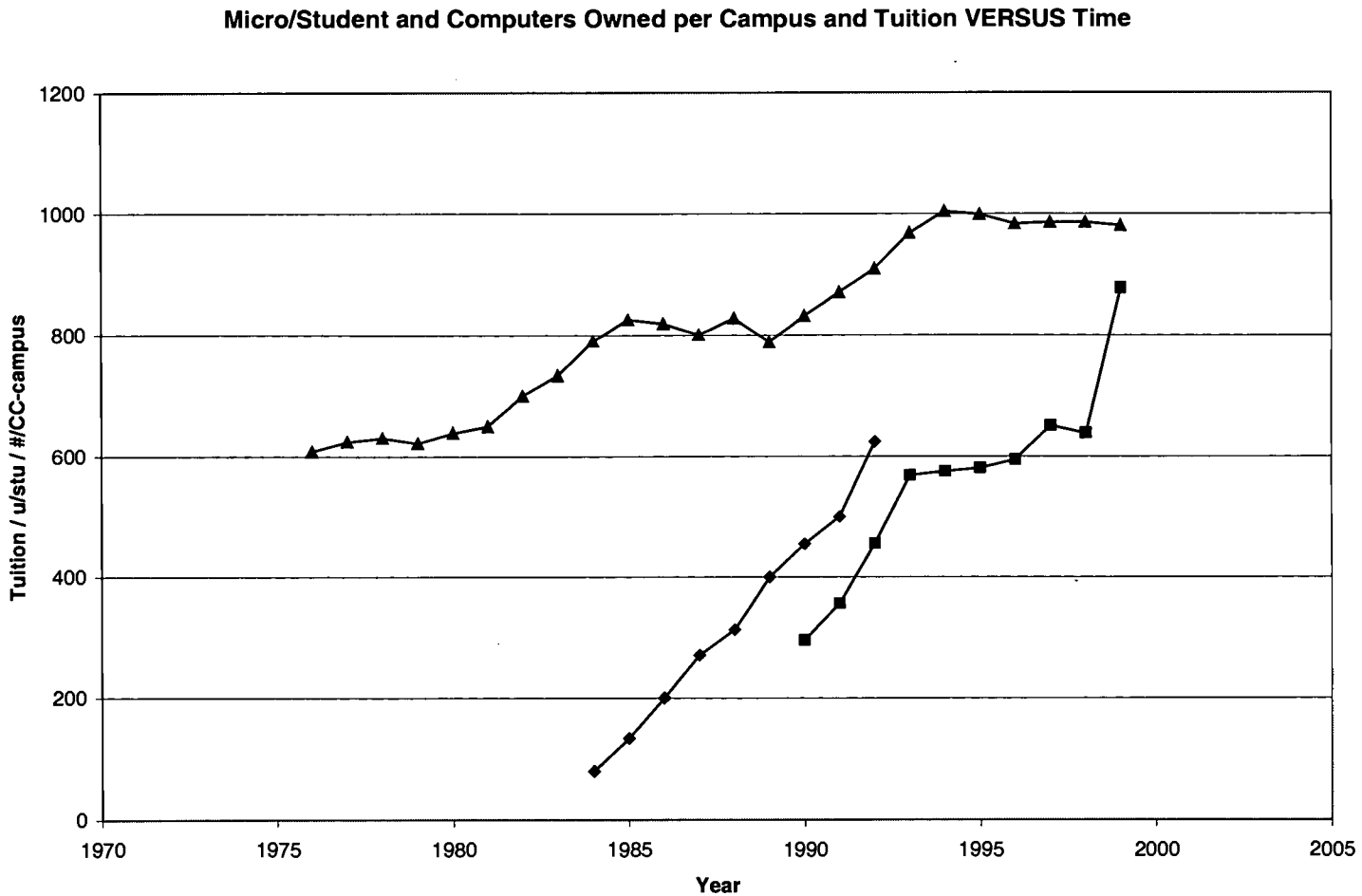

Figure 10: Multiple Data Sets Vs. Time

Future Data Analysis and Concerns to be Considered

There are always issues that must be considered in analyzing data that can easily be effected by how the data are reported. One example here, as pointed out by the Provost of Northern Virginia Community College at Manassas, Dr. Gail Kettlewell, is the use of a separate technology fee. Just as community colleges in Virginia have taken to separate technology fees from the "tuition", so can others. This question of a technology fee should be recommended to the Campus Computing Project as a new survey item. Yet another way to "hide" the costs of campus computing is to require students to have their own computers, as a pre-requisite for taking the course. Changes that may have occurred in the survey procedure itself, is another concern. There was a definite change that took place some time between 1993 and 1995, however, since no data are available from the Campus Computing Project, it is uncertain as to the changes that may have occurred in their own procedures for conducting the survey. It was demonstrated, as depicted in Figure 9, that responses to the survey itself, have declined over the years. This is truly unfortunate, but it is difficult to determine what might be the cause of this decline. Unfortunately, one possibility is that the colleges themselves may not wish to release such information related to the true costs that are being generated by the computing equipment and associated infrastructure. The inconsistent reporting trends themselves may be leading to a distorted view by the analyses.

What the Future Will Hold

In a report by the National Commission on the Cost of Higher Education titled " Straight Talk About College Costs and Prices", there is a statement made that apparently has gone unheeded (my emphasis in bold, added):

> "Although technology holds promise for making educational operations more efficient and less costly, there is **no evidence to date to indicate that the use of technology in higher education has resulted in widespread cost savings to colleges** and universities." [21]

However, there is no indication of any restraint in the use of computers throughout the community college campus in spite of this declaration, which questions the cost savings of computers. While some may hold that the reason is related to the effectiveness of using computers in the college classroom, there are others that would disagree vehemently. In a quote of Professor Gelernter of Yale (my emphasis added):

> "When you hand children an automatic, know-it-all crib sheet, you undermine learning...Professional educators are leading us full-speed **toward a world of smart machines and stupid people**."[13]

Certainly it has been noted before, that tuition costs are rising faster than inflation. As highlighted in an article that appeared in the Seattle Times on Wednesday 24 September 1997, "college costs far outpaced inflation [17]." Also, in the same article, a member of the Board of Regents of Iowa is quoted as stating that "computerizing the whole academic enterprise is costly [17]."

The question then remains how we can perform some cost-benefit analyses that will tell us whether computerization in college campuses has been worthwhile, or a boon for the computer industry? Hopefully, the Campus Computing Project will continue to monitor the state of computer affairs at college campuses (it has yet to approach a single "cycle" as indicated by the Fourier analysis of the data), but this still leaves us to consider some metric for the effects on students' academic performance.

Another key consideration in the computerization of college campuses is the so-called "digital divide." In February 1998, the National Telecommunications and Information Administration held a conference to address concerns of the wide difference of computer access across the socioeconomic and cultural spectrum. Their report is available on the World Wide Web and can be summed up with this paragraph, as reported [my emphasis]:

> "Despite this significant growth in computer ownership and usage overall, the growth has occurred to a greater extent within some income levels, demographic groups, and geographic areas, than in others. In fact, **the "digital divide" between certain groups of Americans has increased between 1994 and 1997** so that there is now an even greater disparity in penetration levels among some groups. **There is a widening gap,** for example, between those at upper and lower income levels."[19]

It is apparent that computer technology in academia has had its positive and negative effects. One can only hope that we can overcome the latter, in favor of the former, as the future of the next generation may well depend upon it.

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