ANALYSIS OF THE QUALITY OF A PHYSICS DEPARTMENT FOCUSED ON THE RESEARCH ACTIVITY.

Interactive Qualifying Project

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Submitted on: October 12, 2005

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ABSTRACT

An important factor to be considered in the analysis of the quality of the physics department is the research activity. Data on Brandeis University, Clark University, Lehigh University, Massachusetts Institute of Technology, Michigan Tech, Rensselaer Polytechnic Institute, Stevens Institute, Texas Christian University, University of Rochester and Worcester Polytechnic Institute was collected for analysis. Web of Science was used to obtain the information for the number of papers published after 1999, the number of citations, the number of papers published after 1990 and the maximum number of citations on a single paper.

The studied data states a direct relationship between the quality of the physics department and the number of physics faculty members. This studied focused on the research activity of each analyzed school as a quality measure. The number of published papers increases exponentially as the number of faculty members increased. The only exception is the Massachusetts Institute of Technology with an extremely large department. Therefore, an increase in department size may lead to a substantial increase in department research productivity, and conversely.

EXECUTIVE SUMMARY

- The physics department of the Massachusetts Institute of Technology has the largest number of faculty members, largest number of papers published after 1990, largest number of citations, largest number of citations published after 1999 and the maximum number of citations on a single paper.
- Brandeis University physics faculty members have the largest number of citations per paper.
- The number of papers published after 1990 and papers published after 1999 is directly related to the number of faculty members. The number of published papers increases exponentially as the number of faculty members increases.
- The number of citations is directly proportional to the number of papers published by every faculty member.
- The number of citations received is directly related to the number of faculty members.
- The number of citations per paper has little correlation with the size of the physics faculty.
- MIT, RPI, University of Rochester and Brandeis University are the top four schools in every category.

INTRODUCTION

The objective of this project is to analyze the relationship between the quality of the physics department and its research productivity. Ten schools of very different quality were chosen for this study. The studied schools are: Brandeis University, Clark University, Lehigh University, Massachusetts Institute of Technology, Michigan Tech, Rensselaer Polytechnic Institute, Stevens Institute, Texas Christian University, University of Rochester and Worcester Polytechnic Institute. The information regarding each faculty member is then examined.

The ISI Web of Science was the instrument used to obtain the necessary data for this analysis. The number of papers published after 1990, the number of citations received in each paper, the number of papers published after 1999, the maximum number of citations on a single publication and the date of the latest publication was collected for each faculty member. Using this data, the number of citations per paper is calculated for each faculty member being analyzed. The information for each faculty member is used to obtain a total and average count of the number of published papers and the number of received citations for each factor for each of the ten schools being analyzed.

An important aspect when analyzing the quality of the physics department is its research activity. The research productivity varies based on the number of publications, number of citations and the number of faculty members. The size of the department influences the research activity and this paper's objective is to show how big this influence is.

CHAPTER 1

DATA COLLECTION

The collection of data was a long process that used the ISI Web of Knowledge as a main source. First, it was necessary to put together a list of every active faculty member in the analyzed schools. This first step was accomplished by going to every school's web page and then to the physics department site. At this point of the process it was very important to pay close attention to the different classifications of the faculty. For instance, the only faculty who should be included in this analysis should be: professor, associate professor, assistant professor and institute professor. On the other hand, professors who fall under the category of emeritus (retired) or adjunct professor should not be included.

After all this information was compiled Web of Science was used to find the number of papers published in the time period of 1990 to 2004 by each faculty member, the number of citations for each publication, the maximum number of citations on a single paper, the number of papers published after 1999 by each faculty member and finally the year of the last publication. To complete this task it was required to go to the General Search. The professor's name and the institution that he was affiliated to when the papers were published were entered under the fields of author and address respectively. The result of this was a list of all the papers published by that author in the time frame and institution specified.

This general search gave the total number of published papers for each faculty member but did not give the number of citations received by the faculty member. For the total number of citations it was necessary to select all the papers in that search and then

proceed to analyze the information of each paper individually. There were different options given as of what fields were going to be included in the output which contained the information from each paper. To make the process more compact the fields of title, source and times cited were selected all at once. The output in this case was very useful since it gave the total number of citations for each paper and the year of publication. The next step was to add all the number of citations to get a total number of citations. The output showed the papers in chronological order so that made it easier and faster to obtain the number of papers published after 1999. All this information was then entered to a spreadsheet for further analysis.

All the data about each faculty member's publications was then used to compare and contrast the different physics departments from the analyzed schools. It was necessary to calculate the total number of citations over the total number of papers. This information is very important because it shows how valuable are the papers written. After this data was collected it was analyzed and compared with the number of faculty members and the NRC report.

CHAPTER 2
INDIVIDUAL ANALYSIS OF EACH PHYSICS DEPARTMENT

2.1 Introduction

The papers published by each faculty member have been analyzed to understand a factor that contributes to the quality of a physics department. The first part of the analysis examines the total number of papers published after 1990 and the number of papers published after 1999 by each faculty member at their current department. Because the number of papers does not necessarily show the quality of the work, it is also important to analyze the significance of each publication. The second part of the analysis examines the number of times each paper has been cited. The size of the faculty is usually directly connected to the quality of the department but it is also important to analyze the impact of the publications. The last part of the analysis compares the number of papers published after 1990 with the total number of citations for each faculty member. The correlation between these two factors will be evaluated.

The first figure shown for each school is a log graph comparing the number of papers published after 1990 (solid line) with the number of papers published after 1999 (dotted line). The vertical axis is the number of papers published by one faculty member and the horizontal axis lists the faculty members for the school being analyzed. The faculty members are ranked in descending order of the number of published papers after 1990. The further away the solid line is from the dotted line, the greater is the difference between the total number of papers and the number of papers published after 1999. For this figure, faculty members who published no papers are plotted at 0.1 because the log (0) is undefined. Also, for the number of citations per paper has also been changed to 0.1

for faculty members who have published zero papers. Therefore, the result of zero number of published papers divided by zero number of citations is not undefined, in this case, it is 0.1.

The second figure shown in the analysis of each school compares the number of papers published after 1990 (solid line) with the citations per paper (dotted line). The left vertical axis is the number of papers after 1990, the right vertical axis is the number of citations per paper and the horizontal axis lists the faculty members for the particular school being analyzed. The faculty members are ranked in descending order of the number of papers published. This figure indicates that the faculty member with the largest number of papers does not necessarily have the largest number of citations per publication. This particular method of analysis is useful for comparing schools with a very different number of faculty members.

The third and last figure described for each school analysis compares the number of papers published after 1990 (solid line) and the number of citations (dotted line). The left vertical axis is the number of papers, the right vertical axis is the number of citations, and the horizontal axis lists the faculty members. The faculty members are listed in descending order of the total number of published papers. The correlation between these two factors is very diverse for different schools.

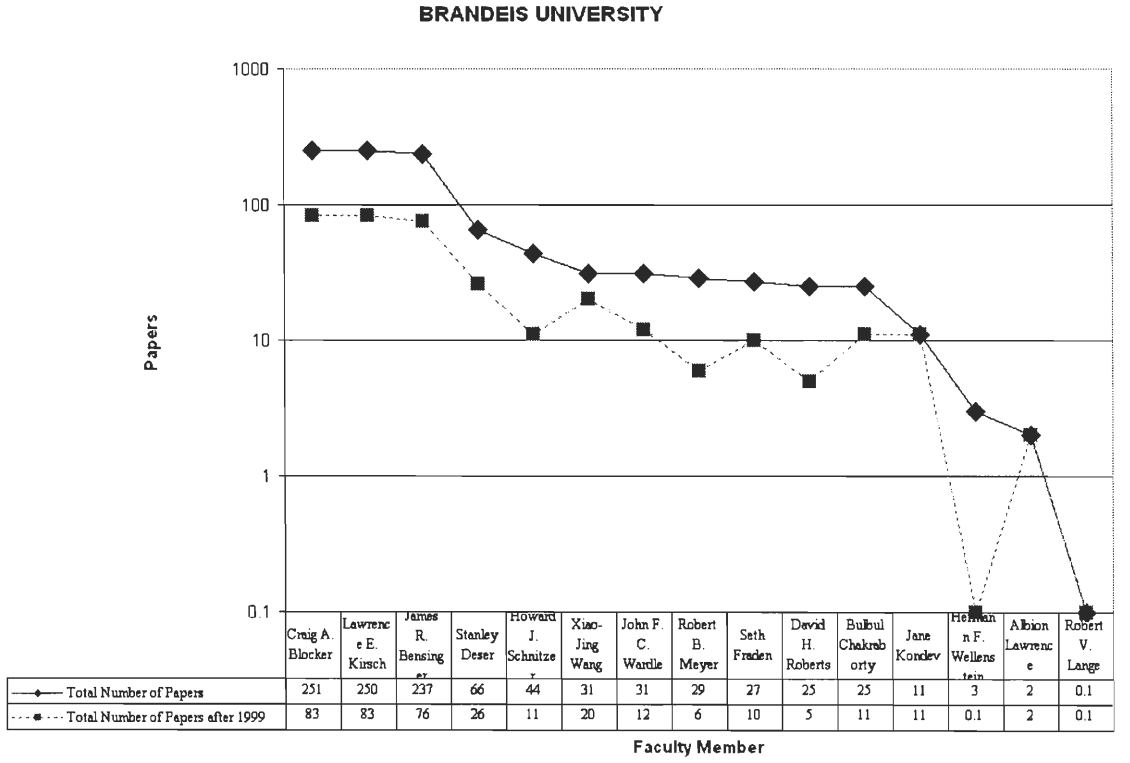
The Table described for each school lists all the faculty member for the school being analyzed with the number of papers published after 1990, the number of citations, the number of citations per paper, the maximum number of citations on one paper, and the year of latest publication, for each faculty member at each school being analyzed. The faculty members are listed in alphabetical order.

2.2 Brandeis University Analysis

Brandeis University has a total graduate enrollment of 1,872. The graduate physics program offers the degree of Ph.D. in physics with major research areas of Astrophysics, Biophysics, Condensed Matter Experiment, Cosmology, Gravity and Strings, High Energy Physics and Neuroscience. Brandeis has a total of 15 active faculty members in the physics department. Since 1990 the Brandeis physics faculty has published a total of 1032 papers with an average of 68.80 papers per faculty member.

Figure 2.2.1 shows the distribution of the total number of papers published after 1990 and the number of papers published after 1999 by each physics faculty member.

FIGURE 2.2.1



	Craig A. Blocker	Lawrence E. Kirsch	James R. Bensinger	Stanley Deser	Howard J. Schnitzer	Xiao-Jing Wang	John F. C. Wardle	Robert B. Meyer	Seth Fraden	David H. Roberts	Bulbul Chakraborty	Jane Kondev	Herman F. Wellenstein	Albion Lawrence	Robert V. Lange
Total Number of Papers	251	250	237	66	44	31	31	29	27	25	25	11	3	2	0.1
Total Number of Papers after 1999	83	83	76	26	11	20	12	6	10	5	11	11	0.1	2	0.1

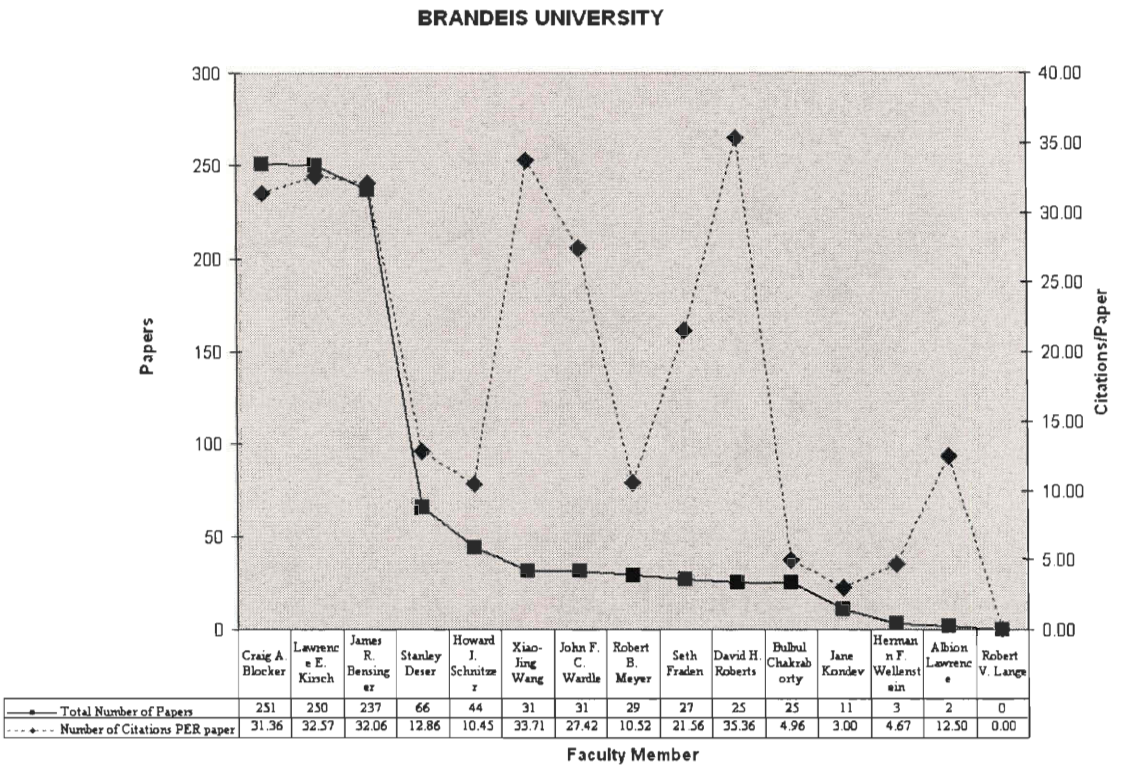
There is a direct correlation between the number of papers published after 1990 and the number of papers published after 1999. As the number of papers published after 1990 decreases, the number of papers published after 1999 decreases as well.

Blocker, the first on the list, has the largest number of papers and the largest number of papers published within the last 5 years. C. A. Blocker, L. E. Kirsch and J. R. Bensinger have each published over 200 papers. The Brandeis physics department has only one faculty member who has not published any papers since 1990 and two professors have not published any papers since 1999. The number of papers published after 1999 shows the recent level of research publication. The physics faculty published 256 papers in total after 1999 with an average of 23.73 papers per faculty member.

Figure 2.2.2 (next page) shows the number of published papers and the number of citations per paper for every faculty member at Brandeis. Papers published by Brandeis faculty members have been cited 28783 times. The number of citations per paper shows that some faculty members have published more papers but others who have fewer published papers hold a greater number of citations. The papers published by the physics department at Brandeis University have an average of 18.20 citations per paper.

Faculty members with the largest number of publications do not necessarily have the largest number of citations per paper. For example, Schnitzer has 44 published papers and an average of 10.45 citations per paper, while Roberts has published only 25 papers but has 35.36 citations per paper. Roberts has more than three times as many citations per paper than Schnitzer even though Schnitzer has published almost twice as many papers.

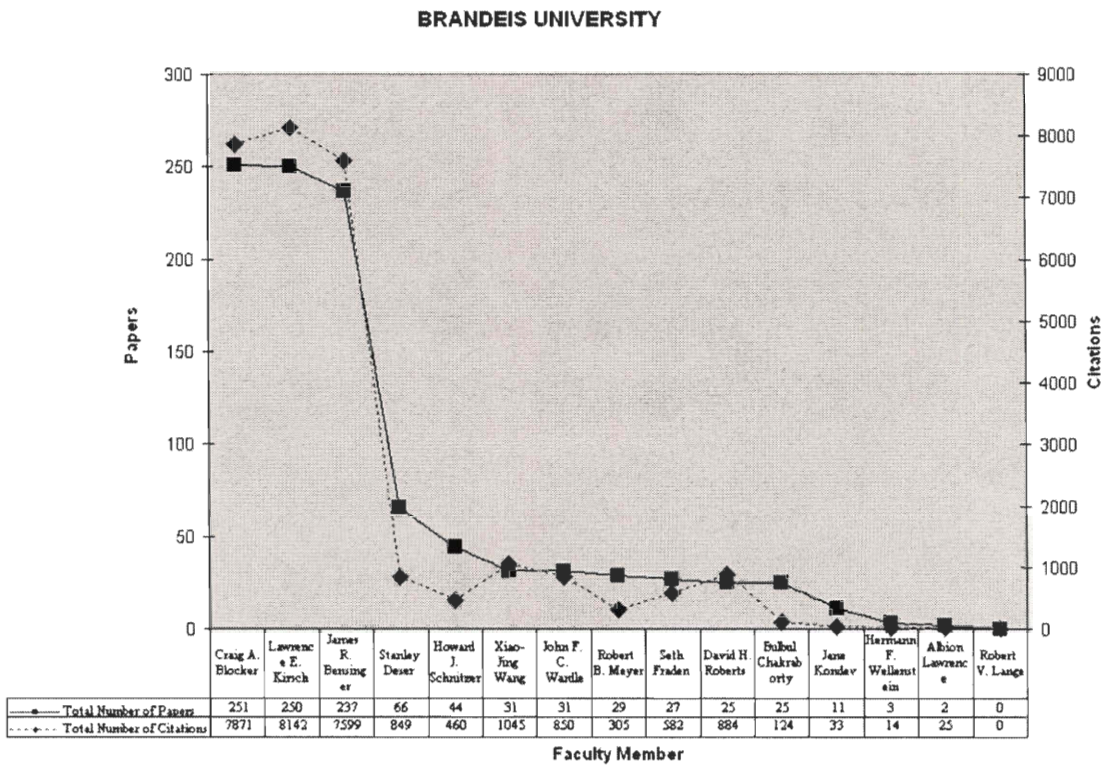
FIGURE 2.2.2



	Craig A. Blocker	Lawrence E. Kirsch	James R. Bensinger	Stanley Deser	Howard J. Schnitzer	Xiao-Jing Wang	John F. C. Wardle	Robert B. Meyer	Seth Fraden	David H. Roberts	Bulbul Chakraborty	Jane Kondev	Herman F. Wellenstein	Albion Lawrence	Robert V. Lange
Total Number of Papers	251	250	237	66	44	31	31	29	27	25	25	11	3	2	0
Number of Citations PER paper	31.36	32.57	32.06	12.86	10.45	33.71	27.42	10.52	21.56	35.36	4.96	3.00	4.67	12.50	0.00

Figure 2.2.3 shows the correlation between the number of published papers and the total number of citations in the physics department. As the number of papers decreases, the number of citations decreases as well. There are some faculty members who have published a similar number of papers but have received a much larger number of citations. For example, Schnitzer and Wang have published a similar number of papers but Wang has more than twice the number of citations as Schnitzer.

FIGURE 2.2.3



We now consider the maximum number of citations for one paper from each faculty member. For Brandeis, the most extensively cited publication belongs to Bensinger, Blocker and Kirsch with 669 citations. These three professors are authors of the same paper. The faculty member with the next largest maximum number of citations in a single publication is Wang with 208. Wang has published 31 papers since his arrival to Brandeis. Deser has published twice as many papers than Wang but his maximum number of citations on a single paper is only 58.

Table 2.2.1 shows every quantity analyzed in this part of the report. The faculty members are listed in alphabetical order.

TABLE 2.2.1

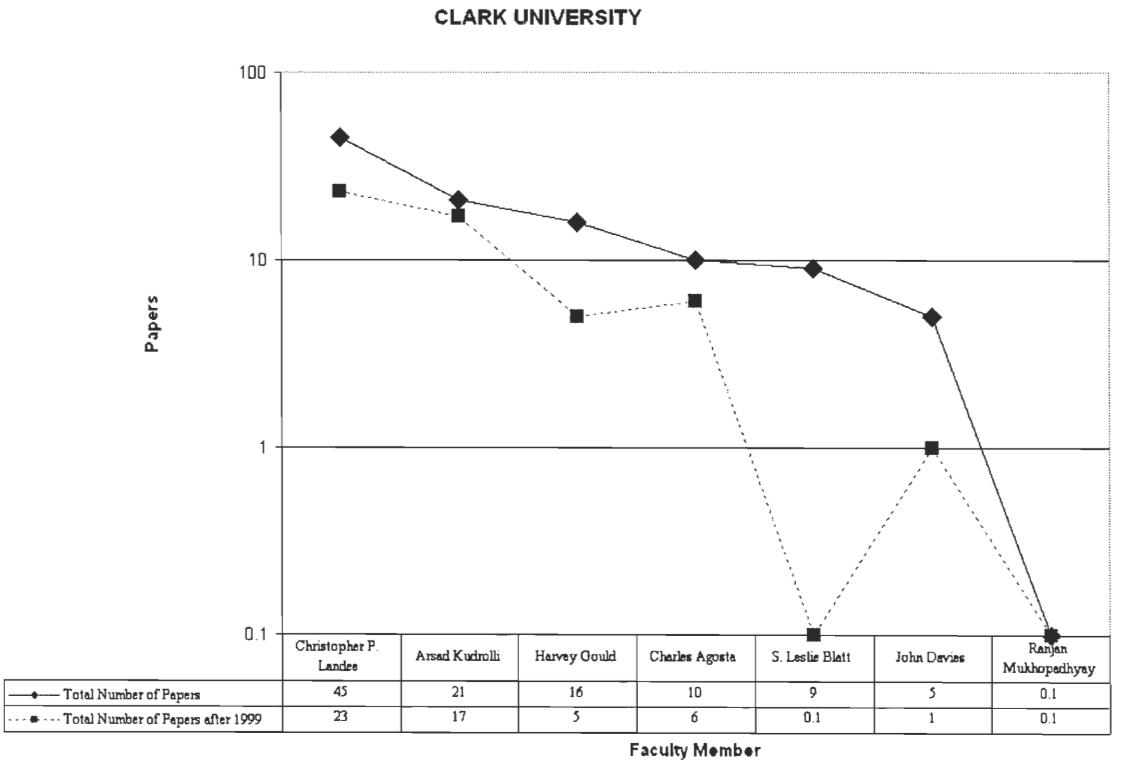
BRANDEIS UNIVERSITY						
Professor Name	**Papers**	**Citations**	**Citations/Paper**	**Max. # of citations on a single paper**	**Papers after 1999**	**Year of Latest publication**
Albion Lawrence	2	25	12.50	25	2	2004
Bulbul Chakraborty	25	124	4.96	38	11	2004
Craig A. Blocker	251	7871	31.36	669	83	2004
David H. Roberts	25	884	35.36	94	5	2004
Hermann F. Wellenstein	3	14	4.67	13	0.1	1995
Howard J. Schnitzer	44	460	10.45	146	11	2004
James R. Bensinger	237	7599	32.06	669	76	2004
Jane Kondev	11	33	3.00	17	11	2004
John F. C. Wardle	31	850	27.42	94	12	2004
Lawrence E. Kirsch	250	8142	32.57	669	83	2004
Robert B. Meyer	29	305	10.52	47	6	2004
Robert V. Lange	0	0	0.00	0	0	0
Seth Fraden	27	582	21.56	162	10	2004
Stanley Deser	66	849	12.86	58	26	2004
Xiao-Jing Wang	31	1045	33.71	209	20	2004

2.3 CLARK UNIVERSITY Analysis

Clark University has a graduate enrollment of 911 students. Clark offers a physics program focuses only on condensed matter physics. The research interests are in organic superconductivity, novel magnetic materials, theoretical biological physics, polymer physics and nuclear physics. Clark has a total of 7 active faculty members in its physics department: Christopher Landee, Arsad Kudrolli, Harvey Gould, Charles Agosta, S. Leslie Blatt, John Davies and Ranjan Mukhopadhyay.

Figure 2.3.1 shows the total number of papers published after 1990 and the number of papers published after 1999 by a faculty member.

FIGURE 2.3.1



	Christopher P. Landee	Arsad Kudrolli	Harvey Gould	Charles Agosta	S. Leslie Blatt	John Davies	Ranjan Mukhopadhyay
Total Number of Papers	45	21	16	10	9	5	0.1
Total Number of Papers after 1999	23	17	5	6	0.1	1	0.1

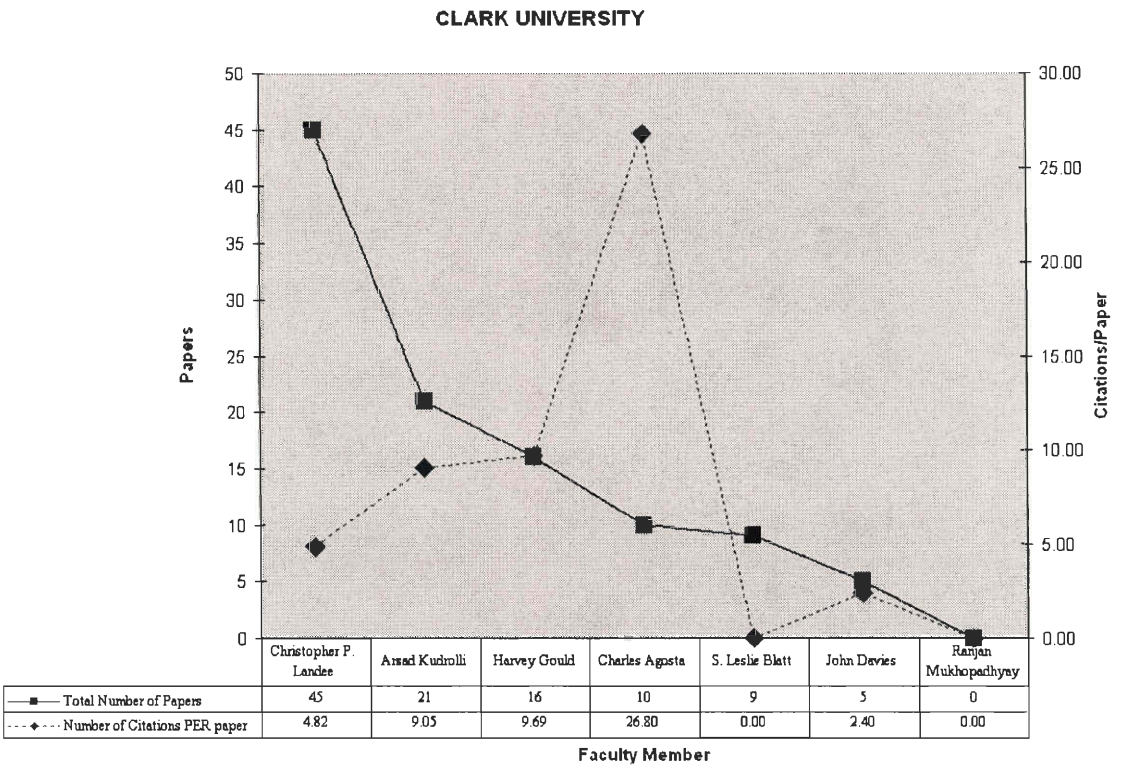
The physics department's faculty members have published a total of 106 papers after 1990, for an average of 15.14 papers per faculty member. There is a direct correlation between these two factors. As the number of papers published after 1990 decreases, the number of papers published after 1999 also decreases. Landee has the largest number of published papers with 45. There is only one professor who has not published any papers since 1990.

The number of papers published after 1999 is about half the total number of papers published after 1990. Clark's physics faculty has published an average of 7.43 papers per faculty member after 1999. The biggest separation between the two numbers is found with Blatt, who has published 9 papers in total, none in the past five years. On the contrary, Kudrolli has published most of his papers in recent years.

Figure 2.3.2 (next page) shows the number of papers and the citations per paper. Clark is the perfect example of how the number of citations per paper is not necessarily correlated with the number of published papers. For example, Landee has 45 published papers but received 4.82 citations per paper. On the contrary, Agosta has published 10 papers but has been cited an average of 26.80 times per paper. One of Agosta's papers was cited 91 times.

The papers published by Clark's faculty members have 842 citations between them with an average of 120.29 citations per faculty member. An average paper gets cited approximately 7.54 times. It is important to focus on the average number of citations per paper and not in the total number of papers because a University like Clark, that has a small number of faculty members is never going to have as many published papers as a school with a physics faculty 10 times its size.

FIGURE 2.3.2



In Figure 2.3.3 (next page), the faculty members are ordered by the number of papers, in descending order, but the citation's peak in the middle of the chart. The physics department has an uneven distribution between the number of papers and the number of citations.

FIGURE 2.3.3

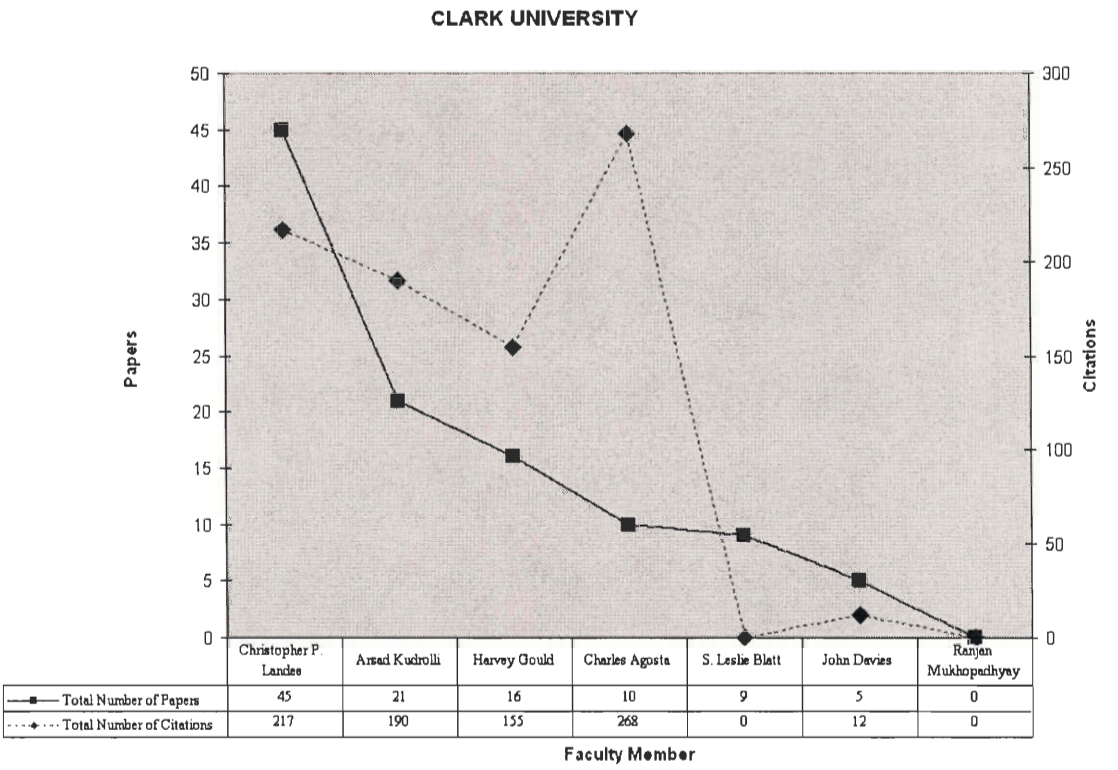


Table 2.3.1 shows a distribution of the values that were analyzed for Clark University.

TABLE 2.3.1

CLARK UNIVERSITY						
Professor Name	**Papers**	**Citations**	**Citations/ Paper**	**Max. # of citations on a single paper**	**Papers after 1999**	**Year of Latest publication**
Arsad Kudrolli	21	190	9.05	47	17	2004
Charles Agosta	10	268	26.80	91	6	2002
Christopher P. Landee	45	217	4.82	24	23	2004
Harvey Gould	16	155	9.69	48	5	2004
John Davies	5	12	2.40	4	1	2000
Ranjan Mukhopadhyay	0	0	0.00	0	0	0
S. Leslie Blatt	9	0	0.00	0	0	0

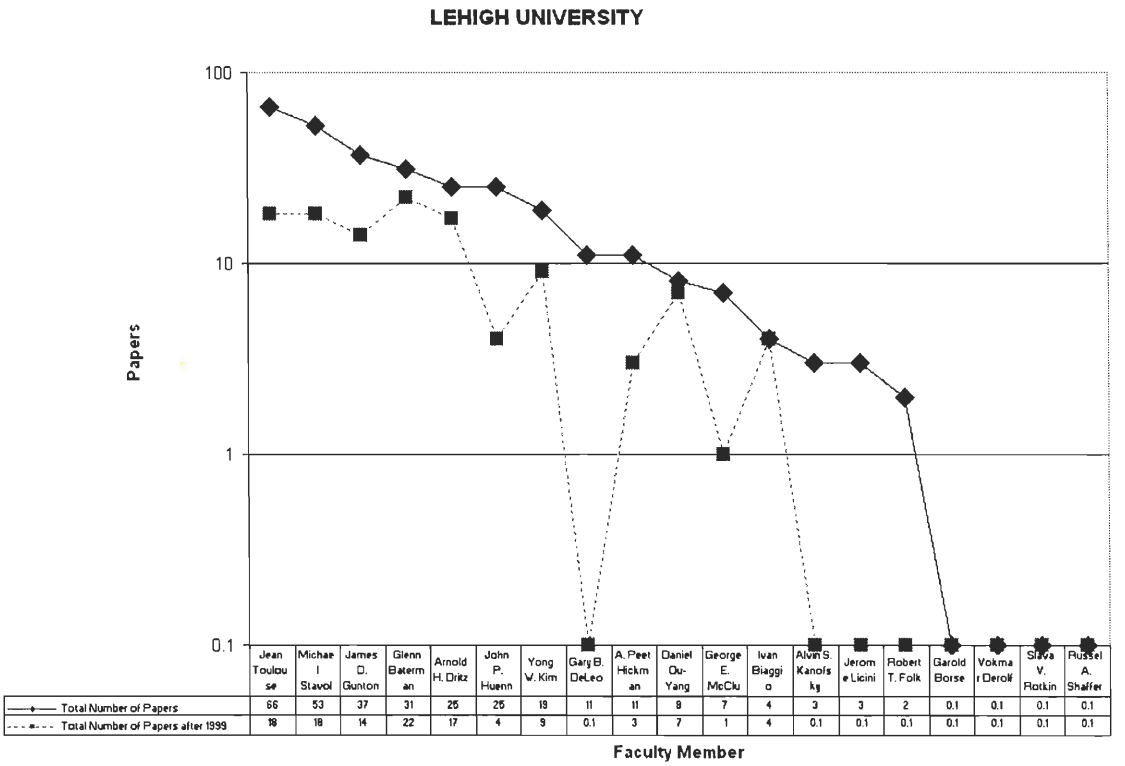
The year of latest publication shows how most faculty members have published their latest paper after 1999.

2.4 LEHIGH UNIVERSITY Analysis

Lehigh University has a total of 2,064 graduate students. It offers the M.S. and Ph.D. degrees in Physics and the M.S. degree in Photonics. The Lehigh physics program has concentrations in condensed matter physics, atomic, molecular and optical physics, plasma physics, statistical physics, complex fluids, and computational physics. Lehigh University's physics department has 19 total faculty members who will be used for this study.

Figure 2.4.1 shows the relationship between the number of papers published after 1990 and the number of papers published a decade later.

FIGURE 2.4.1



Faculty Member	Jean Toulouse	Michael Stavol	James D. Gunton	Glenn Baterman	Arnold H. Dritz	John P. Huenn	Yong W. Kim	Gary B. DeLeo	A. Peet Hickman	Daniel Ou-Yang	George E. McClu	Ivan Biaggio	Alvin S. Kanofsky	Jerome Licini	Robert T. Folk	Garold Borse	Vokmar Derolf	Slava V. Rotkin	Russel A. Shaffer
Total Number of Papers	66	53	37	31	25	25	19	11	11	8	7	4	3	3	2	0.1	0.1	0.1	0.1
Total Number of Papers after 1999	18	18	14	22	17	4	9	0.1	3	7	1	4	0.1	0.1	0.1	0.1	0.1	0.1	0.1

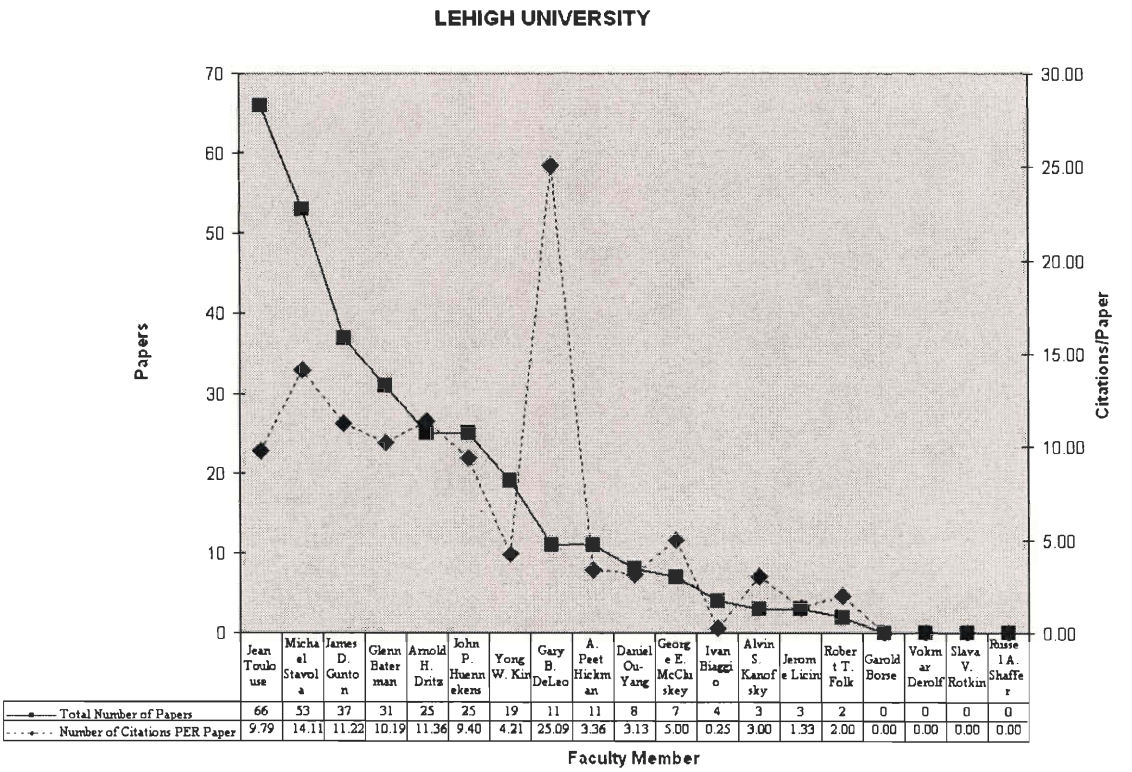
The physics department has published a total of 308 papers after 1990 with an average of 16.05 papers per faculty member. The number of papers published after 1999 is nearly

1/3 of that value. The average number of papers published after 1999 is 6.16 per faculty member.

The distance between the solid and the dotted lines changes dramatically throughout the graph. This illustrates how the number of papers has an uneven correlation with the number of papers published after 1999. For example, Biaggio published all of his papers in the past five years. On the contrary, DeLeo published 11 papers in total but none after 1999.

Figure 2.4.2 shows that the physics department has a close direct correlation between the number of published papers after 1990 and the number of citations per paper. The number of papers published after 1999 decreases as the number of papers published after 1990 decreases.

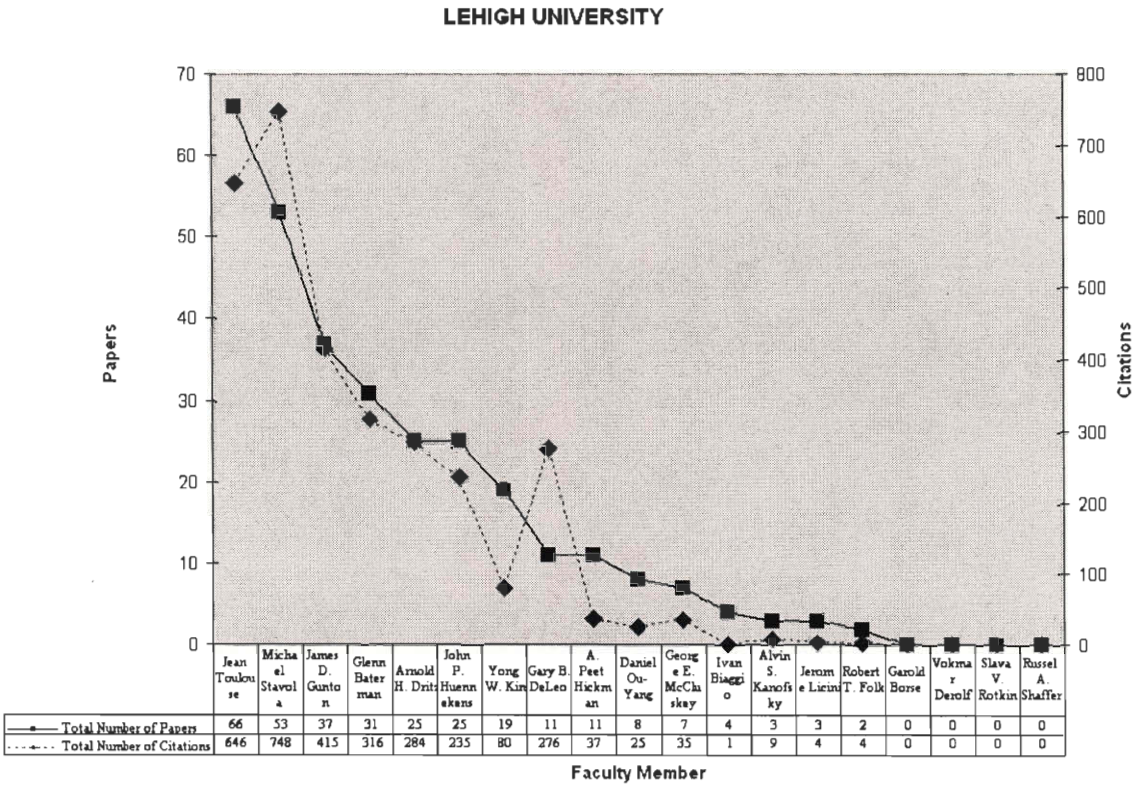
FIGURE 2.4.2



The main two exceptions to this correlation are Derelof with 11 published papers and with an extremely high number of citations per paper of 25.09 and Toulouse with 66 published papers but only 9.79 citations per paper. It could be concluded, for Lehigh Physics Faculty, that the number of citations per paper increases with the total number of published papers.

Figure 2.4.3 shows the correlation between the number of papers published after 1990 and the number of papers published after 1999 in the physics department. The number of citations decreases at a fairly regular rate. As the number of papers decreases, the total number of citations also decreases. Two noticeable peaks occurred with Stavola and DeLeo. Both professors have published papers that have been cited more regularly than fellow faculty members with a similar number of published papers.

FIGURE 2.4.3



DeLeo and Stavola published a paper with the largest number of citations for one publication from the Brandeis physics department. Either faculty member holds the largest number of published papers. Toulouse has the largest number of publications but his maximum number of citations on one of his papers is 88.

Table 2.4.1 shows the 19 faculty members being analyzed listed in alphabetical order.

TABLE 2.4.1

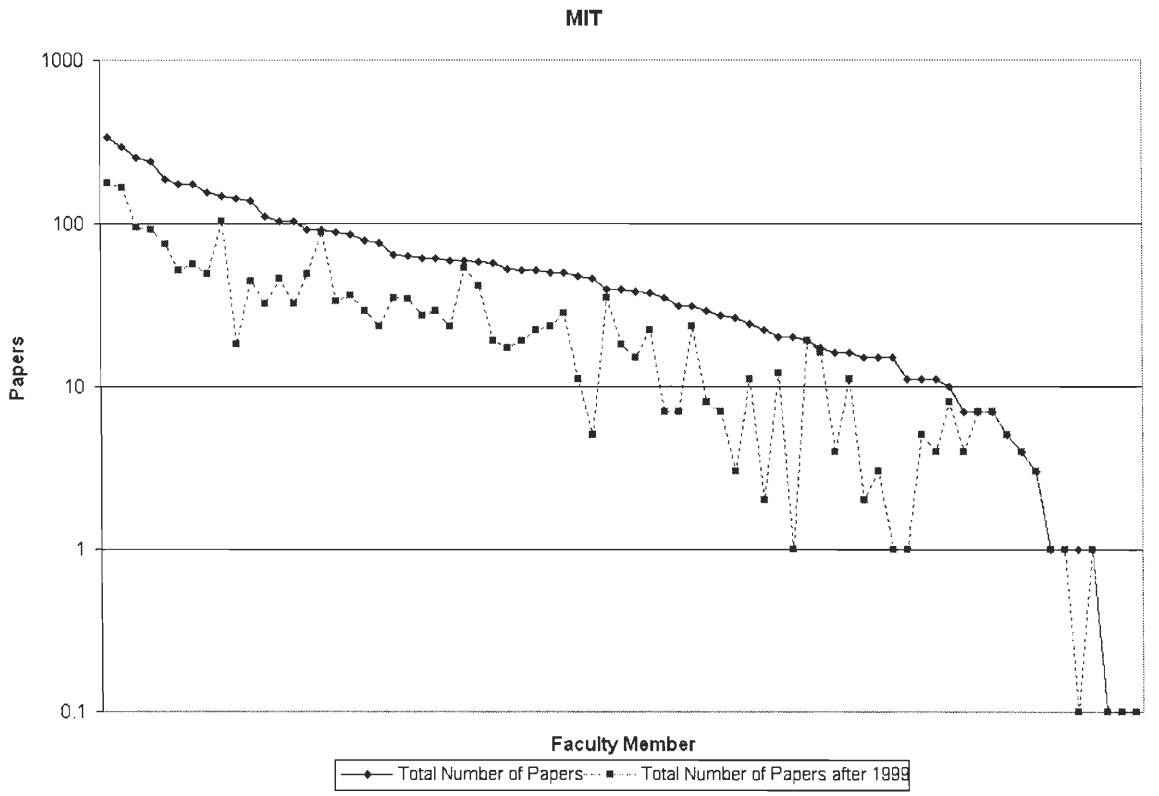
LEHIGH UNIVERSITY						
Professor Name	**Papers**	**Citations**	**Citations/ Paper**	**Max. # of citations on a single paper**	**Papers after 1999**	**Year of Latest publication**
A. Peet Hickman	11	37	3.36	7	3	2003
Alvin S. Kanofsky	3	9	3.00	7	0	1996
Arnold H. Dritz	25	284	11.36	104	17	2004
Daniel Ou-Yang	8	25	3.13	21	7	2004
Garold Borse	0	0	0.00	0	0	0
Gary B. DeLeo	11	276	25.09	148	0	1999
George E. McCluskey	7	35	5.00	9	1	2002
Glenn Baterman	31	316	10.19	104	22	2004
Ivan Biaggio	4	1	0.25	1	4	2004
James D. Gunton	37	415	11.22	63	14	2004
Jean Toulouse	66	646	9.79	88	18	2004
Jerome Licini	3	4	1.33	3	0	1995
John P. Huennekens	25	235	9.40	22	4	2003
Michael Stavola	53	748	14.11	148	18	2004
Robert T. Folk	2	4	2.00	2	0	1993
Russel A. Shaffer	0	0	0.00	0	0	0
Slava V. Rotkin	0	0	0.00	0	0	0
Vokmar Derolf	0	0	0.00	0	0	0
Yong W. Kim	19	80	4.21	25	9	2004

2.5 MIT Analysis

The Massachusetts Institute of Technology is the biggest school being analyzed in this report. MIT has a total graduate enrollment of 6,184 students. The physics department offers research concentrations in Astrophysics, Atomic, Condensed Matter, and Plasma Physics, Experimental Nuclear and Particle Physics and Theoretical Nuclear and Particle Physics. The MIT physics department has a total of 72 faculty members.

Figure 2.5.1 shows a distribution of the number of papers published after 1990 and the number of papers published after 1999 by each faculty member. The names for the faculty members have been omitted in the graph because of a lack of space. MIT's physics faculty members have a direct correlation between the number of papers published after 1990 and the number of papers published after 1999.

FIGURE 4.5.1



Both, the number of papers published after 1990 and the number of papers published after 1999 are very close to each other. This indicates that the majority of faculty members have continued to be very active with research in the past 5 years. In fact, only 16 faculty members have not published any papers in the within the last year. One of the major separations between these two values being analyzed happens with Min Chen. Chen who has published a total of 142 papers, 18 of those papers were published in past five years. On the contrary, 13 faculty members have published most, if not all, of their papers after 1999. This graph also indicates that, in the most part, the MIT physics faculty members are very active in research and publications. There are only four faculty members who have not published a paper since 1990.

Figure 2.5.2 (next page) shows the number of papers published after 1990 and the citations per paper. These two factors are not proportional to each other. There is no direct correlation between number of published papers and the number of citation per paper. As the number of papers decreases, the number of citations per paper stays fairly constant through the graph. The number of papers does not dictate the frequency in which each paper is being cited. The majority of the number of citations per paper is located between 50 and 200 citations per paper. This shows how although the number of papers is decreasing, the number of citations per paper stays fairly constant. MIT's physics faculty members have received a total of 1449 citations per paper. Each paper published by an MIT faculty member gets cited an average of 19.86 times. For example, Wolfgang Ketterle has the largest number of citations per paper -80.49- but has published less than 100 papers. On the other hand, Dresselhaus has published 338 papers but has been cited an average of 25 times per paper.

FIGURE 2.5.2

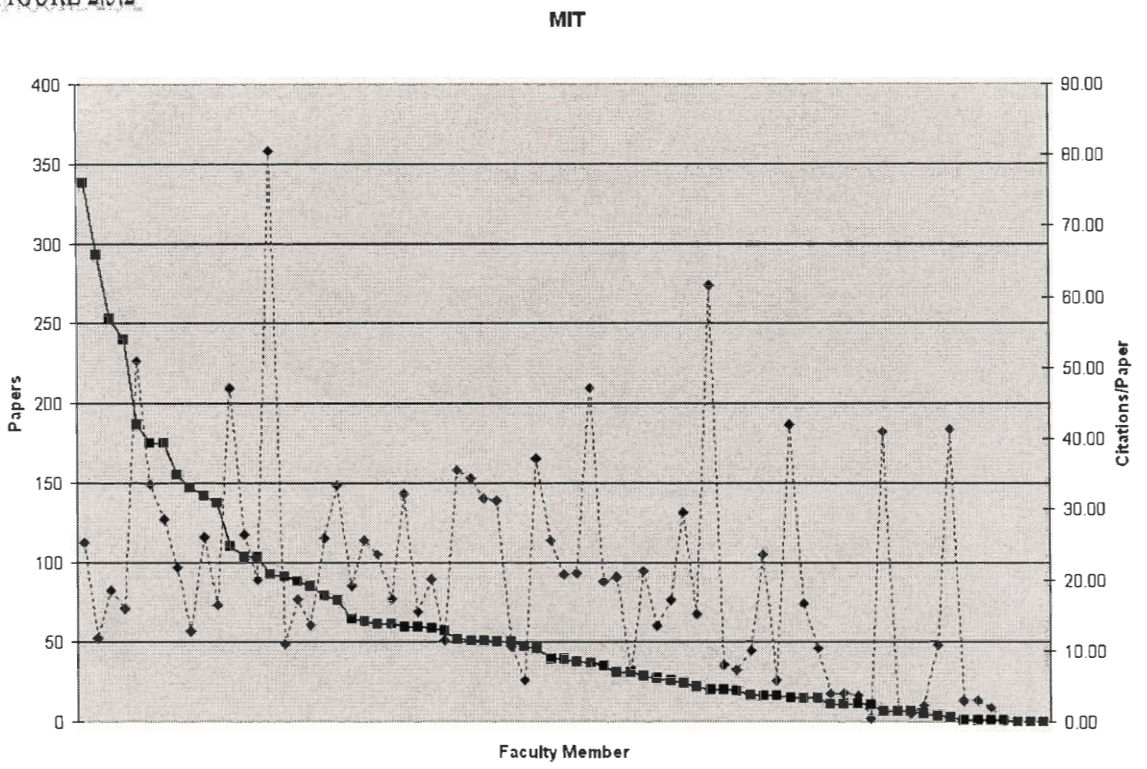
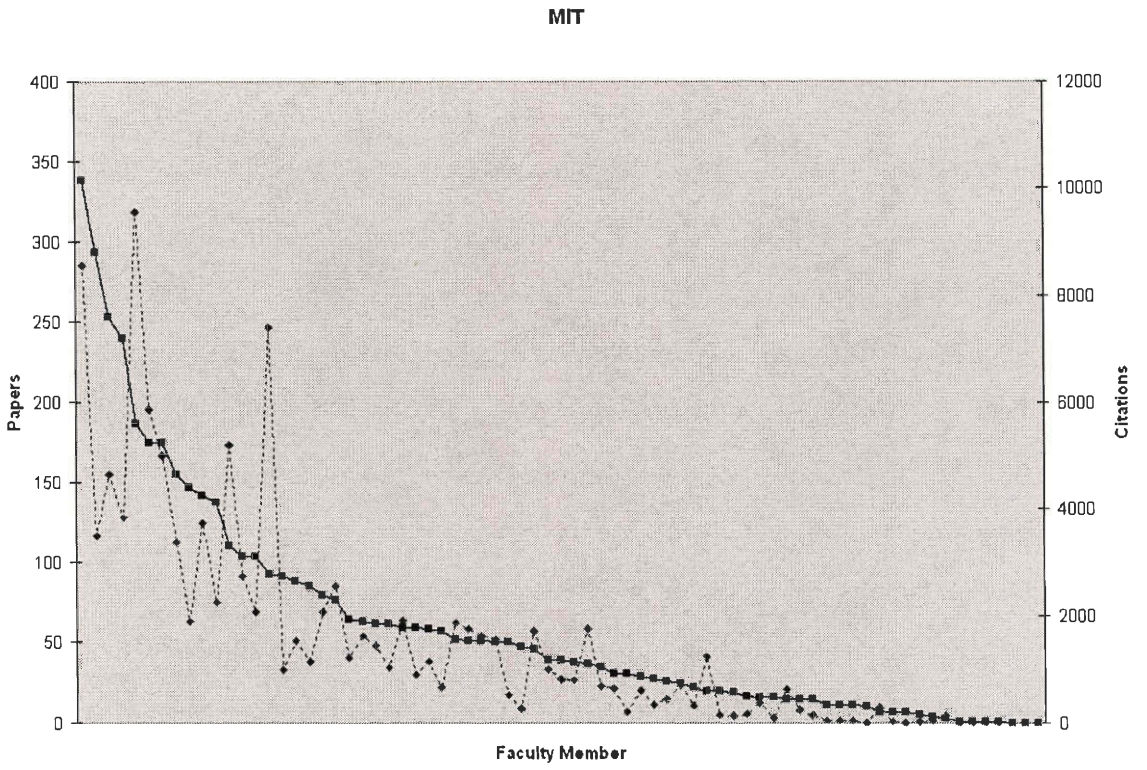


Figure 2.5.3 (next page) shows the distribution of the number of papers published after 1990 and the total number of citations for each faculty member. The faculty members' names have not been included in the graph. This figure shows the direct correlation between the number of published papers and the number of citations received. There are few exceptions to this correlation. The most noticeable separations between the number of published papers and the number of citations happens among the faculty with the largest number of papers. For instance, Paus has published 293 total papers which have been cited 3471 times. On the other hand, Joannapoulos has published a smaller number of papers but carries the largest number of citations. Joannapoulos papers have been cited 9534 times. The difference between the number of papers and the number of citations is minor within the faculty with a smaller number of publications, suggesting that the correlation is more direct.

FIGURE 2.5.3



For the MIT physics department analysis, we now consider the maximum number of citations for one paper. For this particular case the faculty member with the largest number of citations per paper as well as the paper with the maximum number of citations. John Joannapoulos had a total of 2075 citations for one of his publications. The only faculty member with a maximum number of citations on one paper close to Joannapoulos is Wolfgang Ketterle. Ketterle also has the largest number of citations per paper.

Table 2.5.1 (next page) shows the data collection for every faculty member at the MIT' physics department.

Table 2.5.1

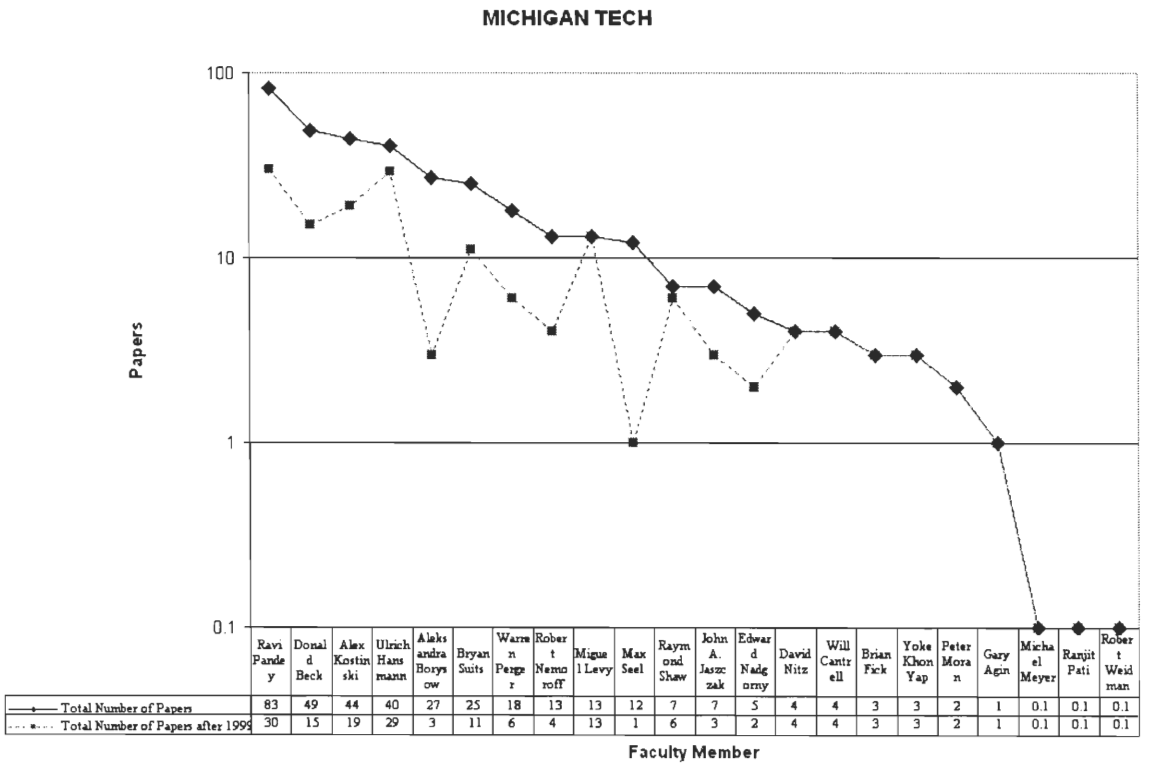
MASSACHUSETTS INSTITUTE OF TECHNOLOGY						
Professor Name	**Papers**	**Citations**	**Citations/ Paper**	**Max. # of citations on a single paper**	**Papers after 1999**	**Year of Latest publication**
A. Nihat Berker	35	694	19.83	199	7	2004
Adam burgasser	0	0	0.00	0	0	-
Alan H. Guth	16	378	23.63	64	4	2003
Alexander Van Oudennarden	17	168	9.88	60	16	2004
Amihay Hanany	31	217	7.00	21	23	2004
Arthur K. Kerman	27	365	13.52	81	7	2001
Barton Zwiebach	51	1613	31.63	126	22	2004
Bernd Surrow	1	3	3.00	3	1	2004
Boleslaw Wyslouch	103	2721	26.42	410	46	2004
Bruce Knuteson	7	8	1.14	4	7	2004
Bruno Coppi	47	274	5.83	35	11	2004
Christoph M. E. Paus	293	3471	11.85	49	167	2004
Claude R. Banizares	64	1219	19.05	105	35	2004
Daniel Freedman	50	1559	31.18	100	23	2004
David E. Pritchard	79	2048	25.92	236	29	2004
David Kaiser	10	5	0.50	2	8	2003
Deepto Chakrabarty	58	1162	20.03	184	41	2004
Edmund Betschinger	46	1710	37.17	195	5	2004
Edward H. Farhi	0	0	0.00	0	0	-
Eric W. Hudson	3	124	41.33	124	3	2003
Erich P. Ippen	175	5000	28.57	236	56	2004
Ernest J. Moniz	11	40	3.64	18	4	2004
Erotokritos Katsavounidis	19	140	7.37	77	19	2004
Frank Wilczek	39	1000	25.64	437	35	2004
Gabreilla Sciolla	91	992	10.90	162	89	2004
Geoge B. Benedek	51	1757	34.45	244	19	2003
Gunther Roland	59	913	15.47	159	53	2004
Haiyan Gao	63	1615	25.63	160	34	2004
Hong Liu	52	1850	35.58	270	17	2004
Iain W. Stewart	5	12	2.40	7	5	2004
Isaac Chuang	20	1232	61.60	549	12	2004
J. David Litster	20	161	8.05	39	1	2001
Jacqueline N. Hewitt	29	614	21.17	110	8	2003
James L. Elliot	57	657	11.53	99	19	2004
Jerome I Friedman	15	155	10.33	49	1	2001
John D. Joannapoulos	187	9534	50.98	2075	75	2004
John W. Belcher	22	331	15.05	48	2	2003
John W. Negele	50	532	10.64	135	28	2004
June L. Mathews	11	44	4.00	13	5	2003
Krishna Rajagopal	37	1747	47.22	437	22	2004
Leonid S. Levitov	38	797	20.97	145	15	2004
Max Tegmark	4	43	10.75	23	4	2004
Mehran Kardar	103	2050	19.90	86	32	2004
Michael S. Feld	155	3369	21.74	291	49	2004
Miklos Porkolab	85	1155	13.59	132	36	2004
Mildred S. Dresselhaus	338	8543	25.28	651	177	2004
Min chen	142	3713	26.15	410	18	2003
Nergis Mavalvala	16	92	5.75	19	11	2004
Patrick a. Lee	110	5194	47.22	770	32	2004
Paul C. Joss	15	248	16.53	73	3	2004
Paul Schechter	61	1440	23.61	319	27	2004
Peter Fisher	240	3833	15.97	219	92	2004
Raymond Ashoori	24	709	29.54	418	11	2004
Richard G. Milner	31	631	20.35	80	7	2004

2.6 MICHIGAN TECH. UNIVERSITY - Analysis

The Michigan Technological University has a graduate enrollment of 831 students. The physics department offers the M.S. and Ph.D. degrees with research concentrations in computational quantum, statistical physics, materials/laser physics and atmospheric physics/astrophysics. The MTU physics department has 22 faculty members who have published a total of 360 papers after 1990, with an average of 16.36 papers per faculty member.

Figure 2.6.1 shows the distribution of the number of papers after 1990 and the number of papers published after 1999 for each faculty member being analyzed. There is a direct correlation between the number of papers published after 1990 and the number papers published ten years later.

FIGURE 2.6.1



	Ravi Pandey	Donald Beck	Alex Kostinski	Ulrich Hansmann	Aleksandra Borysow	Bryan Suits	Warren Perger	Robert Nemiroff	Miguel Levy	Max Seel	Raymond Shaw	John A. Jaszczak	Edward Nadgorny	David Nitz	Will Cantrell	Brian Fick	Yoke Khon Yap	Peter Moran	Gary Agin	Michael Meyer	Ranjit Pati	Robert Weidman
Total Number of Papers	83	49	44	40	27	25	18	13	13	12	7	7	5	4	4	3	3	2	1	0.1	0.1	0.1
Total Number of Papers after 1999	30	15	19	29	3	11	6	4	13	1	6	3	2	4	4	3	3	2	1	0.1	0.1	0.1

Faculty members in the physics department have been very active in the past five years. In fact, 7 faculty members have published all of their papers within the past five years. 158 papers have been published after 1999. The biggest gap between these two quantities happens with Max Seel, who has published 12 papers in total, none after 1999.

Figure 2.6.2 shows the minimal correlation between the number of papers and the number of citations per paper. For example, Brian Fich has published three papers and has been cited 14 times per published paper. On the contrary, Ravi Pandley has published 83 papers and has been cited an average of 10 times per paper. Michigan Tech physics faculty members have 114.38 citations per paper. Each faculty member has published an average of 16 papers and each papers gets cited an average of 5 times.

FIGURE 2.6.2

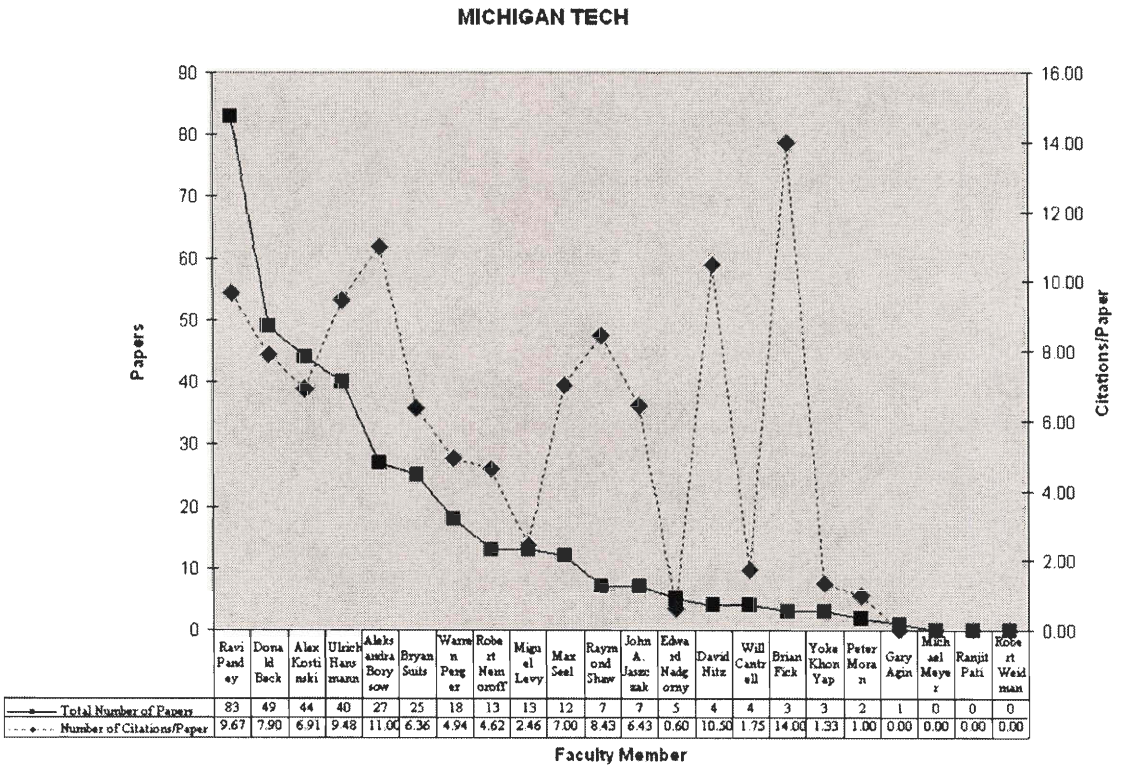
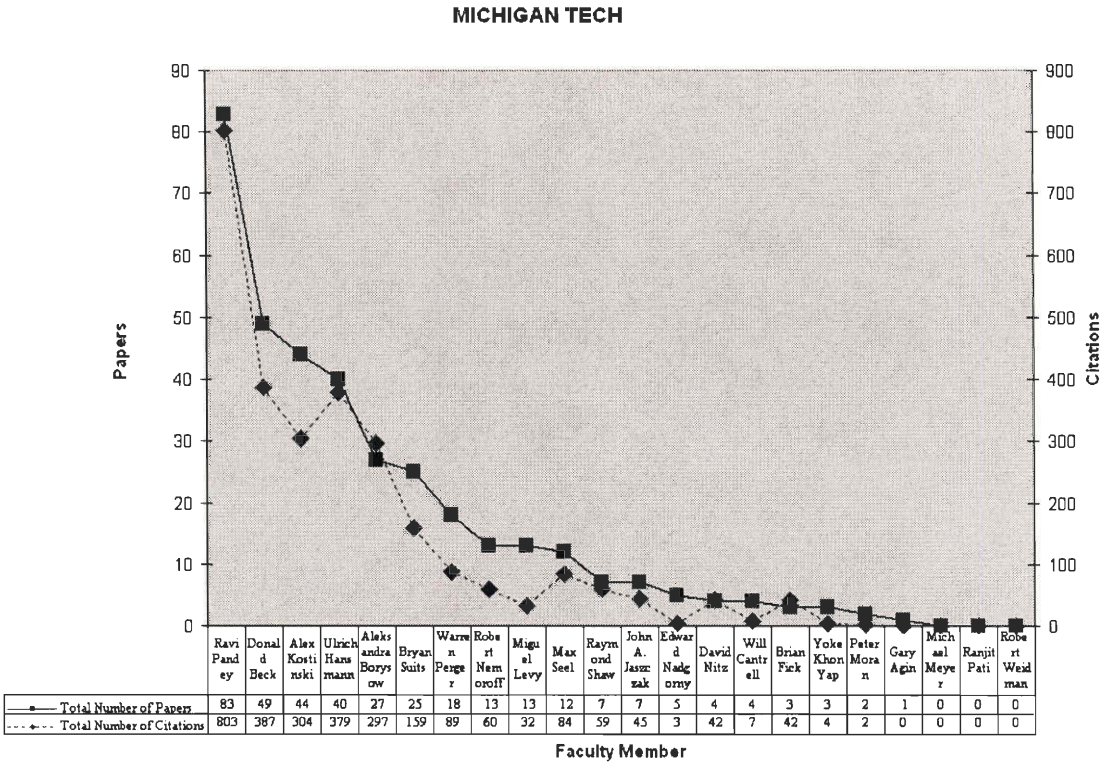


Figure 2.6.3 illustrates the total number of papers and the number of citations. Michigan Tech has one of the most directly related data for the number of papers and the number of citations. There is a direct correlation between these two factors. As the number of published papers increases, the number of citations also increases. There are few exceptions where faculty members with a lesser number of papers get a larger number of citations. Ravi Pandey has the largest number of papers as well as the largest number of citations.

FIGURE 2.6.3



Faculty Member	Ravi Pandey	Donald Beck	Alex Kostinski	Ulrich Hansmann	Aleksandra Borysow	Bryan Suits	Warren Perger	Robert Nemoroff	Miguel Levy	Max Seel	Raymond Shaw	John A. Jaszczak	Edward Nadgorny	David Nitz	Will Cantrell	Brian Fick	Yoke Khon Yap	Peter Moran	Gary Agin	Michael Meyer	Ranjit Pati	Robert Weidman
Total Number of Papers	83	49	44	40	27	25	18	13	13	12	7	7	5	4	4	3	3	2	1	0	0	0
Total Number of Citations	803	387	304	379	297	159	89	60	32	84	59	45	3	42	7	42	4	2	0	0	0	0

Aleksandra Borysow has the maximum number of citations on a single publication. The maximum number of citations on a single publication does not depend of the number of published papers. Borysow does not have the largest number of papers or the largest number of citations.

Table 2.6.1 is a recollection of data for each faculty member in the Michigan Tech physics department.

TABLE 2.6.1

MICHIGAN TECH. UNIVERSITY						
Professor Name	**Papers**	**Citations**	**Citations/ Paper**	**Max. # of citations on a single paper**	**Papers after 1999**	**Year of Latest publication**
Aleksandra Borysow	27	297	11.00	41	3	2001
Alex Kostinski	44	304	6.91	26	19	2004
Brian Fick	3	42	14.00	30	3	2004
Bryan Suits	25	159	6.36	20	11	2004
David Nitz	4	42	10.50	30	4	2004
Donald Beck	49	387	7.90	27	15	2004
Edward Nadgorny	5	3	0.60	2	2	2004
Gary Agin	1	0	0.00	0	1	2003
John A. Jaszczak	7	45	6.43	18	3	2003
Max Seel	12	84	7.00	25	1	1999
Michael Meyer	0	0	0.00	0	0	0
Miguel Levy	13	32	2.46	7	13	2003
Peter Moran	2	2	1.00	2	2	2003
Ranjit Pati	0	0	0.00	0	0	0
Ravi Pandey	83	803	9.67	51	30	2004
Raymond Shaw	7	59	8.43	17	6	2003
Robert Nemoroff	13	60	4.62	12	4	2003
Robert Weidman	0	0	0.00	0	0	0
Ulrich Hansmann	40	379	9.48	39	29	2004
Warren Perger	18	89	4.94	14	6	2004
Will Cantrell	4	7	1.75	5	4	2004
Yoke Khon Yap	3	4	1.33	3	3	2002

2.7 RPI Analysis

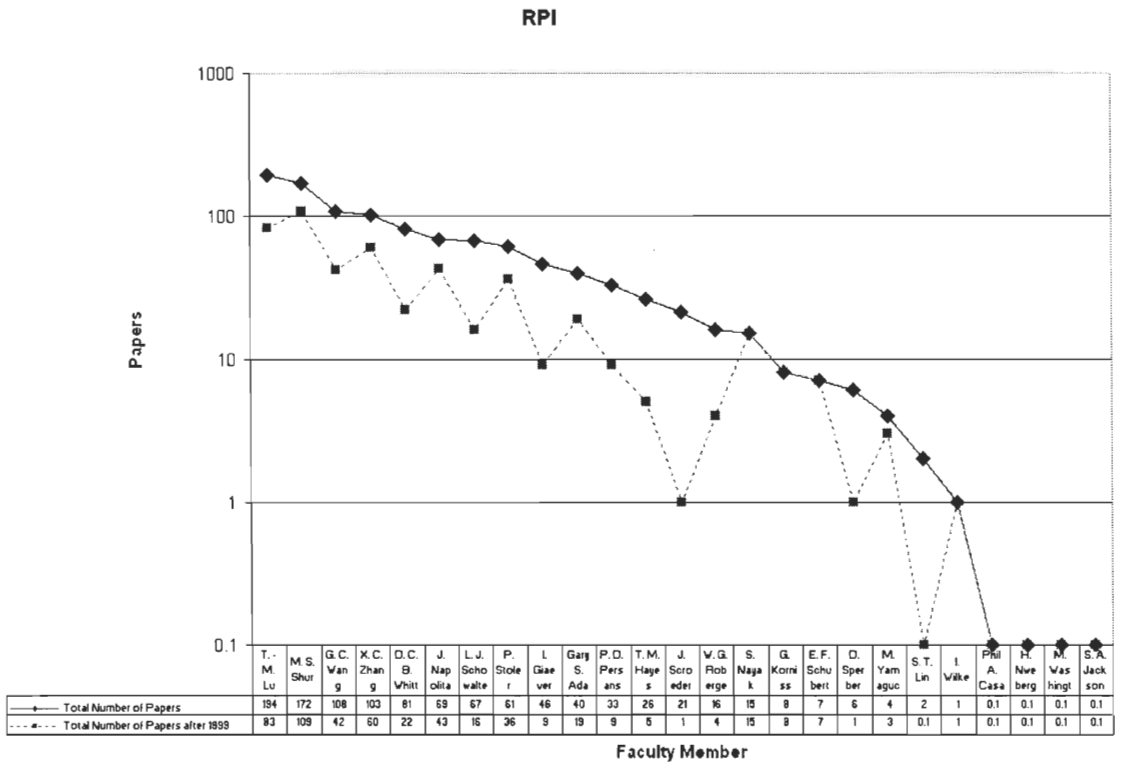
Rensselaer Polytechnic Institute offers the M.S and the Ph.D degrees in astronomy and astrophysics, particle physics, condensed matter physics, THz and photonic physics, biophysics, and educational physics. RPI has a total graduate enrollment of 2,592. The physics department has a total of 25 faculty members.

The RPI physics faculty members have published 1080 papers since 1990. The physics faculty members have published, on average, 43.20 papers. The physics department has only one faculty member who has not published any papers since 1999 and 4 faculty members who have not published any papers since 1990. Eighty percent of the faculty members have been active with research and publications.

Figure 2.7.1 (next page) illustrates the total number of papers published after 1990 and the number of papers published after 1999. A direct correlation can be noticed between both numbers of papers. The number of papers published after 1990 decreases as the number of papers published after 1999 decreases. For the first 6 faculty members, the number of papers after 1990 differs from the number of papers published after 1999 by a factor of 2.

T. M. Lu has published the most number of papers since 1990 and has the second largest number of papers since 1999. J. Scroeder has the biggest difference between the number of papers published after 1990 and the ones published after 1999. Scroeder has published a total of 21 papers but only 1 within the last five years.

FIGURE 2.7.1



	T. M. Lu	M.S. Shur	G.C. Wang	X.C. Zhang	D.C. B. Whitt	J. Napolita	L.J. Schowalte	P. Stoler	L Glaever	Garg S. Ada	P.D. Persans	T.M. Hayes	J. Scroeder	W.G. Roberge	S. Nayak	G. Kornss	E.F. Schubert	D. Sperber	M. Yamaguc	S.T. Lin	I. Wilke	Phil A. Casa	H. Weberg	M. Washingt	S.A. Jackson
Total Number of Papers	194	172	108	103	81	69	67	61	46	40	33	26	21	16	15	8	7	6	4	2	1	0.1	0.1	0.1	0.1
Total Number of Papers after 1999	83	109	42	60	22	43	16	36	9	19	9	5	1	4	15	8	7	1	3	0.1	1	0.1	0.1	0.1	0.1

Figure 2.7.2 (next page) shows the distribution of the number of published papers and the citations per paper. For RPI's physics faculty members, the number of published papers does not dictate how many citations each paper is going to have. There is no correlation between the two factors. For example, T. M. Lu has the largest number of published papers but he is located in the lower half of the citations per paper distribution. On the contrary, B.C.B Whittet has published only 81 papers but his papers were cited an average of 22.67 times. In fact, the three faculty members with the most published papers are not part of the group of faculty members with the largest number of citations per paper.

FIGURE 2.7.2

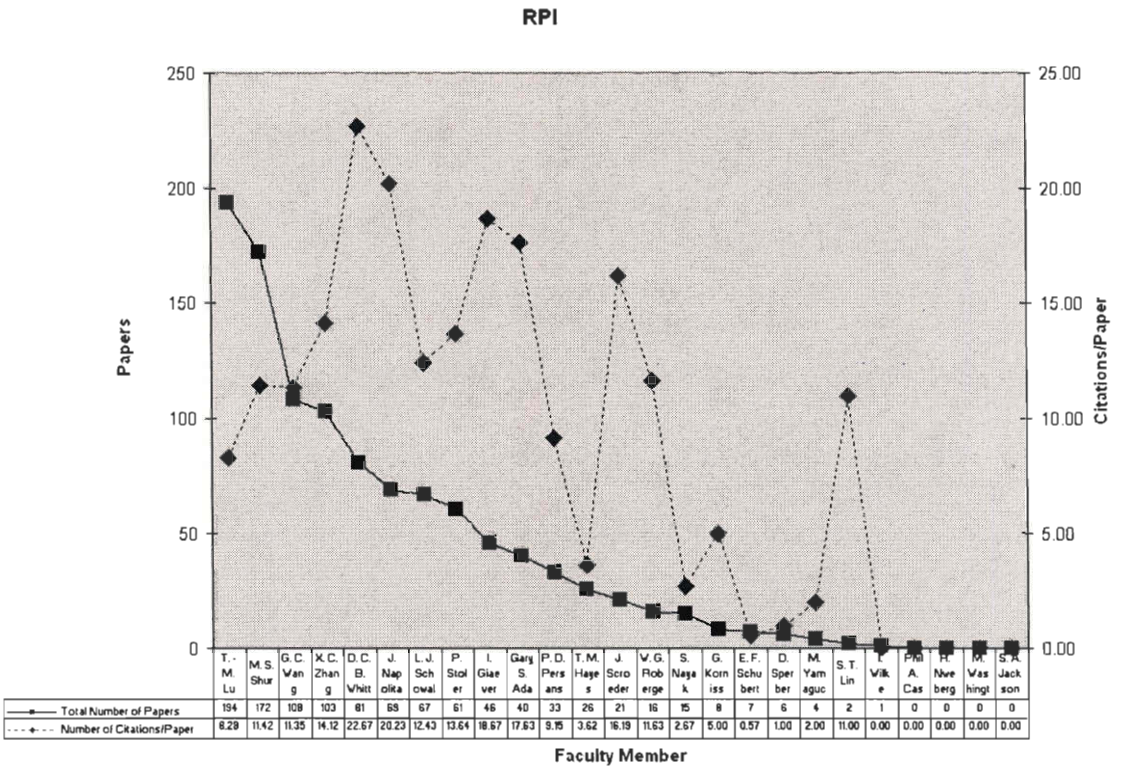
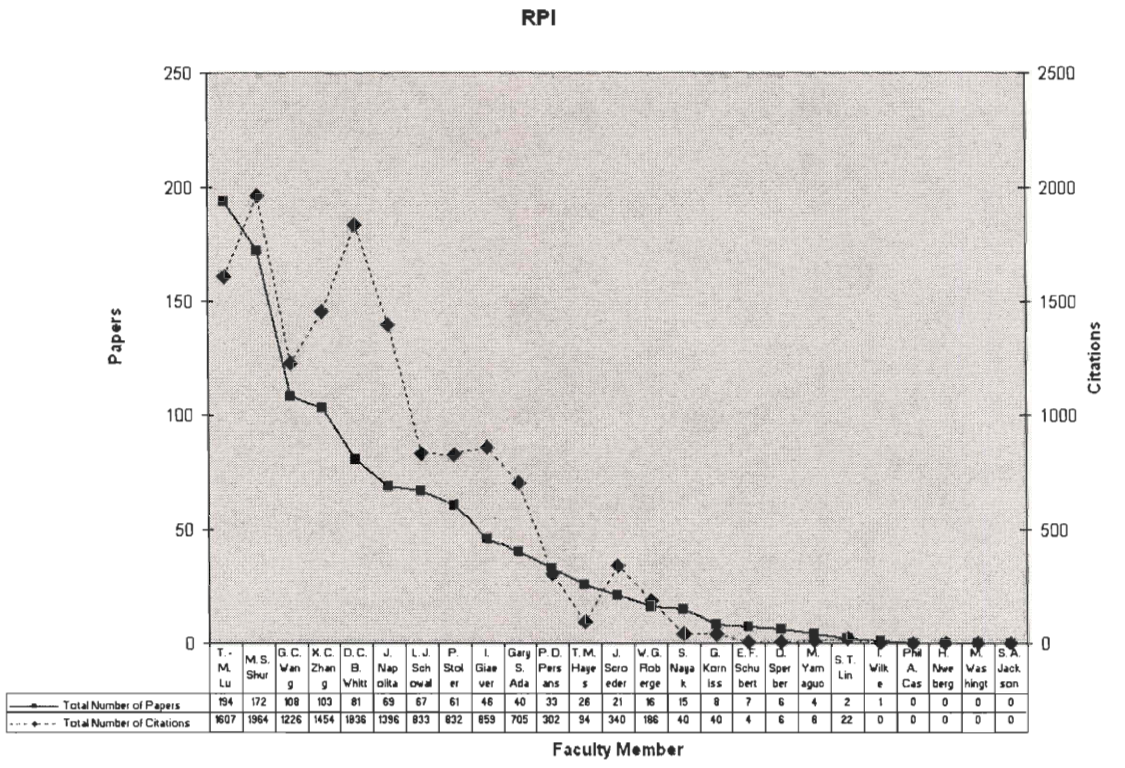


Figure 2.7.3 (next page) illustrates the distribution of the total number of papers published after 1990 and the number of citations received by the physics faculty members at the Rensselaer Polytechnic Institute. There is a direct correlation between the two analyzed factors. As the number of papers decreases, the total citations decrease as well. There are few exceptions to this correlation that are mainly located within the faculty members with the largest number of published papers. For example, Whittet has received a larger number of citations that of three faculty members with a larger number of published papers. Another example is M. S. Shur, who has published the second largest number of papers but has received the most citations.

FIGURE 2.7.3



We now analyze the maximum number of citations for a single paper from each faculty member. J. Napolitano, with 127, has the most citations on one paper. Napolitano has a typical number of published papers when compared with fellow faculty members, but he has a fairly large number of citations and citations per paper. With this we conclude that the maximum number of citations for a single paper is directly related to the number of citations per paper but has no correlation with the total number of published papers.

Table 2.7.1 (next page) shows the data analyzed for each faculty member at Rensselaer Polytechnic Institute. The faculty members are listed in alphabetical order. The year of latest publications shows how, for the most part, faculty members at RPI have published their last paper in the last year.

TABLE 2.7.1

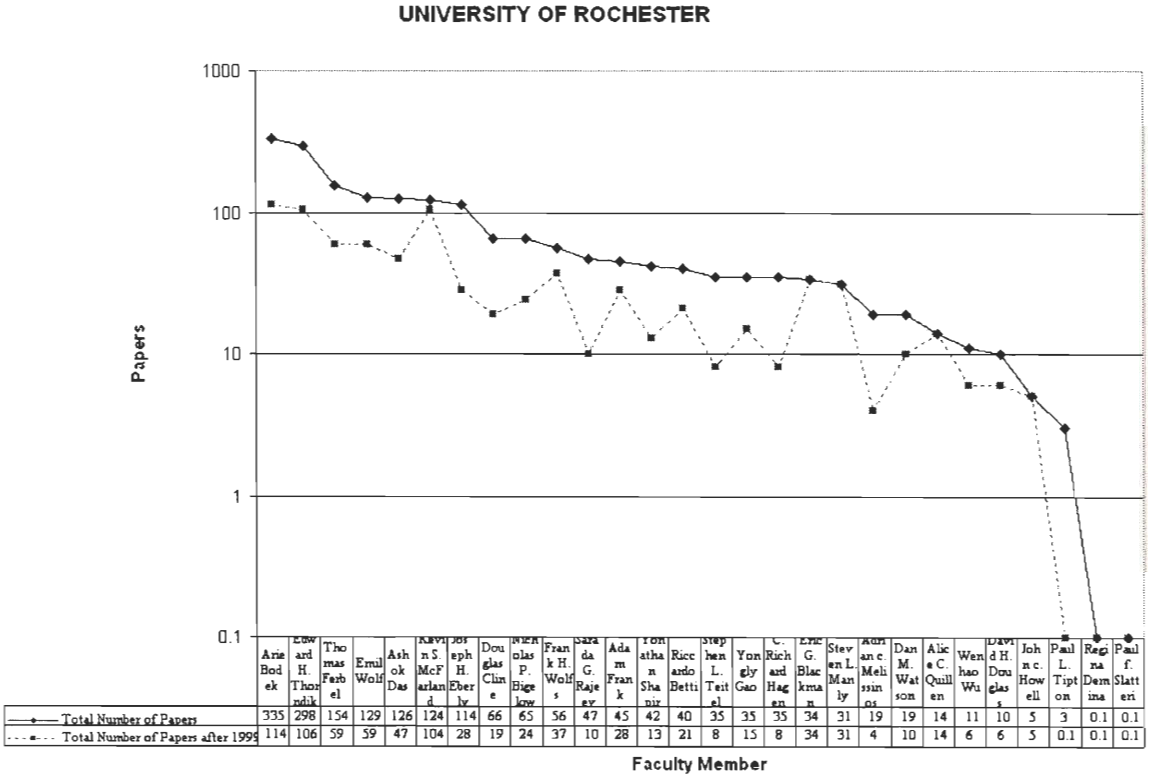
RENSSELAER POLYTECHNIC INSTITUTE						
Professor Name	**Papers**	**Citations**	**Citations/ Paper**	**Max. # of citations on a single paper**	**Papers after 1999**	**Year of Latest publication**
D. C. B. Whittet	81	1836	22.67	90	22	2004
D. Sperber	6	6	1.00	3	1	2000
E. F. Schubert	7	4	0.57	2	7	2004
G. C. Wang	108	1226	11.35	122	42	2004
G. Korniss	8	40	5.00	21	8	2004
Gary S. Adams	40	705	17.63	66	19	2004
H. Nweberg	0	0	0.00	0	0	0
I. Giaever	46	859	18.67	92	9	2004
I. Wilke	1	0	0.00	0	1	2004
J. Napolitano	69	1396	20.23	127	43	2004
J. Scroeder	21	340	16.19	122	1	2003
L. J. Schowalter	67	833	12.43	91	16	2004
M. S. Shur	172	1964	11.42	80	109	2004
M. Washington	0	0	0.00	0	0	0
M. Yamaguchi	4	8	2.00	6	3	2003
P. D. Persans	33	302	9.15	50	9	2004
P. Stoler	61	832	13.64	57	36	2004
Phil A. Casabella	0	0	0.00	0	0	0
S. A. Jackson	0	0	0.00	0	0	0
S. Nayak	15	40	2.67	12	15	2004
S. T. Lin	2	22	11.00	16	0	1991
T. M. Hayes	26	94	3.62	34	5	2001
T. -M. Lu	194	1607	8.28	122	83	2004
W. G. Roberge	16	186	11.63	60	4	2004
X. C. Zhang	103	1454	14.12	93	60	2004

2.8 University of Rochester Analysis

The University of Rochester has 2,248 students enrolled for their graduate programs. The physics department has 28 faculty members who will be used in this study. The Rochester physics faculty members have published a total of 1892 papers with an average of 67.57 papers per faculty member.

Figure 2.8.1 shows the distribution of the total number of papers published after 1990 and the number of papers published after 1999. There is a direct correlation between the number of papers published after 1990 and the number of papers published after 1999. For example, Arie Bodek has the largest number of papers published after 1990 and after 1999.

FIGURE 2.8.1

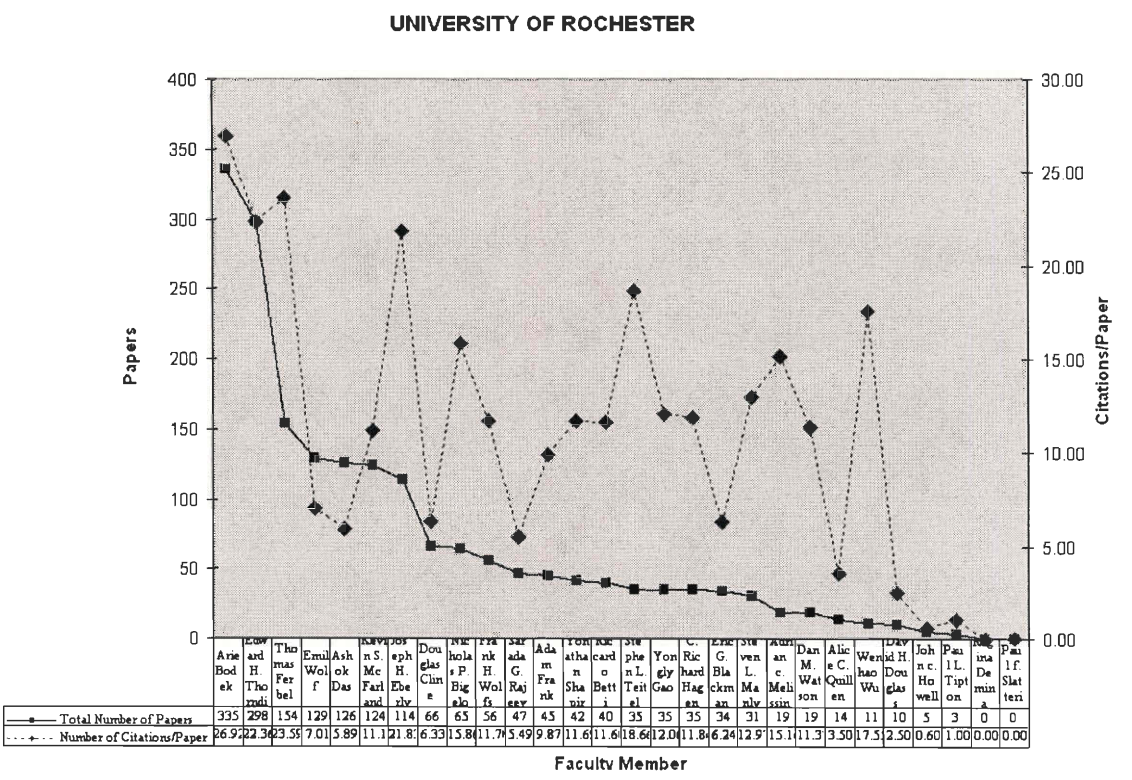


Faculty Member	Arie Bodek	Edward H. Thorndike	Thomas Farbel	Emil Wolf	Ashok Das	Kevin S. McFarland	Joseph H. Eberly	Douglas Cline	Nicholas P. Bigelow	Frank H. Wolfs	Sarada G. Rajeev	Adam Frank	Yonathan Shapir	Riccardo Betti	Stephen L. Teitel	Yonggy Gao	C. Richard Hagen	Eric G. Blackman	Steven I. Manly	Adrian C. Melissinos	Dan M. Watson	Alice C. Quillen	Wenhao Wu	David H. Douglass	John C. Howell	Paul L. Tipton	Regina Demina	Paul f. Slattery
Total Number of Papers	335	298	154	129	126	124	114	66	65	56	47	45	42	40	35	35	35	34	31	19	19	14	11	10	5	3	0.1	0.1
Total Number of Papers after 1999	114	106	59	59	47	104	28	19	24	37	10	28	13	21	8	15	8	34	31	4	10	14	6	6	5	0.1	0.1	0.1

There are only two faculty members who have not published any papers since 1990 and only one faculty member who has published no papers after 1999. After 1999 Rochester University physics faculty members have published 810 papers. For the most part, the number of papers published after 1990 is relatively close to the number of papers published after 1999 which means that the physics faculty members have published the majority of their papers after 1999. There are three faculty members who have published all their papers in the past five years. The first 5 faculty members have a difference between the number of papers published after 1990 and the number of papers published after 1999 of a factor close to 3.

Figure 2.8.2 illustrates the comparison between the number of published papers and the number citations per paper.

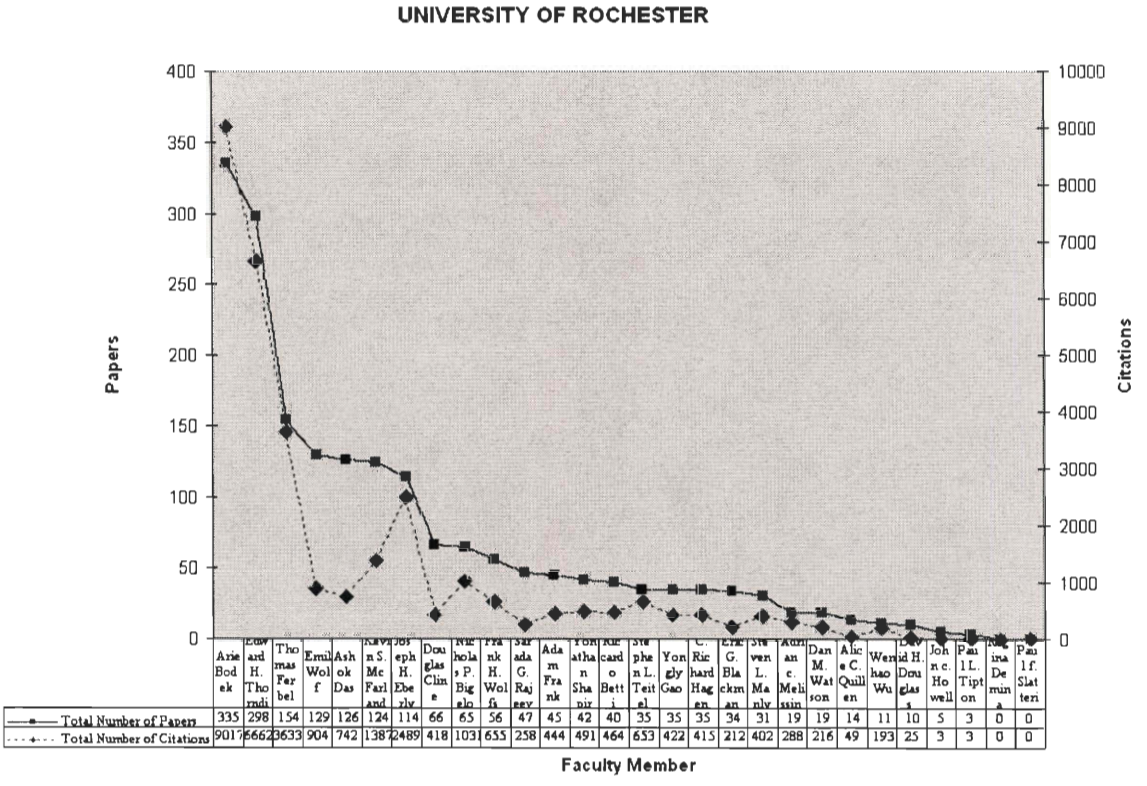
FIGURE 2.8.2



Unlike most schools being analyzed in this report, the three faculty members with the most papers also have the largest number of citations per paper. With the exception of these faculty members with the most published papers, there is not correlation between the number of papers published with the number of citations per paper.

Figure 2.8.3 shows the direct correlation between the number of papers and the number of citations. As the number of papers decreases, the number of citations decreases as well. The three faculty members with the most number of papers have the largest number of citations. The most noticeable exception is Joseph H. Eberly who has a many more citations than fellow faculty members with a similar number of published papers.

FIGURE 2.8.3



	Arie Bodek	Edward H. Thorndi	Thomas Ferbel	Emil Wolf	Ashok Das	Kevin S. McFarland	Joseph H. Eberly	Douglas Cline	Nicholas P. Bigelo	Frank H. Wolfs	Sridada G. Rajeev	Adam Frank	Yoshitaka Shapir	Richard o Betti	Stephen L. Teitel	Yonggy Gao	C. Richard Hagen	Eric G. Blackman	Steven L. Manly	Akhil an c. Melissin	Daniel M. Watson	Alice C. Quillen	Wenhao Wu	David H. Douglas	John c. Howell	Paul L. Tipton	Nandira Deminia	Paul f. Slaterl
Total Number of Papers	335	298	154	129	126	124	114	66	65	56	47	45	42	40	35	35	35	34	31	19	19	14	11	10	5	3	0	0
Total Number of Citations	9017	5662	3633	904	742	1387	2489	418	1031	655	258	444	491	464	653	422	415	212	402	288	216	49	193	25	3	3	0	0

We now consider the maximum number of citations on a single paper to analyze its correlation with the total number of published papers, number of citations and citations per paper. Arie Bodek has the largest maximum number of citations on a publication. The three faculty members with the most published papers, with the largest number of citations and with the most citations per paper also have the largest maximum number of citations on one paper. Arie Bodek, Thomas Ferbel and Edward Thorndike have 669, 599 and 472 maximum number of citations on a single publication respectively.

Table 2.8.1 (next page) shows the University of Rochester physics faculty members in alphabetical order. The year of latest publication shows how, in the most part, the faculty members have published their last paper in 2004.

TABLE 2.8.1

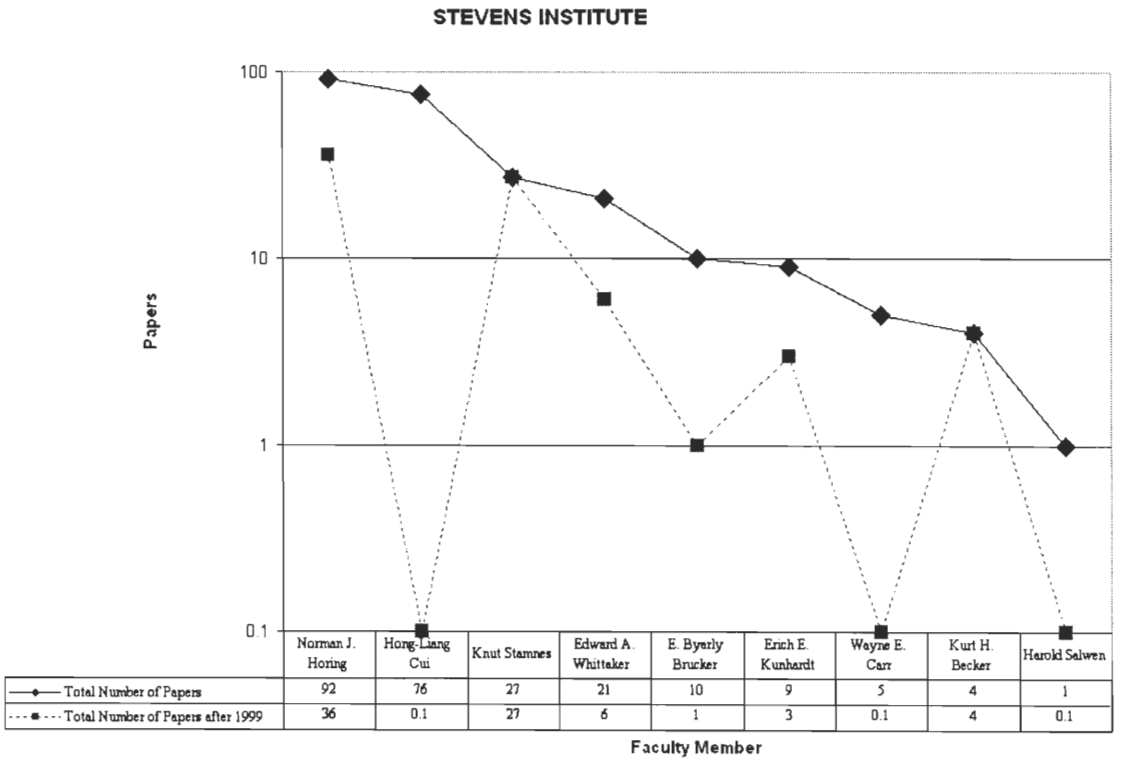
UNIVERSITY OF ROCHESTER						
Professor Name	**Papers**	**Citations**	**Citations/ Paper**	**Max. # of citations on a single paper**	**Papers after 1999**	**Year of Latest publication**
Adam Frank	45	444	9.87	36	28	2004
Adrian c. Melissinos	19	288	15.16	98	4	2003
Alice C. Quillen	14	49	3.50	15	14	2004
Arie Bodek	335	9017	26.92	669	114	2004
Ashok Das	126	742	5.89	32	47	2004
C. Richard Hagen	35	415	11.86	95	8	2004
Dan M. Watson	19	216	11.37	60	10	2004
David H. Douglass	10	25	2.50	14	6	2004
Douglas Cline	66	418	6.33	27	19	2004
Edward H. Thorndike	298	6662	22.36	472	106	2004
Emil Wolf	129	904	7.01	61	59	2004
Eric G. Blackman	34	212	6.24	26	34	2004
Frank H. Wolfs	56	655	11.70	159	37	2004
John c. Howell	5	3	0.60	2	5	2004
Joseph H. Eberly	114	2489	21.83	225	28	2004
Kevin S. McFarland	124	1387	11.19	123	104	2004
Nicholas P. Bigelow	65	1031	15.86	120	24	2004
Paul f. Slatteri	0	0	0.00	0.0001	0	0
Paul L. Tipton	3	3	1.00	3	0	1997
Regina Demina	0	0	0.00	0.0001	0	0
Riccardo Betti	40	464	11.60	47	21	2004
Sarada G. Rajeev	47	258	5.49	30	10	2003
Stephen L. Teitel	35	653	18.66	88	8	2004
Steven L. Manly	31	402	12.97	159	31	2004
Thomas Ferbel	154	3633	23.59	599	59	2004
Wenhao Wu	11	193	17.55	64	6	2004
Yonathan Shapir	42	491	11.69	72	13	2003
Yongly Gao	35	422	12.06	66	15	2004

2.9 STEVENS INSTITUTE OF TECHNOLGY Analysis

The Stevens Institute of Technology has a graduate enrollment of 2,904 students. The physics and engineering physics department offers concentrations in applied optics, engineering physics (optics) and engineering physics (solid state). Stevens also offers an interdisciplinary study in microelectronics and photonics science and technology. The physics department has 9 faculty members.

Figure 2.9.1 illustrates the relationship between the number of papers published after 1990 and the papers published after 1999. Stevens physics faculty members have published 245 papers after 1990 with an average of 27.22 papers per faculty member. Out of the 245 papers, 77 were published after 1999.

FIGURE 2.9.1

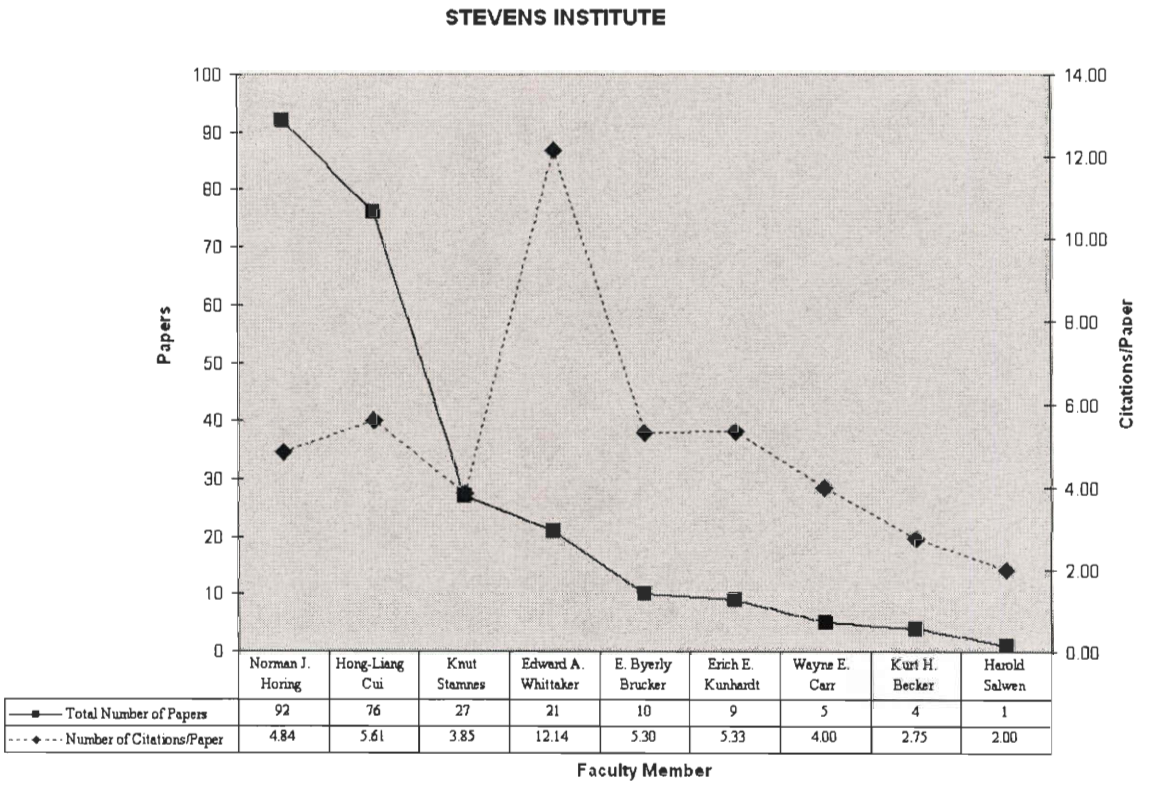


	Norman J. Horing	Hong-Liang Cui	Knut Stamnes	Edward A. Whittaker	E. Byerly Brucker	Erich E. Kunhardt	Wayne E. Carr	Kurt H. Becker	Harold Salwen
Total Number of Papers	92	76	27	21	10	9	5	4	1
Total Number of Papers after 1999	36	0.1	27	6	1	3	0.1	4	0.1

There is a direct correlation between the number of papers published after 1990 and the ones published after 1999 with only a couple of exceptions. One of these exceptions is Hohg-Liang Cui. Cui has published the second largest number of papers after 1990 but none after 1999. On the contrary, Norman J. Horing has the largest number of published papers after 1990 and also the largest number of papers published after 1999. Knut Stamnes and Kurt Becker are the only two faculty members who have published all their papers within the last 5 years.

Figure 2.9.2 shows the number of papers and the citations per paper. There is no correlation between these two factors. As the number of published papers decreases, there is an extremely light decrease in number of citation per paper.

FIGURE 2.9.2



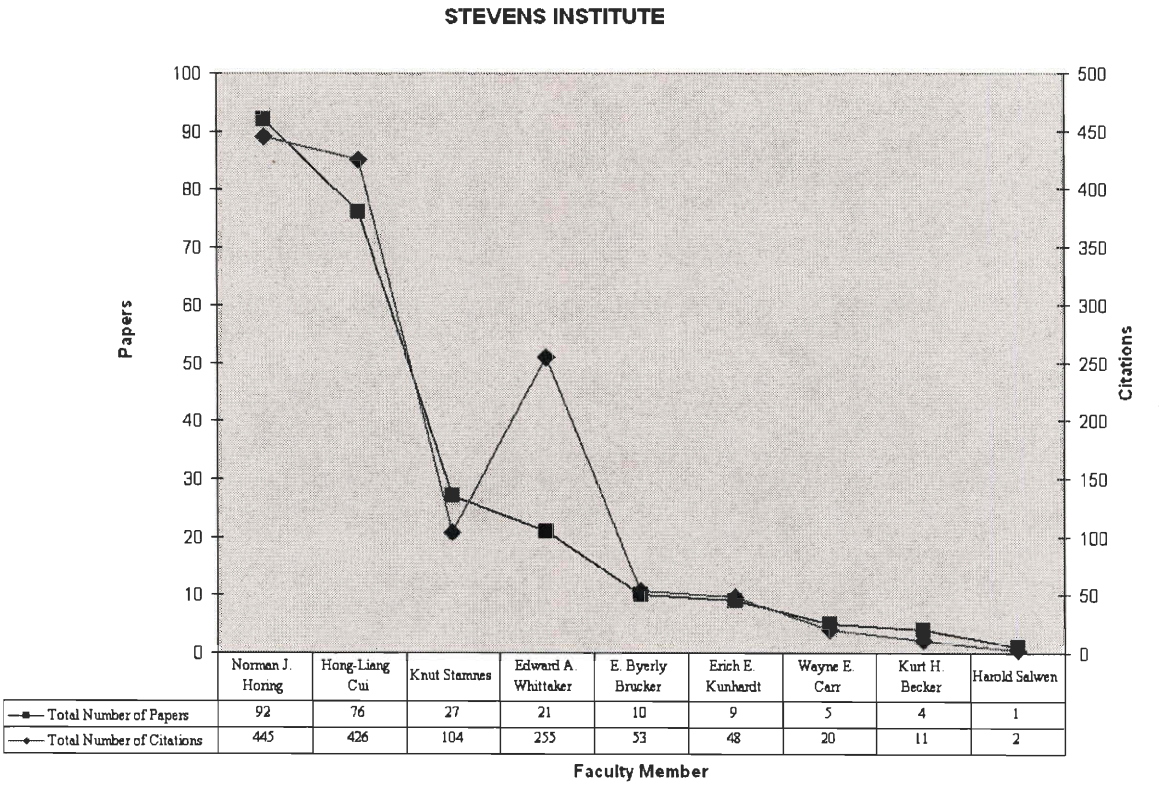
	Norman J. Horing	Hong-Liang Cui	Knut Stamnes	Edward A. Whittaker	E. Byerly Brucker	Erich E. Kunhardt	Wayne E. Carr	Kurt H. Becker	Harold Salwen
Total Number of Papers	92	76	27	21	10	9	5	4	1
Number of Citations/Paper	4.84	5.61	3.85	12.14	5.30	5.33	4.00	2.75	2.00

Edward Whittaker has the most number of citations per paper but is only the fourth one in the number of published papers. Whittaker has 12.14 citations per paper. On the

contrary, Norman J. Horing has the largest number of published papers but has less than 5 citations per paper.

Figure 2.9.3 illustrates the total number of papers and the total number of citations for the physics faculty at Stevens Institute. The faculty members have received a total of 1364 citations in all of their publications. The correlation between the number of papers and the number of citations is very direct. The faculty member with the most number of papers also has the largest number of citations. The single exception is Whittaker, who has published 21 papers but has an extremely large number of citations compared with fellow faculty members with a similar number of published papers.

FIGURE 2.9.3



The largest maximum number of citations on a single publication is for Norman J. Horing and Hong-Liang Cui. These two faculty members are authors of the same paper. Horing and Cui have also the largest number of papers and citations but not of citations per paper. As for most schools, this concludes that the maximum number of citations on a single publication is related to the total number of citations. In this particular case, the maximum number of citations on a single paper is not directly related with the citations per paper. This relationship is broken because the same faculty members who have the maximum number of citations on a paper also have the most number of published papers.

Table 2.9.1 shows the distribution for the data recollected for the analysis for the Stevens faculty members in the physics department. The year of latest publication indicates that only one faculty member has published a paper within the past year.

TABLE 2.9.1

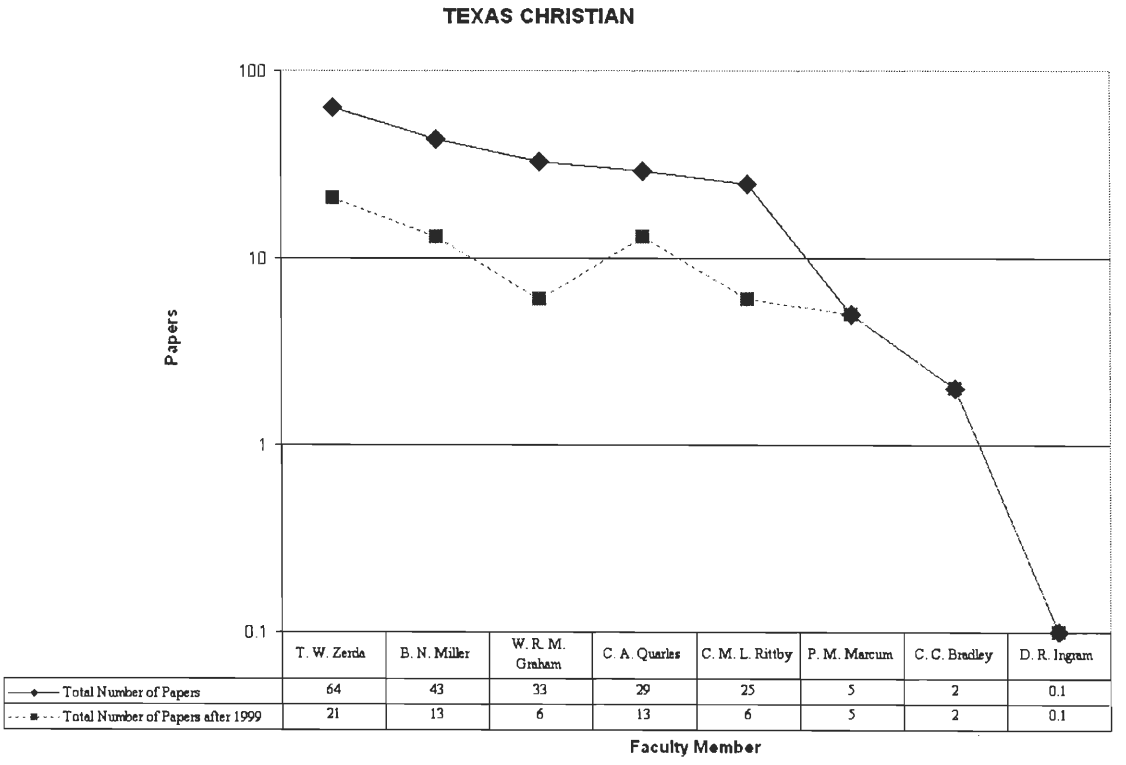
STEVENS INSTITUTE						
Professor Name	**Papers**	**Citations**	**Citations/ Paper**	**Max. # of citations on a single paper**	**Papers after 1999**	**Year of Latest publication**
E. Byerly Brucker	10	53	5.30	15	1	2000
Edward A. Whittaker	21	255	12.14	63	6	2002
Erich E. Kunhardt	9	48	5.33	33	3	2000
Harold Salwen	1	2	2.00	2	0	1994
Hong-Liang Cui	76	426	5.61	121	0	1994
Knut Stamnes	27	104	3.85	27	27	2003
Kurt H. Becker	4	11	2.75	4	4	2002
Norman J. Horing	92	445	4.84	121	36	2004
Wayne E. Carr	5	20	4.00	10	0	1995

2.10 TEXAS CHRISTIAN UNIVERSITY Analysis

The Texas Christian University has a total graduate enrollment of 1,178 students. The physics and astronomy departments offer the degrees in Ph.D and M.B.A with research concentrations in experimental atomic, molecular and solid state physics, theoretical physics, and observational astronomy. The physics department has 8 faculty members who are going to be analyzed in this report.

Figure 2.10.1 illustrates the total number of papers published after 1990 and the number of papers published after 1999. The physics faculty members have published 201 papers after 1990 with an average of 25.13 papers per faculty member. For the first five faculty members, the number of papers published after 1990 and the number of papers published after 1999 have an average separation of 25 papers.

FIGURE 2.10.1

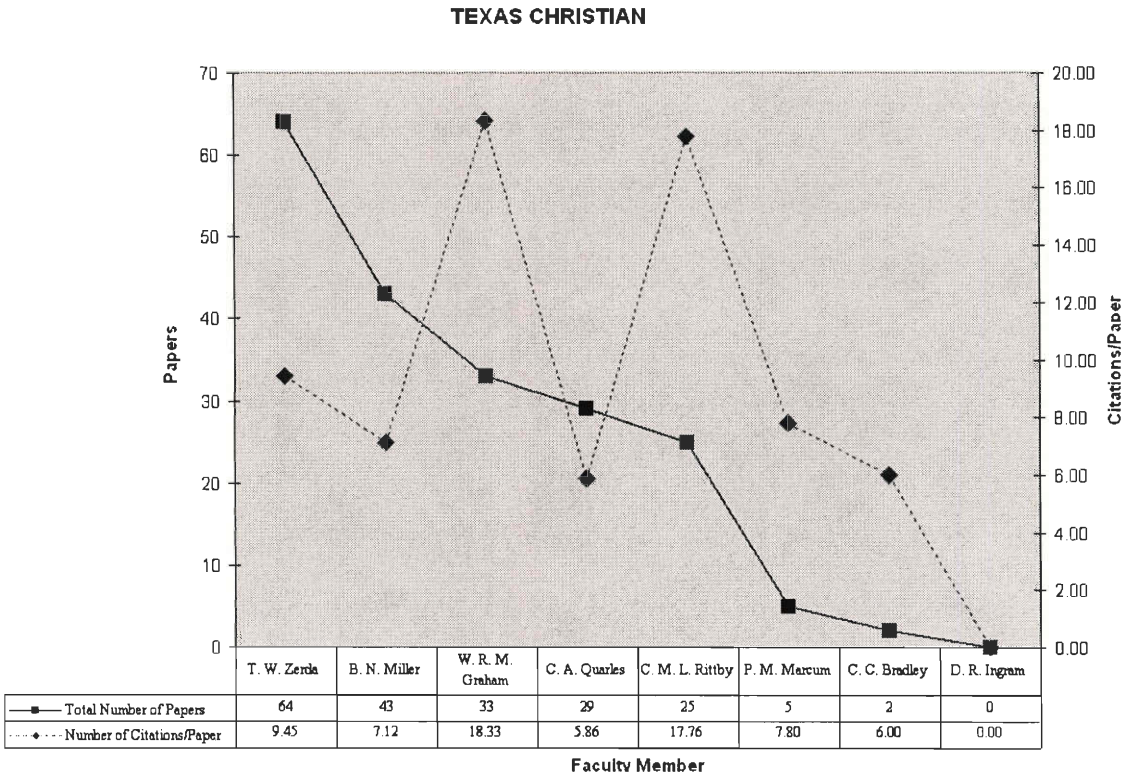


	T. W. Zerda	B. N. Miller	W. R. M. Graham	C. A. Quarles	C. M. L. Rittby	P. M. Marcum	C. C. Bradley	D. R. Ingram
Total Number of Papers	64	43	33	29	25	5	2	0.1
Total Number of Papers after 1999	21	13	6	13	6	5	2	0.1

66 papers have been published after 1999 by the physics faculty members. Two faculty members have published all of their papers after 1999. Only one faculty member has not published any papers since 1990. The Texas Christian University physics faculty members have an almost perfect direct correlation between the number of papers they have published after 1990 and the number of papers they have published after 1999.

Figure 2.10.2 establishes the distribution of the number of published papers and the number of citations per paper. Three is no correlation between these two factors. For instance, the faculty member with the most published papers has an average of 9.45 citations per paper.

FIGURE 2.10.2

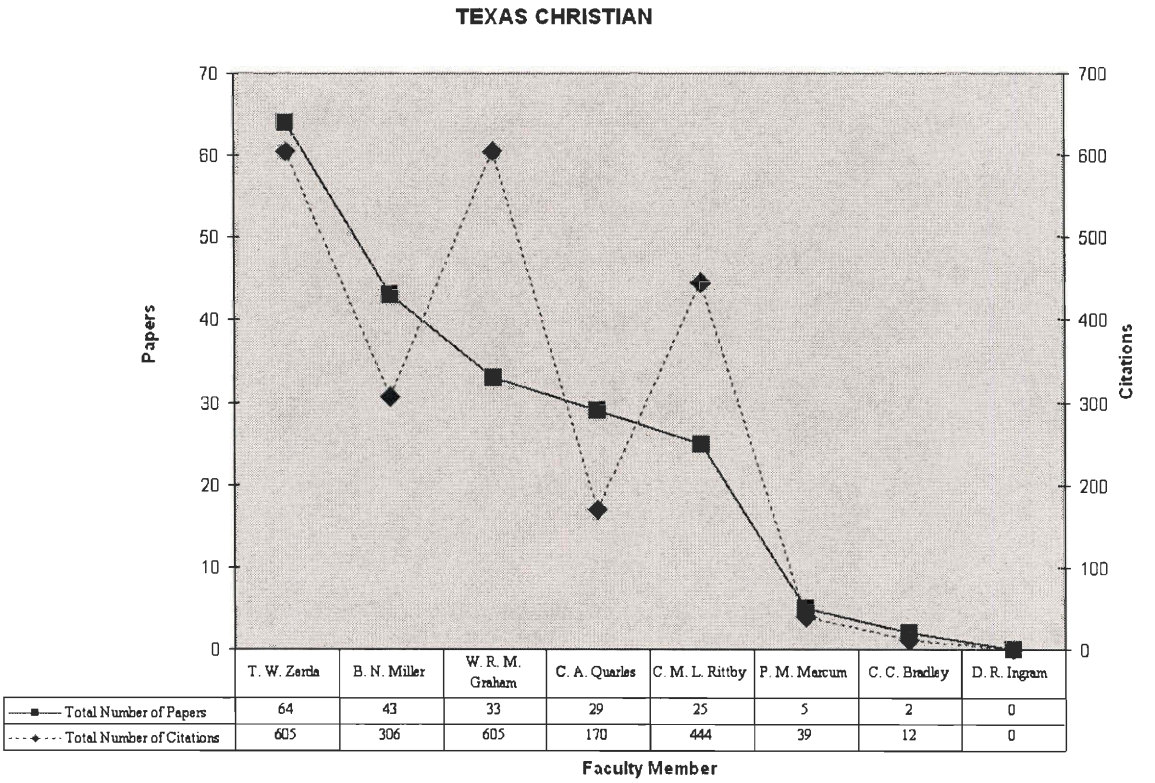


On the contrary, faculty members ranked third and fifth in number of papers, have the largest number of citations per paper. W.R.M. Graham has published 33 papers with an

average of 18.33 citations per paper and C.M.L. Rittby has published 25 papers, 17.76 citations per paper.

Figure 2.10.3 illustrates the number of papers published after 1990 and the total number of citations for each faculty member at the Texas Christian University physics department. The faculty members have received a total of 2181 citations. The five faculty members with the most published papers also have the largest number of citations. As with every school being analyzed, the number of papers published after 1990 has a correlation with the number of citations. In this case, it is a less regular direct correlation.

FIGURE 2.10.3



For example, T.W. Zerda and W.R.M. Graham have the largest number of citations. Zerda has almost twice as many published papers than Graham. Also, Miller has published more papers than Rittby but Rittby has a much larger number of total citations.

C. M. L. Rittby and W.R.M. Graham have the maximum number of citations on a single publication. These two faculty members are authors of the same research paper. Rittby and Graham also have the largest number of citations per paper. The maximum number of citations on a single paper influences the number citations per paper it does not affect the total number of published papers.

Table 2.10.1 has the distribution of the data recollection for each faculty member for Texas Christian University. The year of latest publications indicates that 6 out of the 8 physics faculty members have published their last paper in the past year.

TABLE 2.10.1

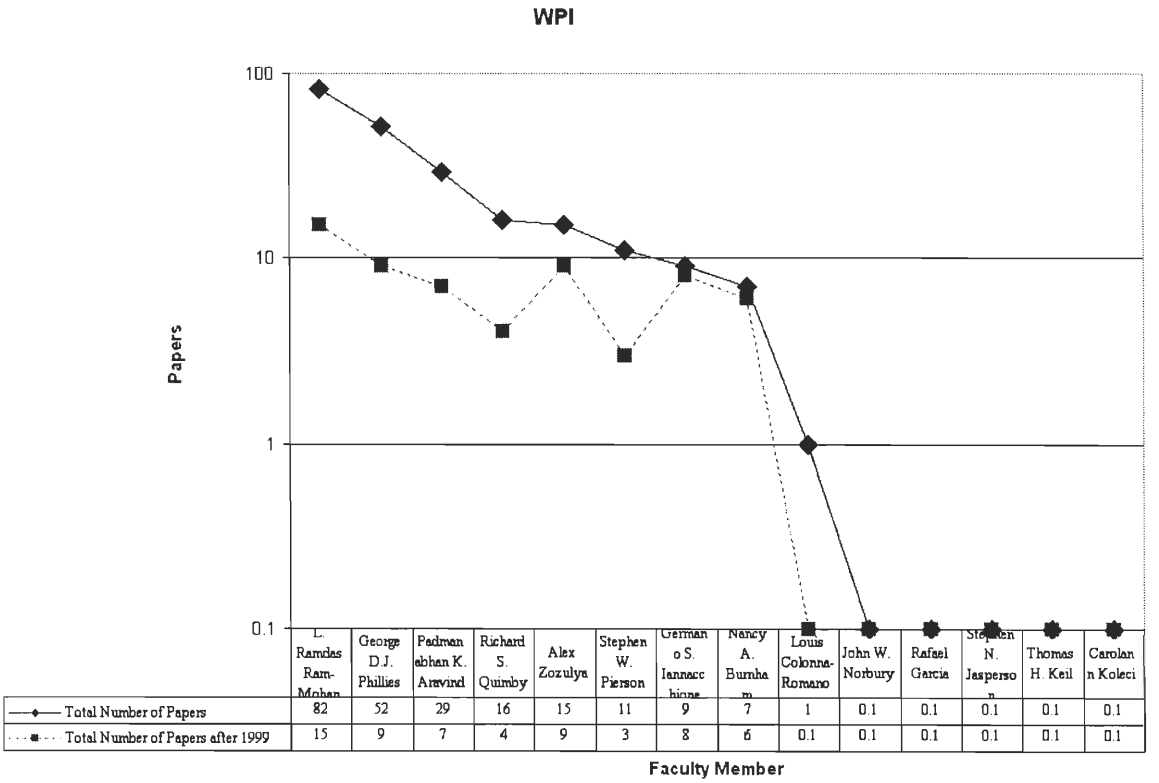
TEXAS CHRISTIAN UNIVERSITY						
Professor Name	**Papers**	**Citations**	**Citations/ Paper**	**Max. # of citations on a single paper**	**Papers after 1999**	**Year of Latest publication**
B. N. Miller	43	306	7.12	22	13	2004
C. A. Quarles	29	170	5.86	20	13	2004
C. C. Bradley	2	12	6.00	12	2	2003
C. M. L. Rittby	25	444	17.76	59	6	2004
D. R. Ingram	0	0	0.00	0	0	0
P. M. Marcum	5	39	7.80	19	5	2004
T. W. Zerda	64	605	9.45	41	21	2004
W. R. M. Graham	33	605	18.33	59	6	2004

2.11 WORCESTER POLYTECHNIC INSTITUTE Analysis

Worcester Polytechnic Institute has a graduate enrollment of 949 students. The physics program offers research areas in quantum physics, optics, condensed matter, soft condensed matter/complex fluids and physics education. WPI has 13 physics faculty members.

Figure 2.10.1 illustrates the total number of papers published after 1990 and the number of papers published after 1999. Since 1990, WPI physics faculty members have published a total of 222 papers with an average of 15.86 papers per faculty member. 61 papers have been published by the physics faculty members after 1999, which gives an average of 4.36 papers per faculty member.

FIGURE 2.10.1



	L. Ramdas Ram-Mohan	George D.J. Phillies	Padman abhan K. Aravind	Richard S. Quimby	Alex Zozulya	Stephen W. Pierson	German o S. Iannacc hione	Nancy A. Burnha m	Louis Colonna-Romano	John W. Norbury	Rafael Garcia	Stephen N. Jasperso n	Thomas H. Keil	Carolan n Koleci
Total Number of Papers	82	52	29	16	15	11	9	7	1	0.1	0.1	0.1	0.1	0.1
Total Number of Papers after 1999	15	9	7	4	9	3	8	6	0.1	0.1	0.1	0.1	0.1	0.1

There are five faculty members who have not published any papers since 1990. Only one faculty member has published a paper after 1990 but none since 1999. L. Ramdas Ram-Mohan has the most number of papers published after 1990 as well as after 1999. Germano Iannacchione and Nancy A. Burnham have published most of their papers within the past five years.

Figure 2.10.2 shows the distribution of the number of papers and the citations per paper after 1990. Richard S. Quimby, with 16 published papers, has the largest number of citations per paper. Quimby has an average of 20.93 citations per paper. There is no rigid correlation between the number of published papers and the number of citations per paper.

FIGURE 2.10.2

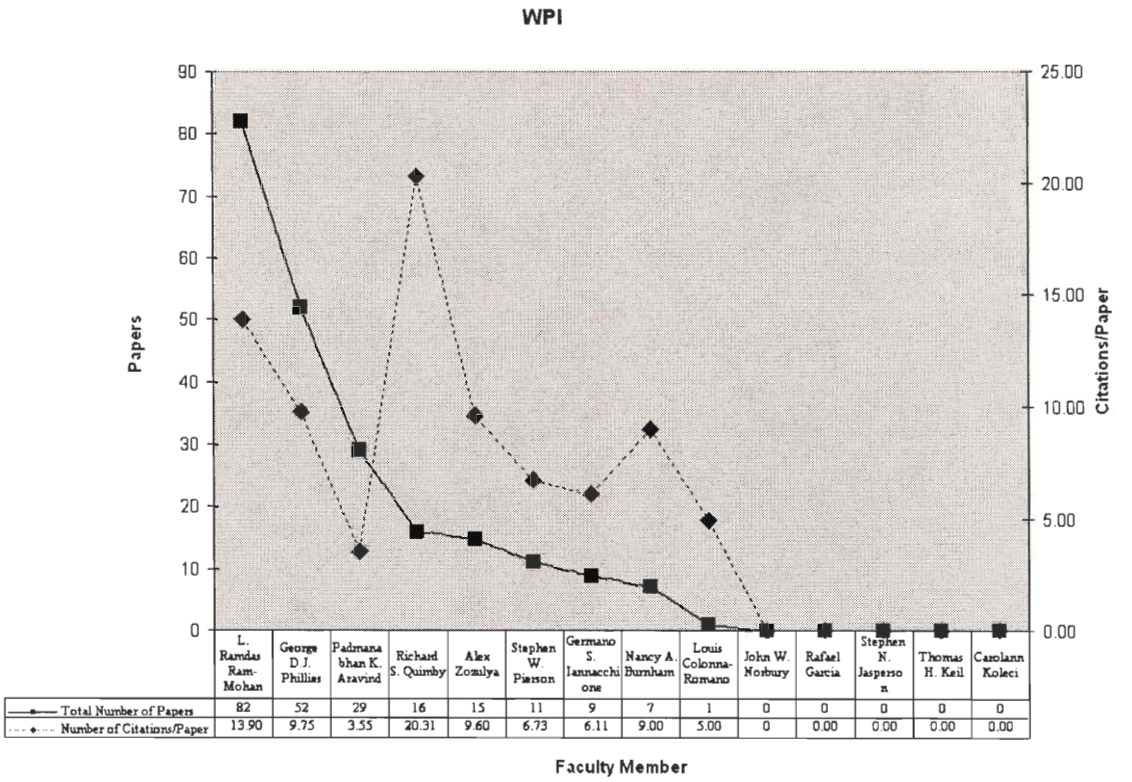
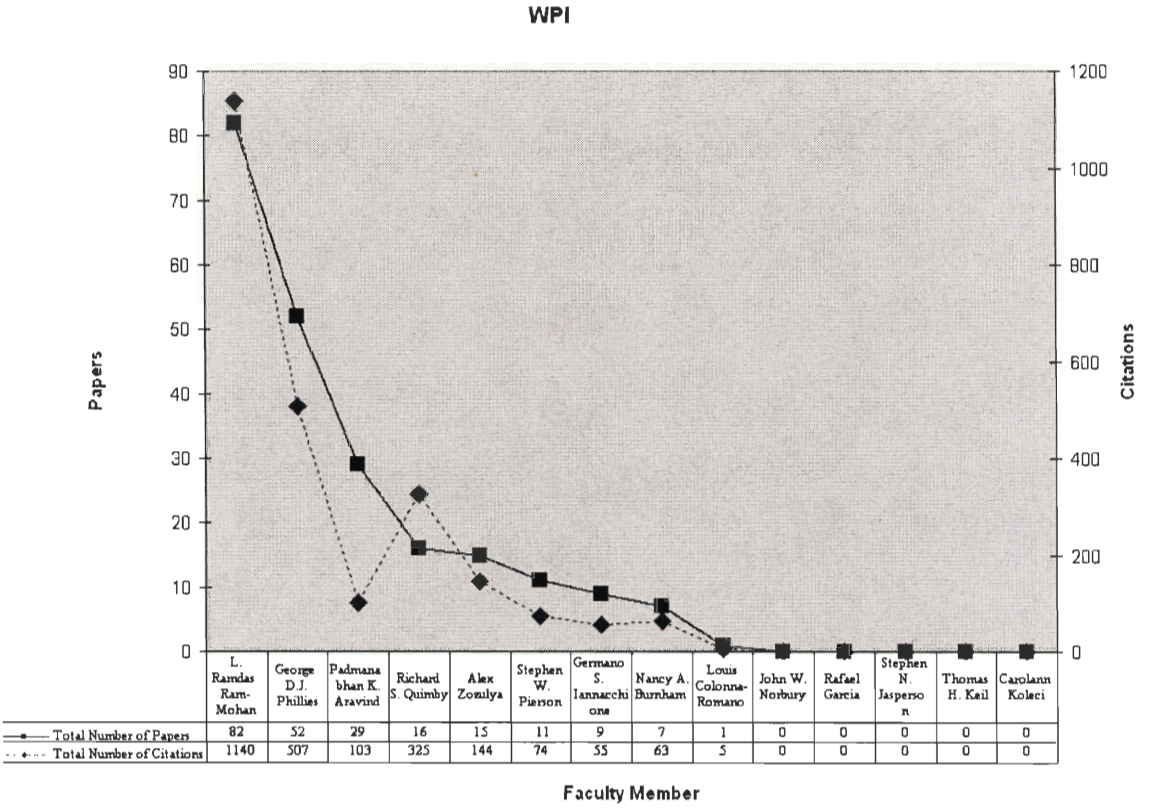


Figure 2.10.3 shows the total number of papers published after 1990 and the number of citations for each faculty member. There is a direct correlation between the number of papers and the number of citations. The faculty member with the most published papers has the largest number of citations. Ram-Mohan has the largest number of papers and he has also received the largest number of citations.

FIGURE 2.10.3



Now we consider the maximum number of citations for a single paper. Ram-Mohan has the largest maximum number of citations on one publication with 258. Ram-Mohan is also the faculty member with the most number of papers published after 1990 and after 1999, the largest number of citations per paper, and the most citations. The maximum number of citations on a single publication has a correlation with the number of citations per paper but no relationship with the total number of published papers. For

instance, Quimby has the second largest number of citations on a single paper but has published 16 papers.

Table 2.10.1 has the data summary for every physics faculty member at Worcester Polytechnic Institute. The year of latest publication shows that 5 faculty members have published their last WPI paper within the last year.

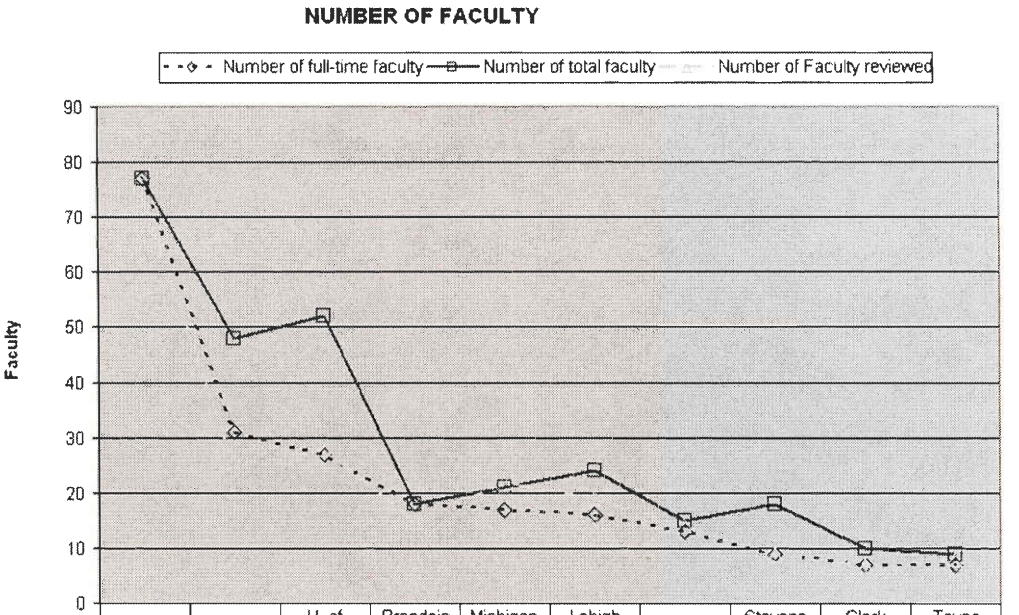
TABLE 2.10.1

WORCESTER POLYTECHNIC INSTITUTE						
Professor Name	**Papers**	**Citations**	**Citations/ Paper**	**Max. # of citations on a single paper**	**Papers after 1999**	**Year of Latest publication**
Alex Zozulya	15	144	9.60	58	9	2004
Carolann Koleci	0	0	0.00	0	0	0
George D.J. Phillies	52	507	9.75	52	9	2004
Germano S. Iannacchione	9	55	6.11	16	8	2004
John W. Norbury	0	0	0	0	0	0
L. Ramdas Ram-Mohan	82	1140	13.90	258	15	2004
Louis Colonna-Romano	1	5	5.00	5	0	1995
Nancy A. Burnham	7	63	9.00	30	6	2004
Padmanabhan K. Aravind	29	103	3.55	13	7	2003
Rafael Garcia	0	0	0.00	0	0	0
Richard S. Quimby	16	325	20.31	110	4	2003
Stephen N. Jasperson	0	0	0.00	0	0	0
Stephen W. Pierson	11	74	6.73	20	3	2000
Thomas H. Keil	0	0	0.00	0	0	0

CHAPTER 3
COMPARISON BETWEEN DIFFERENT PHYSICS DEPARTMENTS

Figure 3.1 shows the number of full-time faculty members, total number of faculty members and the number of faculty members recollected for this analysis. The number of faculty members is represented in the vertical axis and the schools being analyzed are being represented in the horizontal axis. The schools are ranked based on the number of full-time faculty members in descending order.

FIGURE 3.1



	MIT	RPI	U. of Rochester	Brandeis University	Michigan Tech.	Lehigh University	WPI	Stevens Institute	Clark University	Texas Christian
Number of full-time faculty	77	31	27	18	17	16	13	9	7	7
Number of total faculty	77	48	52	18	21	24	15	18	10	9
Number of Faculty reviewed	73	25	28	15	22	19	14	9	7	8

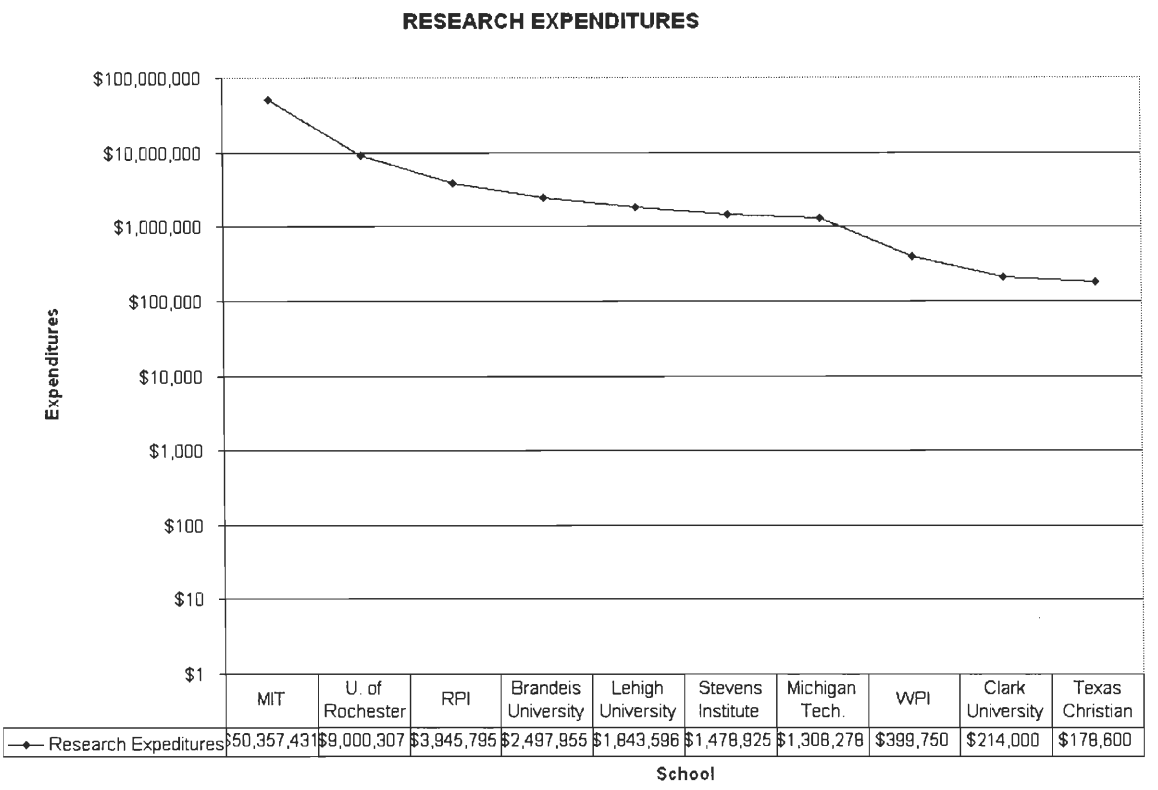
The largest difference is found between the number of full-time faculty members and the number of total faculty members at each school. The number of faculty members that was recollected is only based on the full-time faculty members. The slight difference between the number of full-time faculty members and the faculty members collected is

due to a miscount between the NRC report and the information given at each school's webpage. The faculty members that were listed in each school's webpage is being used because this information is updated more frequently than the NRC report. The number of the faculty members recollected for the analysis in this report for MIT, RPI and Brandeis University is less than the total number of full-time faculty members. On the contrary, the number of faculty members recollected for the University of Rochester, Michigan Tech. University, Lehigh University, WPI and Texas Christian University is more than the number of full-time faculty members listed in the NRC report. Finally, the number of full-time faculty members matches the number of faculty members recollected only for the physics department at Stevens Institute and Clark University

Figure 3.2 is a logarithmic graph that illustrates the research expenditures for the ten schools being analyzed. The research expenditures are represented in the vertical axis and the schools are located in the horizontal axis. The schools are ranked by descending order of research expenditures.

The ten schools used in this report can be divided into three groups for this analysis. The first group is formed by only the Massachusetts Institute of Technology since it has an extremely large amount of money designated for research expenditures compared with the rest of the schools. The second group consists of the University of Rochester, Rensselaer Polytechnic Institute, Brandeis University, Lehigh University, Stevens Institute and Michigan Tech. Institute. The second group has research expenditures between 1 and 10 millions of dollars. Finally, the third group is formed by Worcester Polytechnic Institute, Clark University and Texas Christian University with research expenditures of under $500,000.

FIGURE 3-2



The physics department for the Massachusetts Institute of Technology spends over $50,000,000 in research. It is important to remember that MIT has published the largest number of papers after 1990 and has received the most citations among the ten schools being analyzed. MIT also has the largest number of physics faculty members. It can be concluded that the rank for the physics department at MIT in the previously named categories is directly linked to the money being spent in research. The more money designated for research, the more publications. In the same manner, the more publications, the more total number of citations.

Table 3.1 (next page) the distribution for the number of full-time faculty members, the number of total faculty members, the number of faculty members that were

recollected and the annual graduate tuition and the research expenditures. The schools have been ranked in descending order of research expenditures.

The annual graduate tuition values were gotten from the websites for each school being analyzed. While some schools have a combined total tuition cost, other schools only give the value per credit, per semester or per hour.

TABLE 3.1

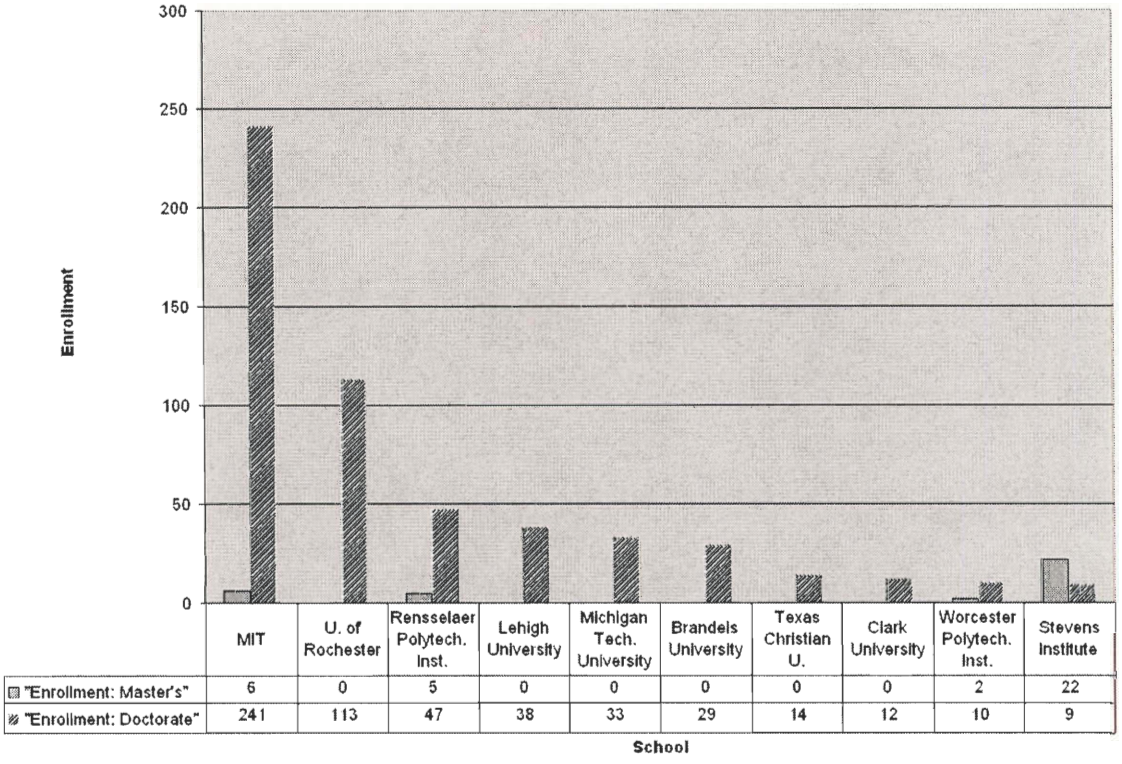
SCHOOL	Number of full-time faculty	Number of total faculty	Number of Faculty reviewed	Annual Graduate Tuition	Research Expeditures
MIT	77	77	73	$29,400	$50,357,431
U. of Rochester	27	52	28	$26,880	$9,000,307
RPI	31	48	25	$27,700	$3,945,795
Brandeis University	18	18	15	$28,984	$2,497,955
Lehigh University	16	24	19	$940/credit	$1,843,596
Stevens Institute	9	18	9	$775/credit	$1,478,925
Michigan Tech.	17	21	22	$3186/sem	$1,308,278
WPI	13	15	14	$796/credit	$399,750
Clark University	7	10	7	$26,700	$214,000
Texas Christian	7	9	8	$490/sem.hr.	$178,600

Figure 3.3 (next page) illustrates the comparison between the Master's enrollment (dotted) and the Doctorate Enrollment (lined) for the physics department in the 10 schools analyzed. The number of enrolled students for a physics program is represented in the vertical axis and the schools being analyzed are in the horizontal axis. The schools are ranked in descending order of doctorate enrollment.

There are more students enrolled for a Doctorate degree than for a Master's degree in 9 out of the 10 schools in this report. Stevens Institute is the only school that has more students enrolled for a Master's degree than for a Doctorate degree. In fact, six schools have no students enrolled for their Master's program. This shows that there is a

bigger inclination towards the Doctorate degree than towards the Master's degree in physics.

FIGURE 3.3



	MIT	U. of Rochester	Rensselaer Polytech. Inst.	Lehigh University	Michigan Tech. University	Brandeis University	Texas Christian U.	Clark University	Worcester Polytech. Inst.	Stevens Institute
"Enrollment: Master's"	6	0	5	0	0	0	0	0	2	22
"Enrollment: Doctorate"	241	113	47	38	33	29	14	12	10	9

The 10 schools can be divided into three groups for this analysis. The first group consists of the Massachusetts Institute of Technology and the University of Rochester. The physics department from the Massachusetts Institute of Technology has the largest number of students enrolled seeking for a Doctorate degree. MIT has a Doctoral enrollment of 241 students. The University of Rochester is next with less than half as many students enrolled than MIT. MIT has six students enrolled for their Master's program while the University of Rochester has none.

The second group consists of Rensselaer Polytechnic Institute, Lehigh University, Michigan Technological Institute and Brandeis University. These four schools have a Doctoral enrollment in physics between 47 and 29. RPI is the only school with students enrolled in their Master's program; the other three physics departments have students enrolled searching only for a Doctorate degree in physics. Finally, the third and last group is formed by Texas Christian University, Clark University, Worcester Polytechnic Institute and Stevens Institute. This last group has a Doctorate enrollment of less than 15 students. WPI has 2 students enrolled for a Master's degree in physics, Stevens has 22 and the other two schools none.

Figure 3.4 (next page) shows the number of research assistants (dotted) in comparison with the teaching assistants (solid) for each school. The number of assistants is represented in the vertical axis and the ten schools are in the horizontal axis. The schools are ranked in descending order of number of research assistants. The top four schools in this category have a larger number of research assistants than of teaching assistants. On the contrary, the other six schools have a larger number of teaching assistants than of research assistants.

The Massachusetts Institute of Technology physics department has an extremely large number of research assistants when compared with the rest of the schools used in this analysis. MIT has the largest number of research assistants as well as the largest number of teaching assistants. The University of Rochester has the second largest number of teaching assistants as well as the second largest number of teaching assistants. The Rensselaer Polytechnic Institute is the only school with the same number of research and teaching assistants. Lehigh University has a really large number of teaching

assistants in comparison with its number of research assistants. Finally, the Texas Christian University physics department is the only school with no research assistants.

FIGURE 3.4

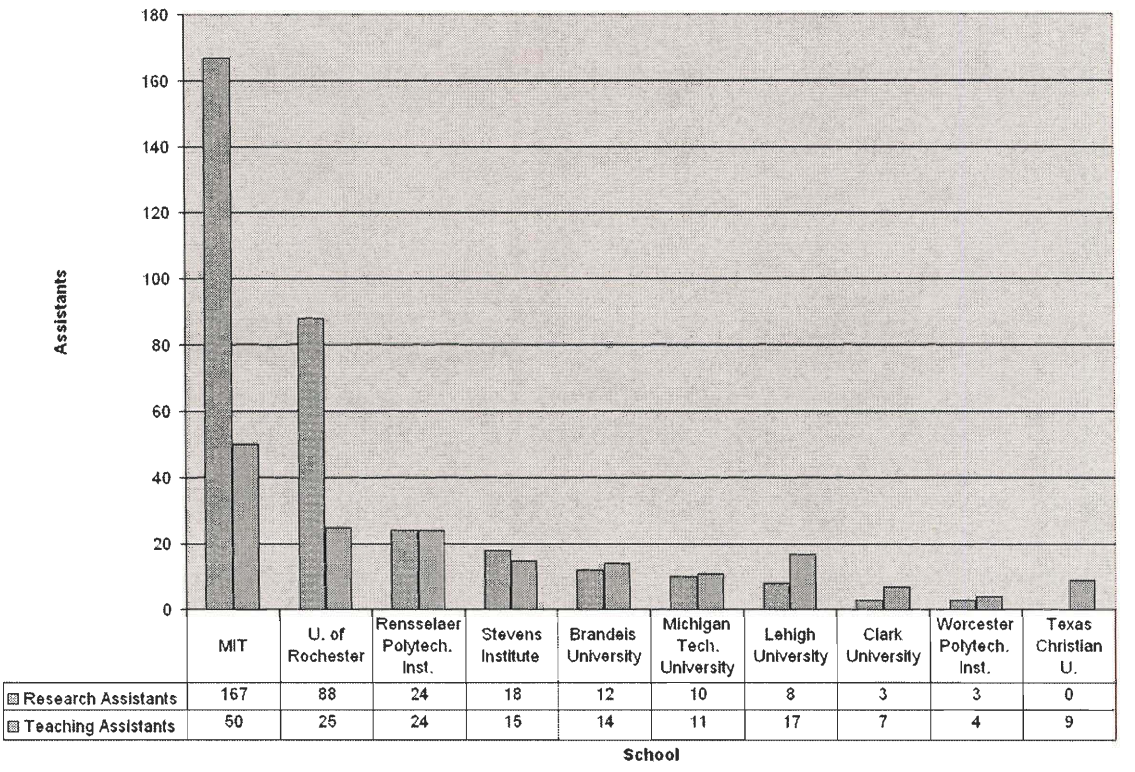
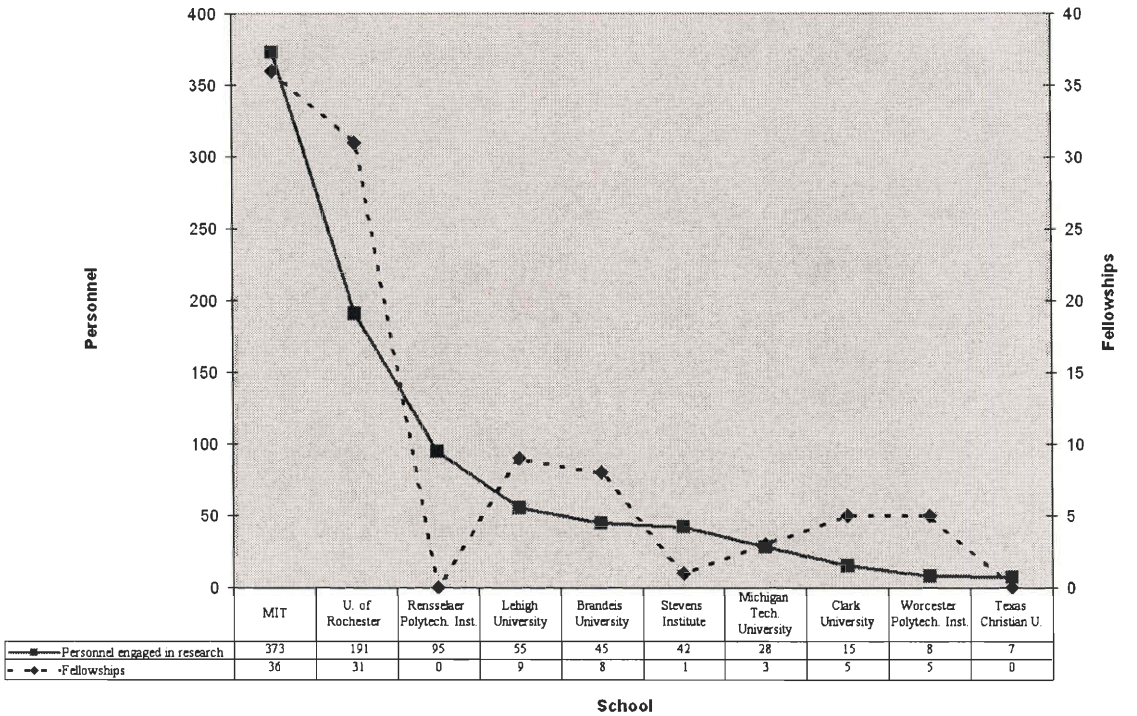


Figure 3.5 illustrates the number of personnel engaged in research (solid line) for the physics department in each school compared with the number of fellowships received (dotted line). The number of personnel is represented in the left vertical axis, the number of fellowships is represented in the right vertical axis and the ten schools are positioned in the horizontal axis. The schools are ranked in descending order of the number of personnel engaged in research.

The Massachusetts Institute of Technology physics department has the largest number of faculty members engaged in research as well as the most fellowships received.

On the contrary, the Texas Christian University physics department has the smallest number of faculty members active in research and it has not received any fellowships. The Rensselaer Polytechnic Institute physics department has a considerable number of faculty members active in research but has received no fellowships.

FIGURE 3.5



	MIT	U. of Rochester	Rensselaer Polytech. Inst.	Lehigh University	Brandeis University	Stevens Institute	Michigan Tech. University	Clark University	Worcester Polytech. Inst.	Texas Christian U.
Personnel engaged in research	373	191	95	55	45	42	28	15	8	7
Fellowships	36	31	0	9	8	1	3	5	5	0

Table 3.2 (next page) shows the distribution of the Master's Enrollment, Doctorate Enrollment, Undergraduate Degrees (2001/02), Undergraduate Degrees 5-year, Teaching Assistants, Research Assistants, Fellowships, Personnel Engaged in Research and Stipend for Academic Year. The schools are in alphabetical order.

TABLE 3.2

SCHOOL	Enrollment: Master's	Enrollment: Doctorate	Undergraduate degrees 2001/02	Undergraduate degrees 5-year	Teaching Assistants	Research Assistants	Fellowships	Personnel engaged in research	Stipend for academic year
Brandeis University	0	29	9	29	14	12	8	45	$14,625 12 months
Clark University	0	12	4	16	7	3	5	15	$12,375 9 months
Lehigh University	0	38	7	23	17	8	9	55	$14,000 9 months
Michigan Tech. University	0	33	5	45	11	10	3	28	$18,566 12 months
MIT	6	241	61	242	50	167	36	373	$21,800 9 months
Rensselaer Polytech. Inst.	5	47	23	81	24	24	?	95	$14,000 9 months
Stevens Institute	22	9	7	66	15	18	1	42	$14,500 9 months
Texas Christian U.	0	14	4	16	9	0	0	7	$15,100 12 months
U. of Rochester	0	113	25	90	25	88	31	191	$19,240 12 months
Worcester Polytech. Inst.	2	10	6	51	4	3	5	8	$13,203 9 months

Figure 3.6 shows the distribution of the number of citations vs. the number of papers published after 1990 for every physics faculty member at the schools being analyzed. The number of papers is in the horizontal axis and the number of citation is in the vertical axis. The Massachusetts Institute of Technology has the faculty member with the most publications and another faculty member with the largest number of citations. For the University of Rochester, the same faculty member has the second largest number of published papers as well as the second largest number of citations. The vast majority of faculty members published between 0 and 50 papers and the majority of citations fits into the 0 to 2000 range. The number of faculty members in a higher range decreases as the number of papers and the number of citations increases.

There are only three schools that have faculty members located in the high range of the number of papers and of the number of citations. MIT, Brandeis and the University of Rochester each have faculty members who have both published over 200 papers and who also received total number of citations larger than 7000.

FIGURE 3.6

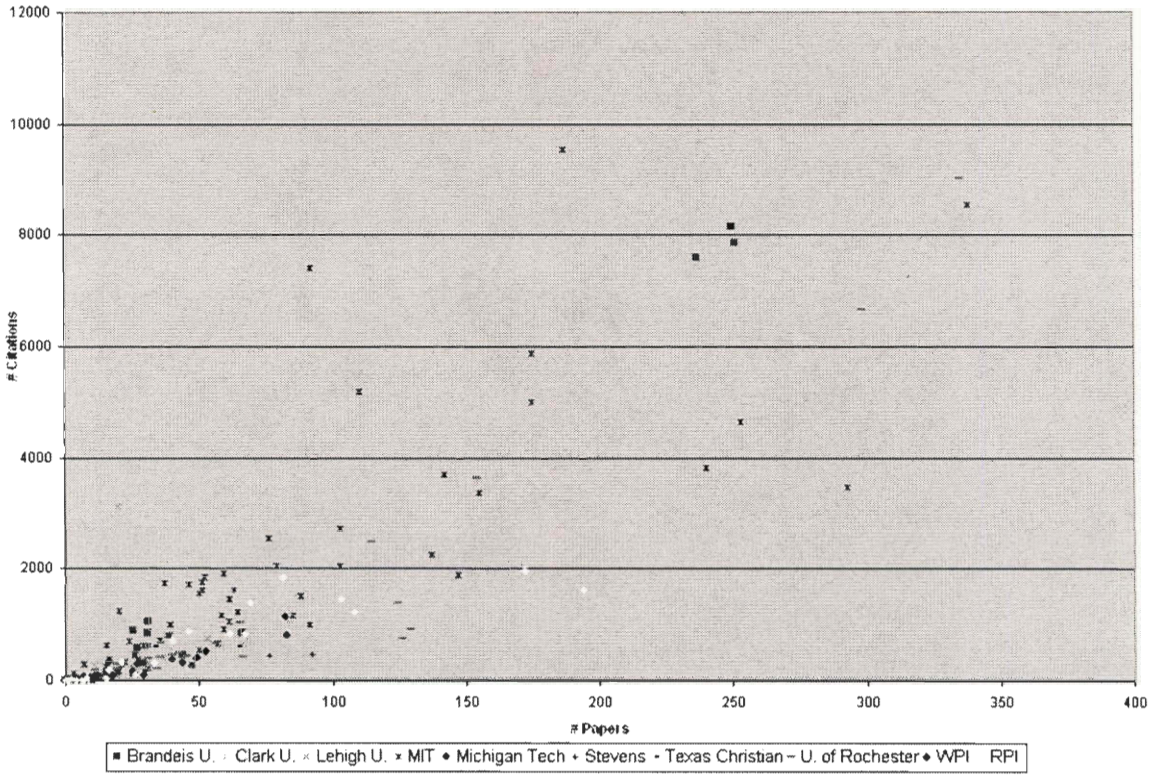


Figure 3.7 (next page) shows the number of citations within a range of 0 to 2000 citations compared with the number of published papers within a range of 0 to 100 papers. This figure shows more clearly the majority of faculty members that have a fewer number of published papers as well as a fewer number of citations.

FIGURE 3.7

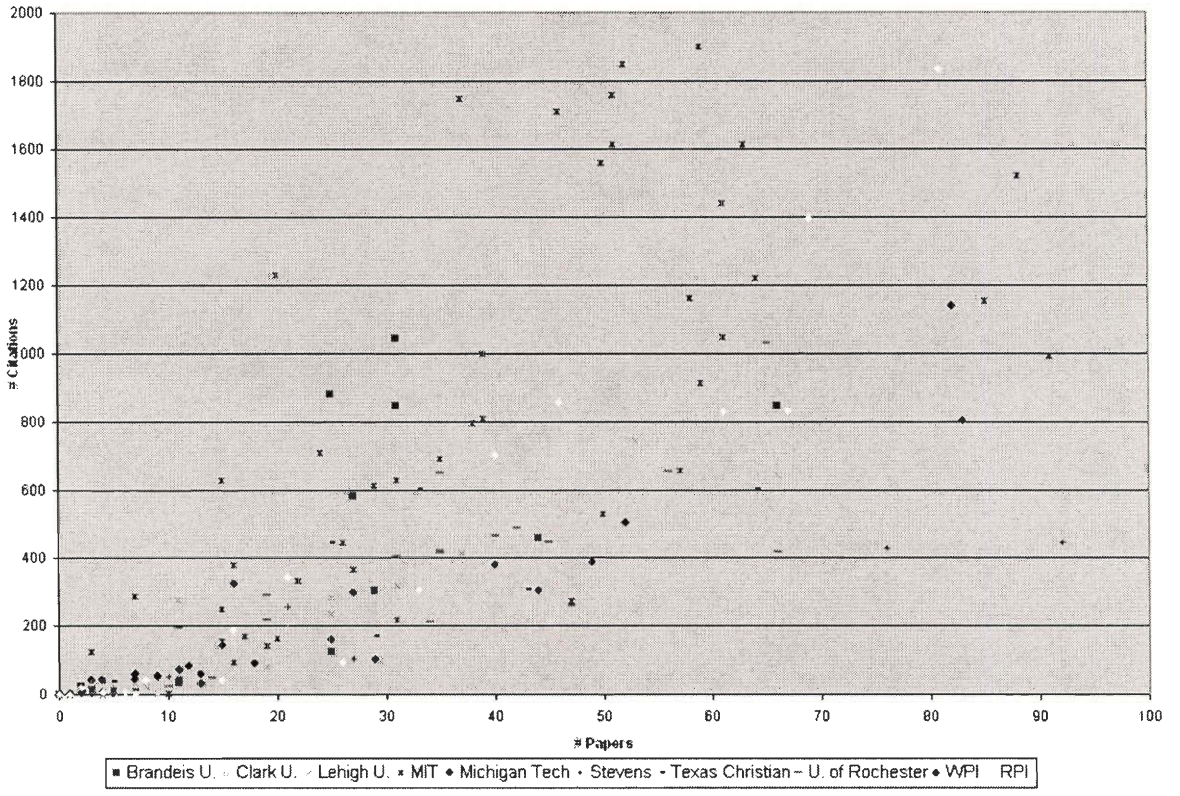


Figure 3.8 (next page) illustrates the number of citations compared with the number of published papers for the top 5 schools with the largest number of papers published after 1990. These top 5 schools are: Brandeis University, Lehigh University, Massachusetts Institute of Technology, Rensselaer Polytechnic Institute and the University of Rochester. Figure 3.8 makes the same comparison that Figure 2.6 does but the distribution is easier to analyze. MIT physics faculty members have published the most papers and have received the largest number of citations. The majority of faculty members are located in the lower range of number of published papers as well as in the lower range of the number of citations.

FIGURE 3.8

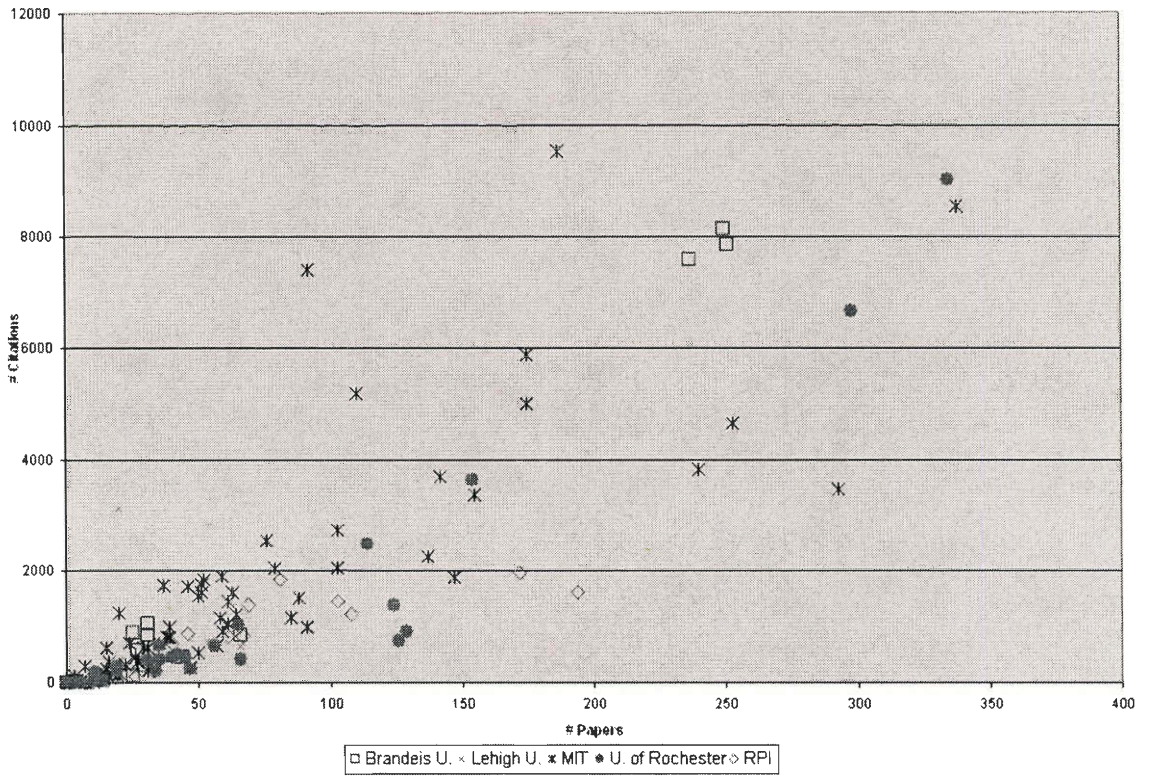
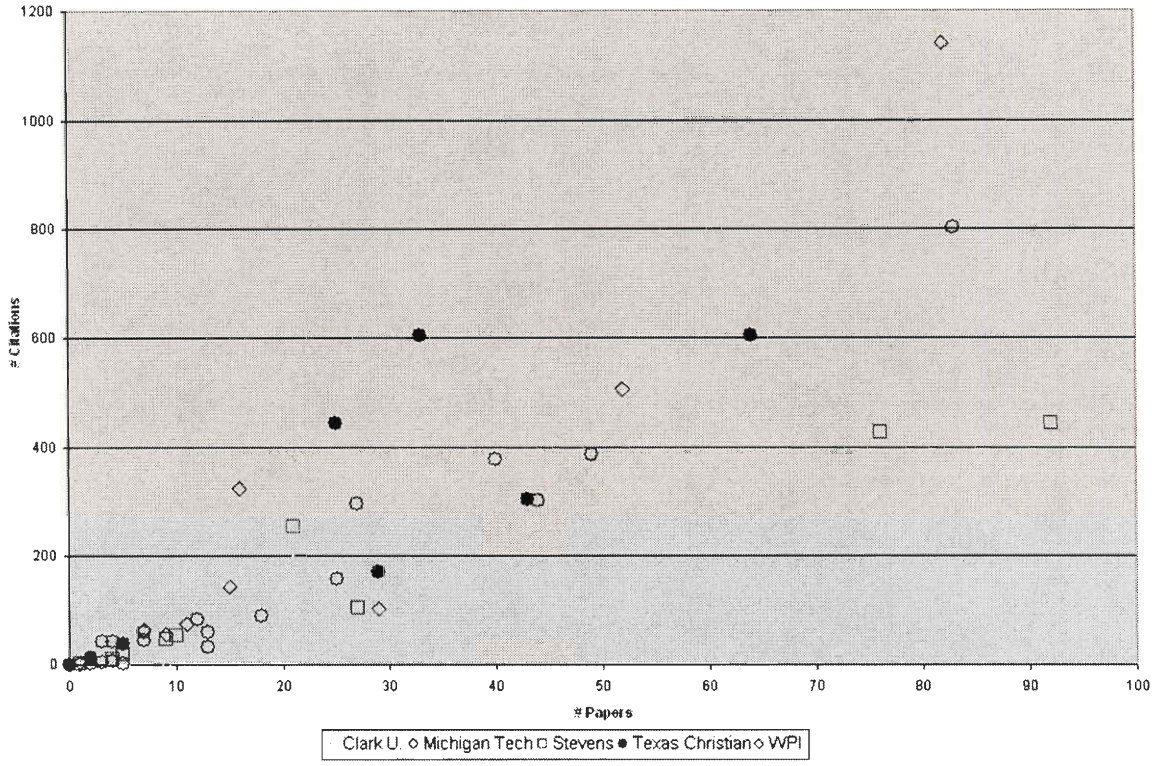


Figure 3.9 (next page) compares the total number of papers published after 1990 and the number of citations for the second half of the schools, ranked by number of published papers. These schools are: Clark University, Michigan Tech. University, Stevens Institute, Texas Christian University and WPI. The faculty members from the Stevens Institute physics department have published the most papers but the papers published by the Worcester Polytechnic Institute physics faculty members have been the most cited. The greater concentration of faculty members is with the lower number of published papers and lower number of received citations.

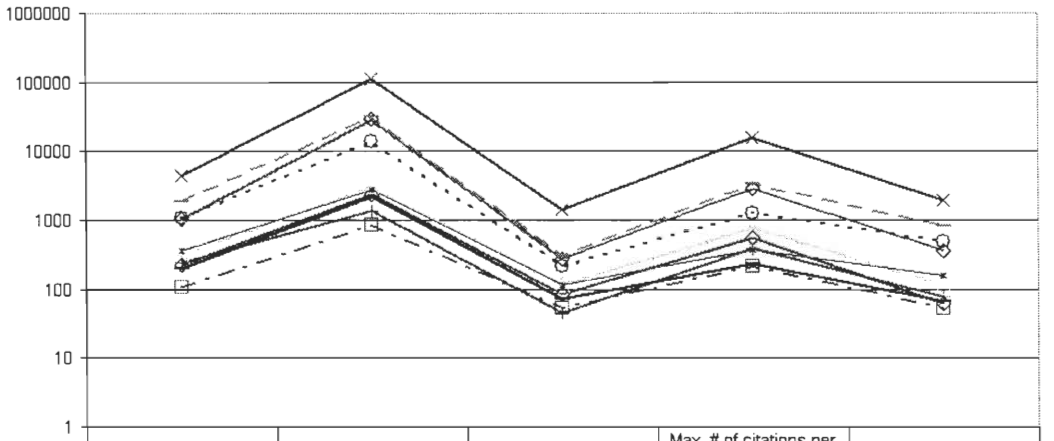
FIGURE 3.9



It can be concluded that, in general, as the number of papers increases, the number of citations increases as well. For some schools the rate in which the citations increases is not strictly proportional with the rate in which the number of published papers increases. For example, the Rensselaer Polytechnic Institute physics faculty members have published a large number of papers but the number of citations received is not increasing proportionally. RPI has some faculty members who have published almost 200 papers after 1990 but no faculty member has received over 2000 citations.

Figure 3.10 (next page) compares the number of papers published after 1990, the number of citations, the citations per paper, the maximum number of citations on a single paper, and the number of papers after 1999 for the physics department of every school being analyzed in this report.

FIGURE 3.10



	#Papers	#Citations	#Citations/Paper	Max. # of citations per paper	#Papers after 2000
Brandeis	1032	28783	273.00	2910	356
Clark	106	842	52.76	214	52
Lehigh	305	3115	113.44	752	117
MIT	4509	109170	1449.79	15695	1960
Michigan Tech	360	2798	114.38	369	158
RPI	1080	13754	213.26	1266	493
Stevens	245	1364	45.82	396	77
Texas Christ.	201	2181	72.32	232	66
U. of Rochester	1892	31476	304.76	3362	810
WPI	222	2416	83.96	562	61

Most schools have the same position in every aspect being analyzed. For instance, the Massachusetts Institute of Technology physics faculty is first in every category followed by the University of Rochester. The faculty members from Stevens are an exception. Steven's physics faculty members have published more papers than the faculty members from Texas Christian University, Worcester Polytechnic Institute and Clark University. But Stevens has fewer citations per paper than all the previously named schools.

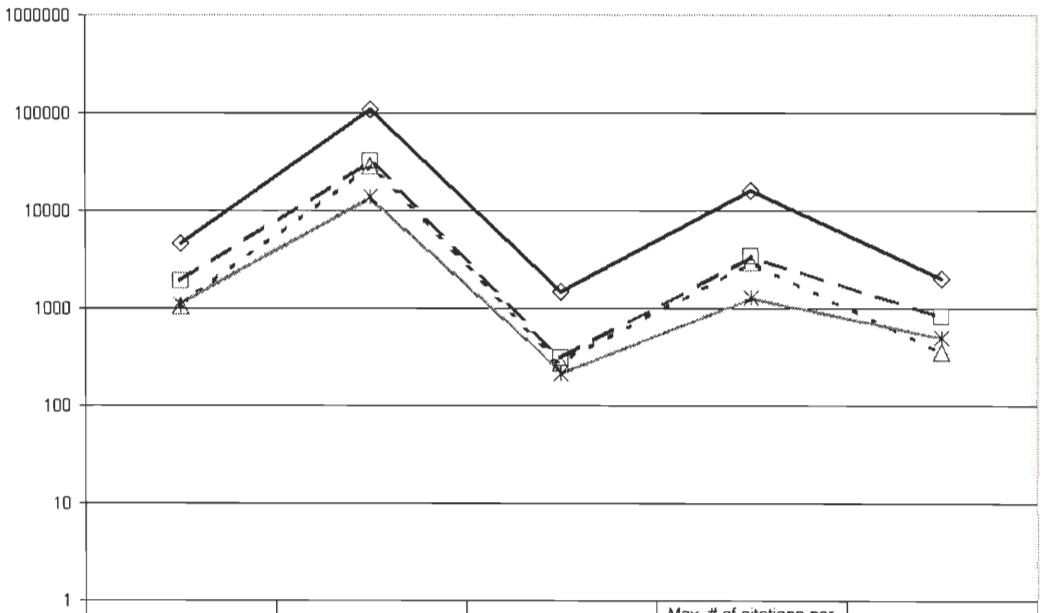
The largest gap between the physics departments in the schools in any factor being analyzed is in the total number of citations. There is one group of schools that has over 10,000 citations. This group is formed by the University of Rochester, Brandeis

University and the Rensselaer Institute of Technology. The second group, which is formed by all the rest of the schools, has a number of citations that is less than 5,000.

Figure 3.11 shows the same comparison as Figure 3.10 but only for the top 4 schools ranked upon the number of published papers by their physics faculty members. These schools are: Massachusetts Institute of Technology, Brandeis University, Rensselaer Polytechnic Institute and the University of Rochester.

MIT has a much larger number of papers published after 1990, number of citations, number of citations per paper, maximum number of citations on a single paper and number of papers published after 1999 than the other three schools. The physics faculty members from Brandeis University, RPI and the University of Rochester have a very similar number of citations per paper.

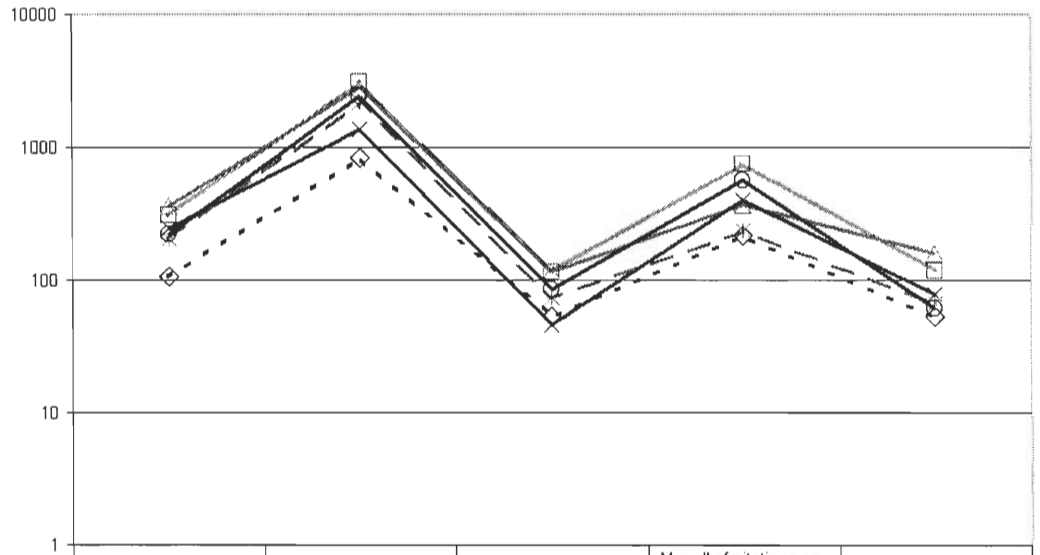
FIGURE 5.10



	#Papers	#Citations	#Citations/Paper	Max. # of citations per paper	#Papers after 2000
MIT	4509	109170	1449.79	15695	1960
U. of Rochester	1892	31476	304.76	3362	810
Brandeis	1032	28783	273.00	2910	356
RPI	1080	13754	213.26	1266	493

Figure 3.12 shows the same distribution as Figure 3.11 for Clark University, Lehigh University, Michigan Tech. University, Stevens Institute, Texas Christian University and Worcester Polytechnic Institute. Clark University has published much fewer papers since 1990 in comparison with the other analyzed schools. Figure 3.12 shows more clearly how the Stevens Institute physics faculty members have the fewest number of citations per paper but are ranked higher in every other category.

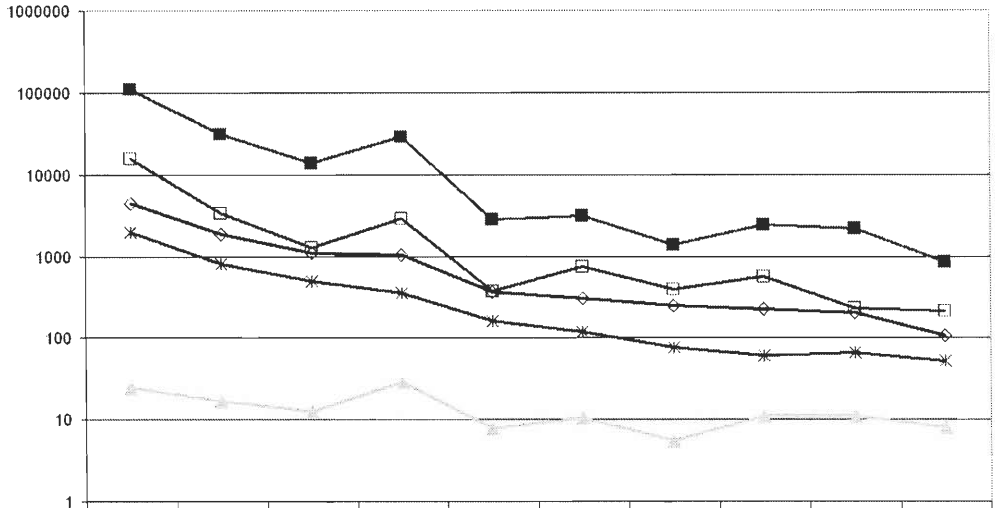
FIGURE 3.12



	#Papers	#Citations	#Citations/Paper	Max. # of citations per paper	#Papers after 2000
Clark	106	842	52.76	214	52
Lehigh	305	3115	113.44	752	117
Michigan Tech	360	2798	114.38	369	158
Stevens	245	1364	45.82	396	77
Texas Christ.	201	2181	72.32	232	66
WPI	222	2416	83.96	562	61

Figure 3.13 (next page) shows the distribution of the number of papers published after 1990, the number of citations, the citations per paper, the maximum number of citations on a single paper, and the number of papers after 1999 for each school. Schools are ranked in descending order of number of papers published since 1990.

FIGURE 3.13



	Massachusetts Institute of	University of Rochester	Rensselaer Polytechnic Institute	Brandeis University	Michigan Tech. University	Lehigh University	Stevens Institute	Worcester Polytechnic Institute	Texas Christian University	Clark University
#Papers	4509	1892	1080	1032	360	305	245	222	201	106
#Citations	109170	31476	13754	28783	2798	3115	1364	2416	2181	842
#Citations/Paper	24.21	16.64	12.74	27.89	7.77	10.21	5.57	10.88	10.85	7.94
"Max. # of Citations"	15695	3362	1266	2910	369	752	396	562	232	214
# Papers after 1999	1960	810	493	356	158	117	77	61	66	52

School

It is important to notice how the number of citations per paper decreases at a much slower rate than every other factor being analyzed. This is significant because it is a fair comparison between schools that have a very different number of faculty members. Schools with a larger number of faculty members will publish more papers and therefore, will get more citations.

Figure 3.14 (next page) illustrates the distribution of the total number of papers per school. The name of each school is in the horizontal axis and the total number of papers is the vertical axis. The Massachusetts Institute of Technology physics faculty members obviously have published the largest number of papers. MIT physics faculty members have published 4509 since 1990. The faculty members from the University of Rochester, RPI and Brandeis University have published between 1000 and 2000 papers.

The last six schools are in a common range of number of papers published after 1990, below 500.

FIGURE 3.14

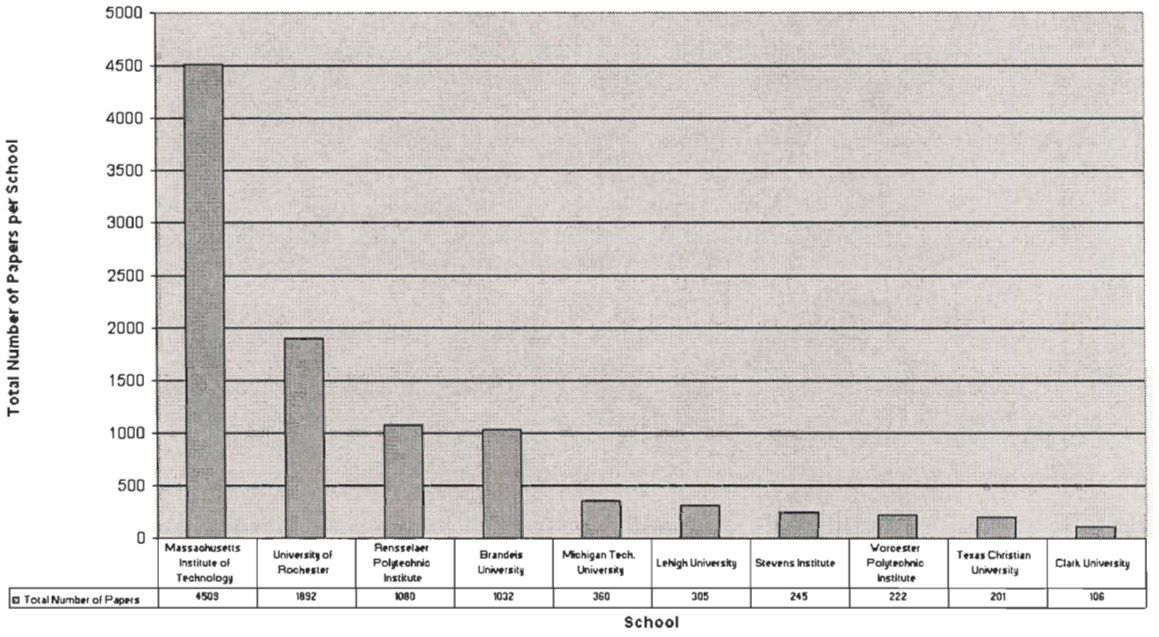
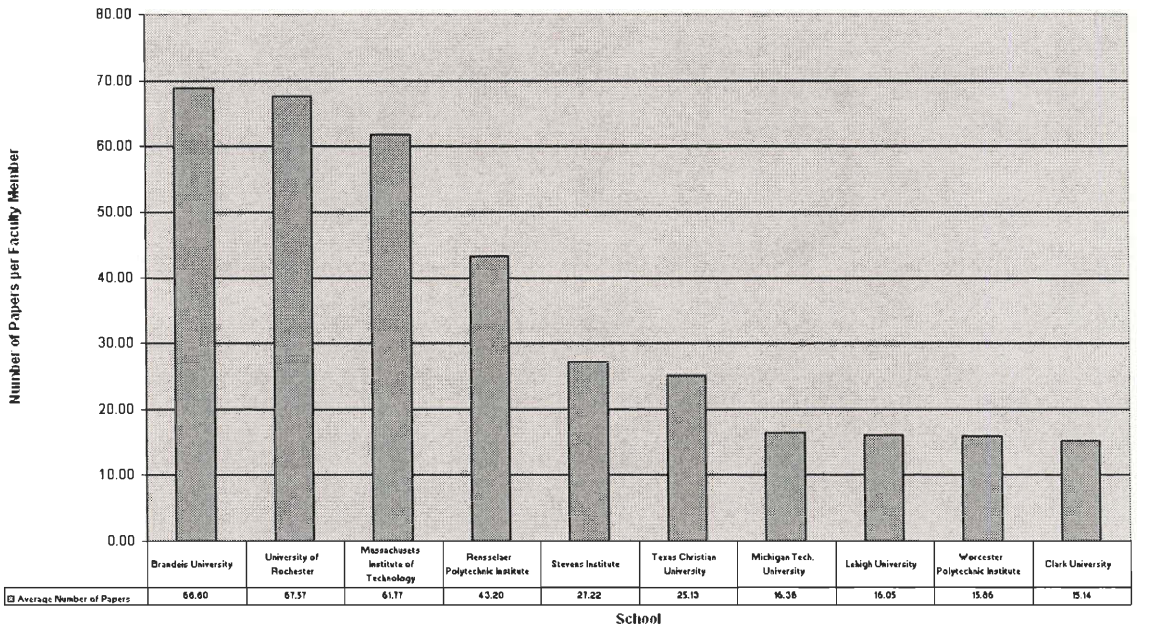


Figure 3.15 (next page) shows the distribution of the number of papers per faculty member for every school being analyzed. The vertical axis is the number of papers per faculty members while the horizontal axis lists the schools in this analysis. The number of papers for each school per faculty member is the total number of papers published after 1999 divided the number of faculty members.

It is important to compare the number of papers with the average number of papers per faculty member because schools with a larger number of faculty members usually publish more papers. For instance, MIT has 72 physics faculty members, who have published the most papers since 1990 when compared with the other 9 schools in this report. But when MIT is analyzed for the average number of papers per faculty

member its physics faculty members have a fewer number of papers than the ones from Brandeis University and from the University of Rochester.

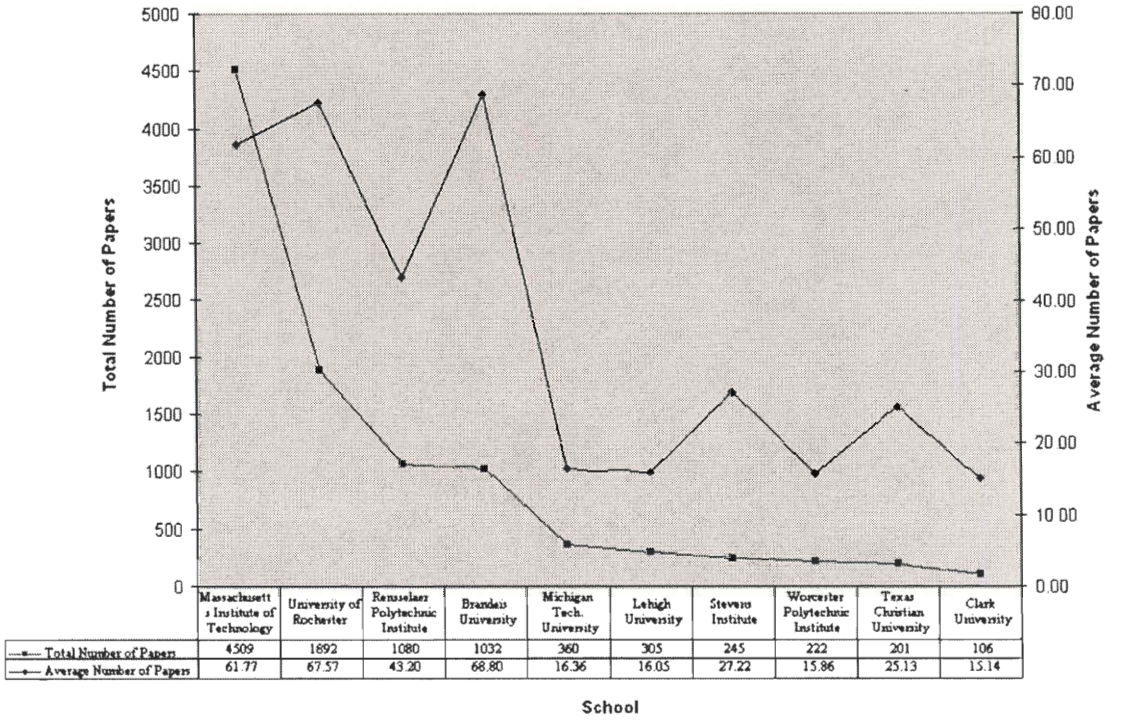
FIGURE 3.15



MIT faculty members have published an average number of papers per faculty member of 61.77 while the Brandeis University physics faculty members have published the largest average of 68.80. The four schools that have the most published papers stayed as the schools with the largest average number of papers per faculty member. The six schools with the fewest published papers also stayed as the schools with the fewest average number of papers.

Figure 3.16 shows more clearly the difference between the total number of papers published after 1990 with the average number of published papers per faculty member. The left vertical axis is the total number of papers published after 1990 by the physics faculty members, the right vertical axis is the average number of papers and the horizontal axis is the list of schools being analyzed.

FIGURE 3.16



	Massachusetts Institute of Technology	University of Rochester	Rensselaer Polytechnic Institute	Brandeis University	Michigan Tech. University	Lehigh University	Stevens Institute	Worcester Polytechnic Institute	Texas Christian University	Clark University
Total Number of Papers	4509	1892	1080	1032	360	305	245	222	201	106
Average Number of Papers	61.77	67.57	43.20	68.80	16.36	16.05	27.22	15.86	25.13	15.14

The number of papers is in descending order.

This graph again shows the marked separation between a first group of the four schools having the larger total and average number of publications and a second group of six schools having a fewer total and average number of publications. The first group is composed of MIT, University of Rochester, RPI and Brandeis University. The second group is composed by MTU, Lehigh University, Stevens Institute, WPI, Texas Christian University and Clark University.

There is a noticeable decrease in the average number of papers between the first and the second group. This great decrease is located between Brandeis University and Michigan Tech University. If each group is analyzed separately, the average number of

papers stays fairly constant in comparison with the number of papers published after 1990.

Figure 3.17 illustrates the total number of citations received by each school analyzed in this report. The Massachusetts Institute of Technology physics faculty members have the most number of citations. In fact, MIT has over three times the number of citations as the University of Rochester faculty members who are part of the department with the second largest number of received citations. The faculty members from the University of Rochester, Brandeis University and RPI can be grouped as they were in the analysis for the total number of papers. In a similar way, the other six schools may be also grouped due to the similar number of citations each of them obtained.

FIGURE 3.17

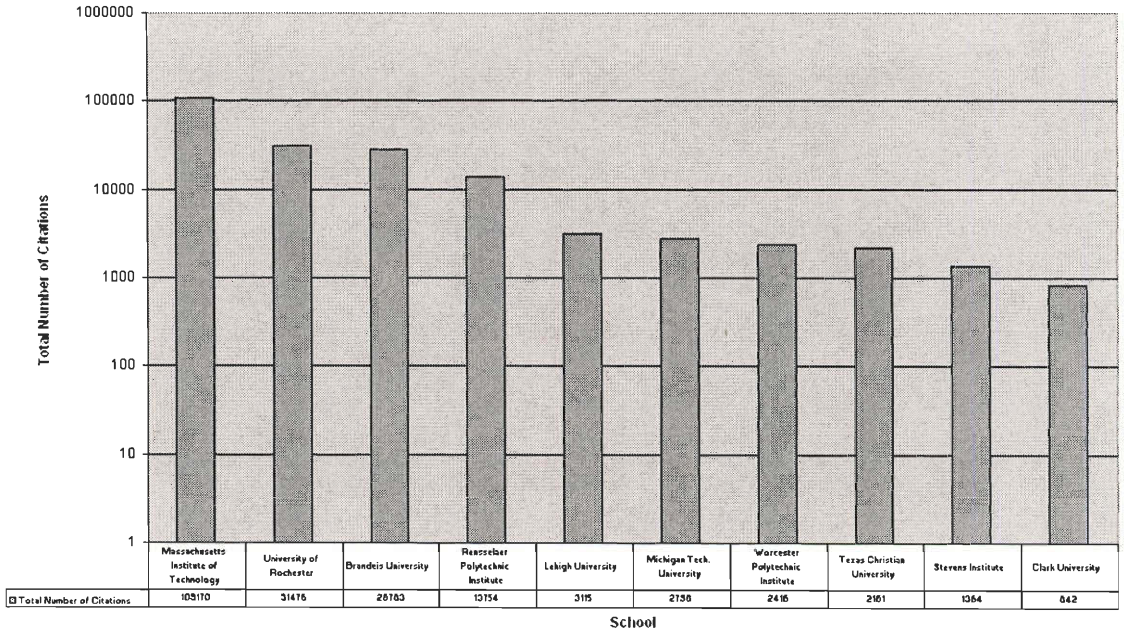


Figure 3.18 shows the number of citations for the schools being analyzed. This is a log graph that shows the rather constant rate in which the number of citations decreases for the University of Rochester, Brandeis University and RPI. It also shows the constant decrease rate for every school from Lehigh University down to Clark University.

FIGURE 3.18

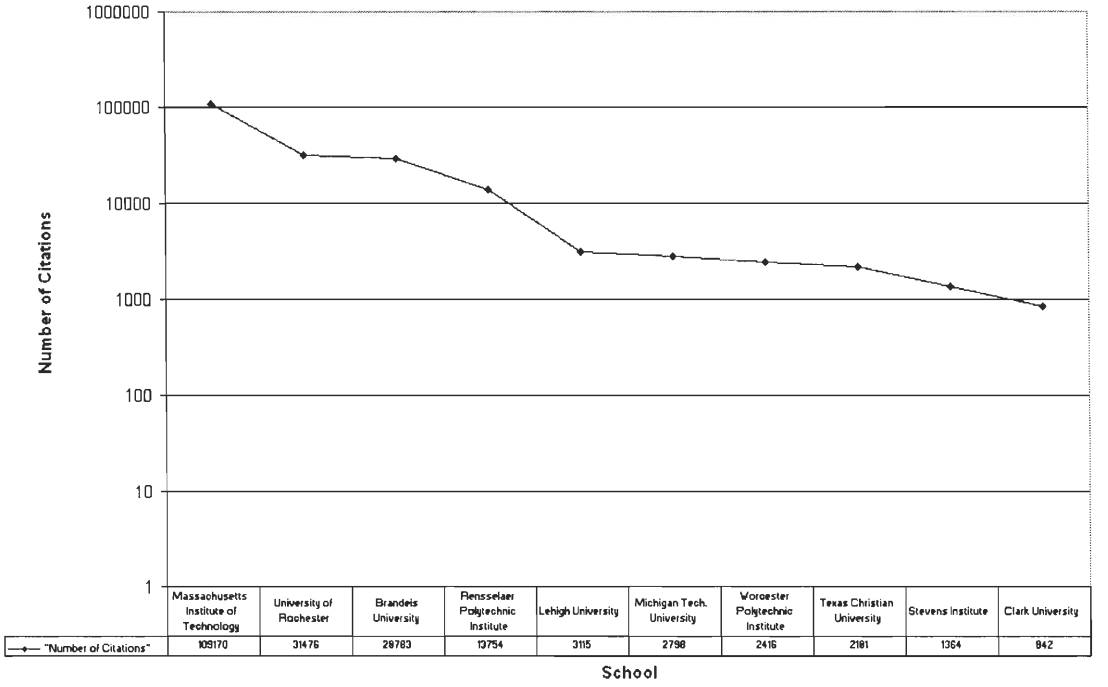
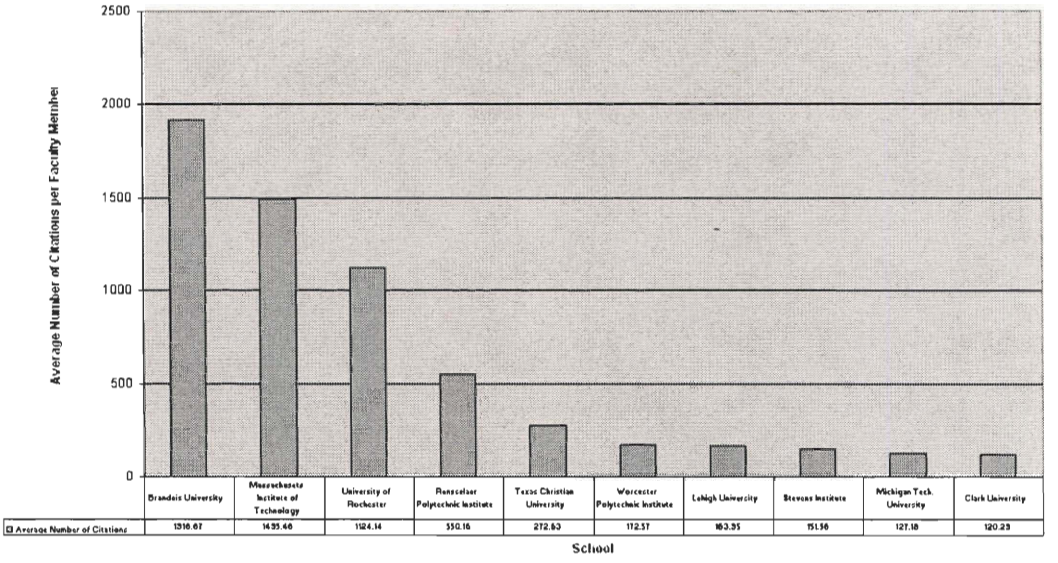


Figure 3.19 (next page) shows the distribution of the average number of citations per faculty member at each school being analyzed. The average number of citations per faculty member is represented in the vertical axis and the 10 schools used in this report are illustrated in the horizontal axis. The schools are in descending order of the average number of citations.

The physics faculty members Brandeis University, MIT and the University of Rochester have the largest average number of citations per faculty member. In average, a faculty member from the Brandeis University physics department gets cited 1918 times.

The physics department from MIT has the largest number of citations but is second in the study of the average number of citations per faculty member with 1495. The Rensselaer Polytechnic Institute and the Texas Christian University physics faculty members are next with 550 and 272 average citations per faculty member respectively.

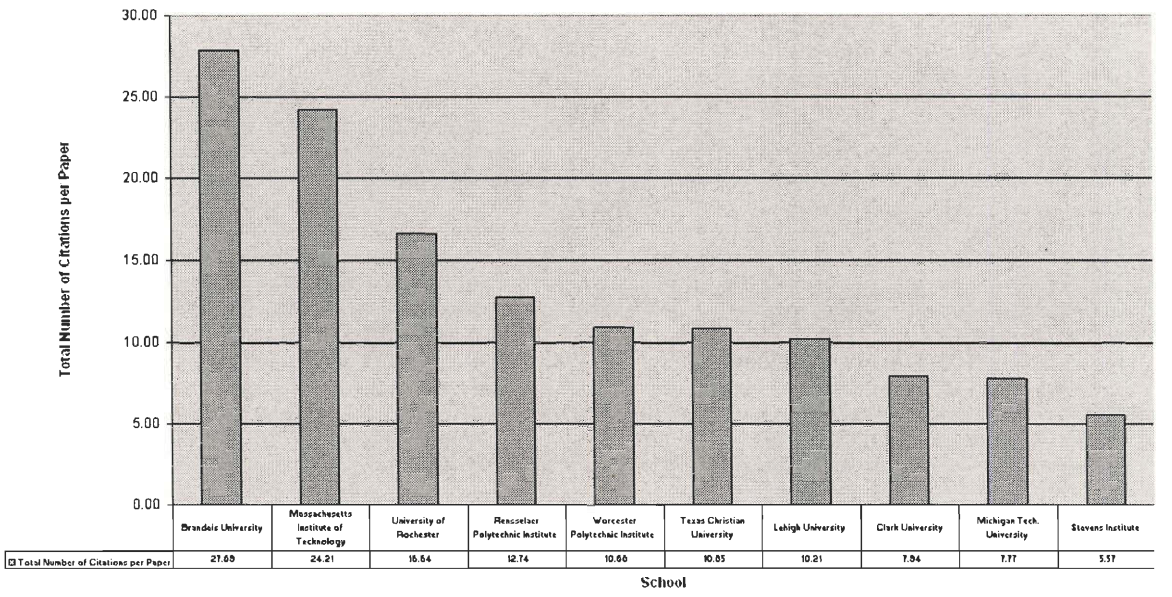
FIGURE 3.19



The last group of schools formed by WPI, Lehigh University, Stevens Institute, Michigan Tech. University and Clark University has a very similar average number of citations per faculty member. These last five schools have an average of 100 to 200 citations per faculty member.

Figure 3.20 illustrates the number of citations received per paper by the faculty members at each school. The schools are ranked by descending order of the number of citations per paper. The vertical axis is the number of citations per paper and the horizontal axis are the 10 schools being analyzed. There is a less marked difference between the first group of schools and the rest of the schools.

FIGURE 3.20

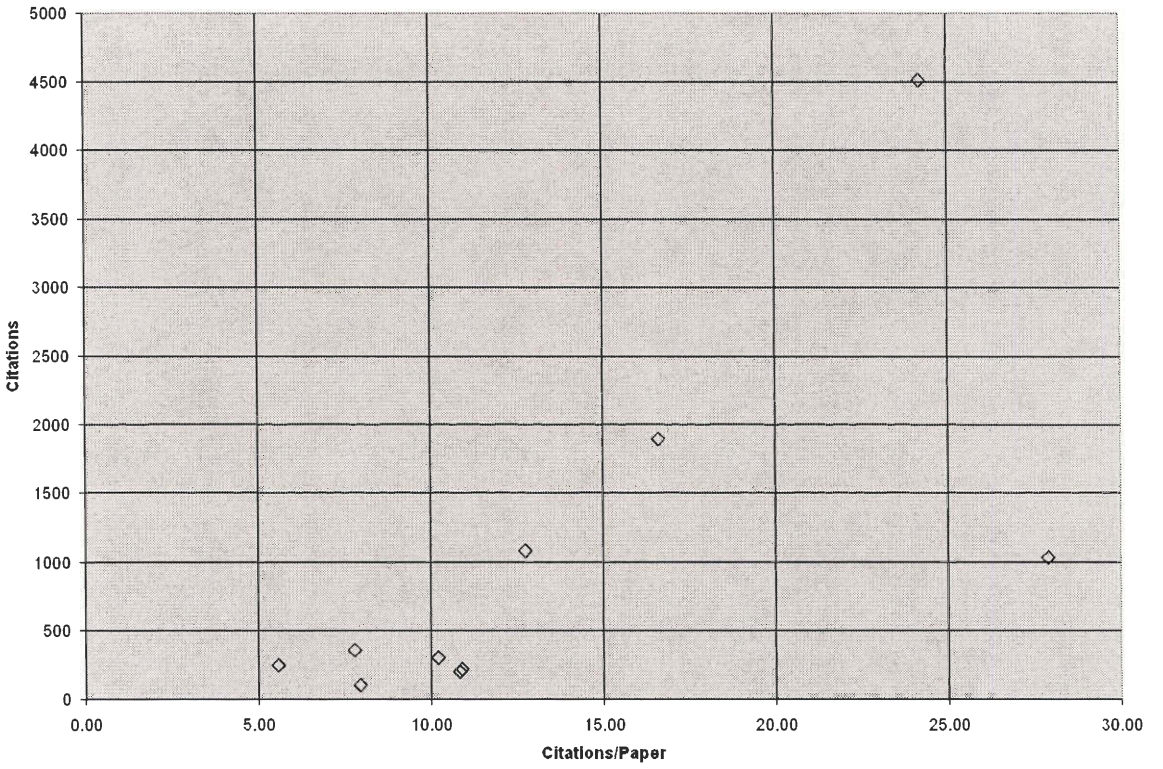


The Massachusetts Institute of Technology is no longer by itself; now MIT is part of the group formed by Brandeis University, Rochester University and RPI. The remaining six schools can be divided into a second group of schools with 10 to 11 citations per paper and a third group of schools with less than 10 citations per paper. The second group of schools is formed by the physics department from WPI, Texas Christian University and Lehigh University. The third and last group is formed by the physics department from Clark University, Michigan Tech University and Stevens Institute. Brandeis has the largest average number of citations per faculty member as well as the largest number of citations per paper.

Figure 3.21 compares the number of citations and the number of citations per paper. The vertical axis represents the total number of citations for each school and the horizontal axis shows the number of citations per paper. It is important to compare and contrast the number of citations and the citations per paper because schools with fewer faculty members will have a fewer number of papers and therefore a fewer number of

citations. For this reason, the number of citations does not fully represent the level of publications of the physics department for each school being analyzed.

FIGURE 3.21



The physics faculty members from MIT, Brandeis, RPI and Rochester University have received the most citations and also the most citations per paper. The order of the first three schools varies between the number of citations and the number of citations per paper. The Massachusetts Institute of Technology, which was the school with the largest number of citations, is second in the count of citations per paper. The faculty members from Brandeis University are third in number of citations but first in citations per paper. MIT has published the most papers among the 10 schools being analyzed and therefore it has the largest amount of total citations. Brandeis University has published a smaller number of papers and has received fewer citations than MIT but the papers published but

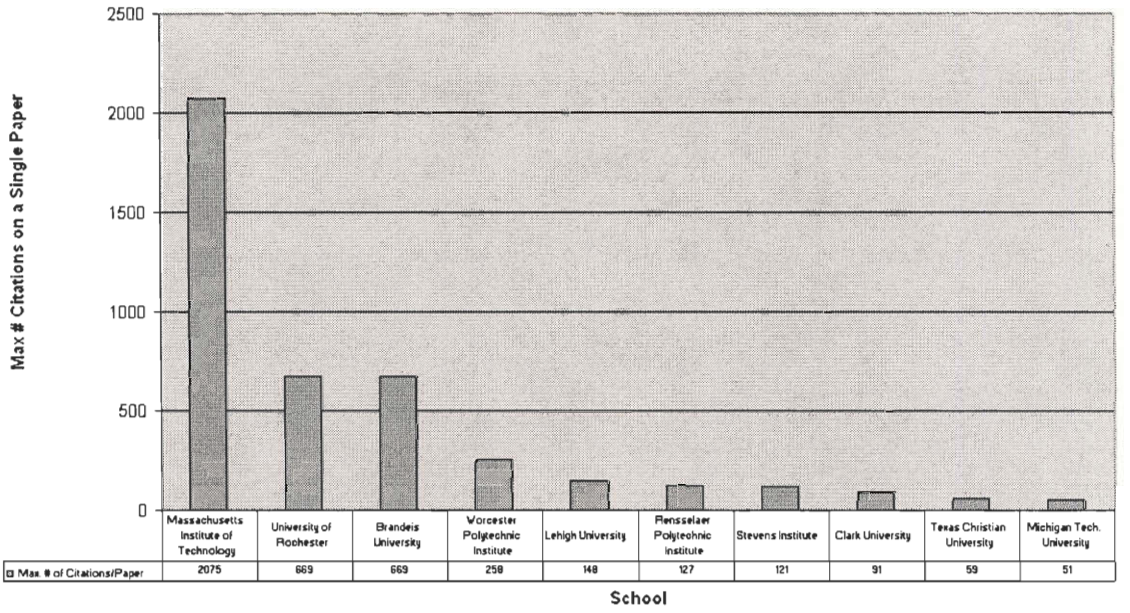
the physics faculty members from Brandeis have received more citations per paper. If both schools had the same number of faculty members Brandeis would have a larger number of citations.

With Brandeis University as the major exception the number of citations per paper decreases proportional to the total number of citations. In fact, the citations per paper for the physics faculty members from Rensselaer Polytechnic Institute, Lehigh University and Michigan Tech University decrease on a perfectly constant rate.

Figure 3.22 (next page) shows the maximum number of citations received on a single published paper. The number of citations is represented in the vertical axis and the schools being analyzed are represented in the horizontal axis. The schools are ordered by the number of citations in descending order.

The Massachusetts Institute of Technology has the largest maximum number of citations on a single publication by a physics faculty member. MIT has more than three times as many citations as the second and third schools with the largest maximum number of citation son one paper. The physics faculty members from the University of Rochester and Brandeis University received 669 citations on their most cited single paper. Arie Bodek from the University and Rochester and Craig Blocker from Brandeis University worked together in the same publication. Worcester Polytechnic Institute is fourth in this analysis with 258 citations. The remaining 6 schools have a maximum number of citations between 50 and 150.

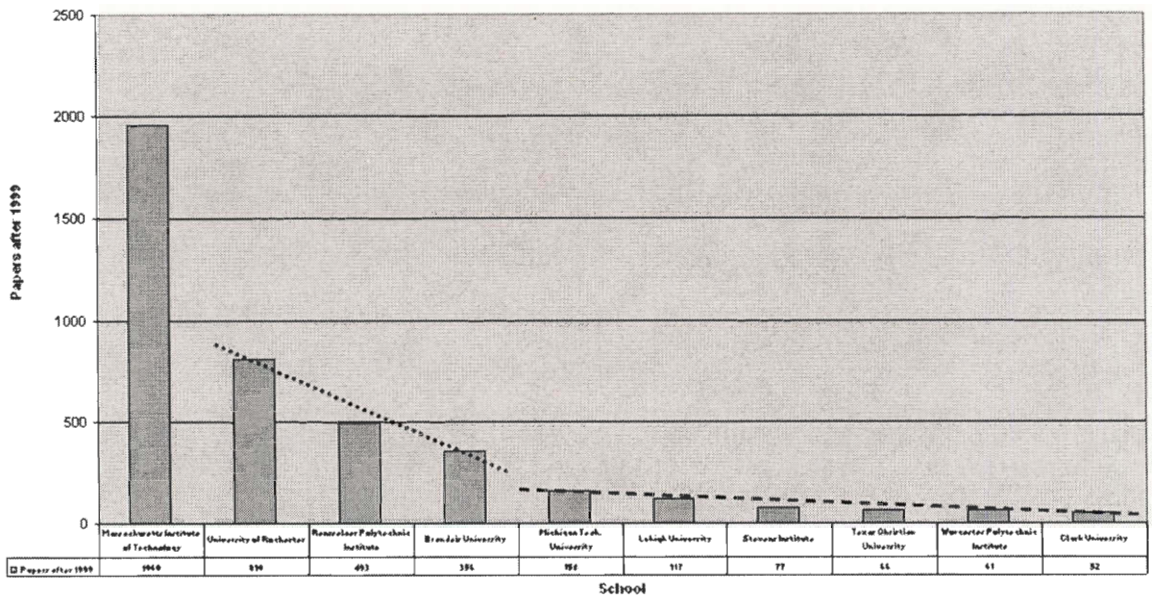
FIGURE 3.22



It is important to notice that even though the physics department from MIT has the largest maximum number of citations on one paper; it is still second, after Brandeis, in the average of citations per faculty member and in the number of citation per paper. This is significant to analyze because schools with a larger number of faculty members generally publish papers with the most citations and the papers that are mostly cited. But when compared with the average number of citations and the number of citations per paper the schools with the most faculty members is not always the first one.

Figure 3.23 illustrates the total number of papers published after 1999 by each school analyzed in this report. The number of publications after 1999 is represented in the vertical axis and the different schools are in the horizontal axis.

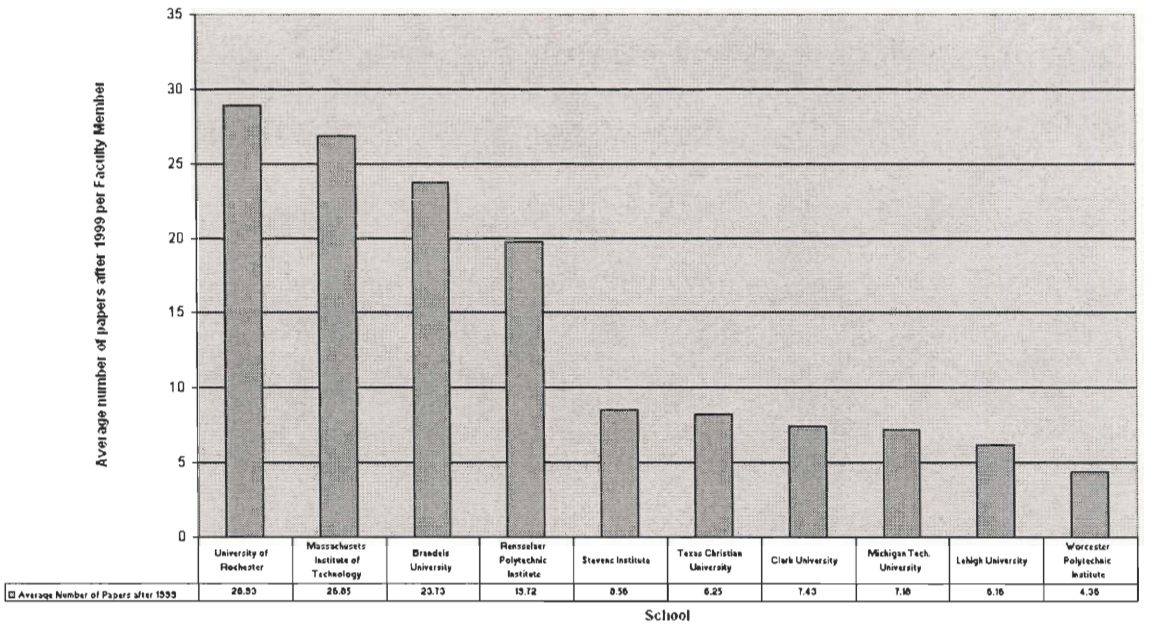
FIGURE 3.23



The physics faculty members from the Massachusetts Institute of Technology have the largest number of total papers published as well as the largest number of papers published after 1999. The second group is formed by the University of Rochester, the Rensselaer Polytechnic Institute and the Brandeis University physics faculty members. This second group has published between 350 and 810 papers after 199 which are linked with a dotted line to show the inclination in comparison with the third and last group. The third group is formed by Michigan Technological University, Lehigh University, Stevens Institute, Texas Christian University, Worcester Polytechnic Institute and Clark University. The slope connecting the schools from this last group is obviously less inclined that the slope connecting the schools from the second group. This means that the schools with a larger number of papers published after 1999 will have a bigger difference of number of papers than the schools with fewer publications.

Figure 3.24 shows the distribution of the average number of papers published after 1999 per faculty member. The average number of papers is represented in the vertical axis and the schools ranked by the average number of papers per faculty member in descending order are represented in the horizontal axis.

FIGURE 3.24



For this analysis the schools can be divided into two main groups. The first group consists of the University of Rochester, the Massachusetts Institute of Technology, Brandeis University and Rensselaer Polytechnic Institute. The second group is formed by the Stevens Institute, Clark University, Michigan Tech. University, Lehigh University and Worcester Polytechnic Institute. The first group of schools has a larger difference in the average number of papers published after 1999 between each school than the second group.

For the first time, the physics faculty members from the University of Rochester have are first in line. The first group has an average number of papers per faculty

member published after 1999 between 19 and 30 papers. The second group has a much lower average of published papers between 4 and 9 papers. There is a marked difference of the average number of published paper between the first and the second group.

Table 3.1 shows the data collection for the ten schools being analyzed. The schools are in alphabetical order. This date collection consists of the total number of papers published after 1990, number of citations, number of citations per paper, maximum number of citations on a single paper and number of papers published after 1999.

TABLE 3.1

School	#Papers	#Citations	#Citations/ Paper	Max. # of Citations on a single paper	# Papers after 1999
Brandeis University	1032	28783	27.89	2910	356
Clark University	106	842	7.94	214	52
Lehigh University	305	3115	10.21	752	117
Massachusetts Institute of Technology	4509	109170	24.21	15695	1960
Michigan Tech. University	360	2798	7.77	369	158
Rensselaer Polytechnic Institute	1080	13754	12.74	1266	493
Stevens Institute	245	1364	5.57	396	77
Texas Christian University	201	2181	10.85	232	66
University of Rochester	1892	31476	16.64	3362	810
Worcester Polytechnic Institute	222	2416	10.88	562	61

CHAPTER 4
INTERPRETATION OF THE DATA COLLECTION

The following is a study comparing the NRC ranking with an equation that summarizes that the quality of a school is based on the number of faculty members. The NRC report analyzes different aspects for each physics department such as the number of full time faculty, the enrollment for a Master's degree, the enrollment for a Doctorate degree, the Undergraduate degrees, the Undergraduate degrees 5 year program, the number of teaching assistants, the number of research assistants, the fellowships, the personnel engaged in research, the research expenditures and the stipend for academic year. The quality of Physics PhD programs are calculated in the National Research Council (NRC) ranking for a time period between 1987 and 1992. There is no quantitative analysis for the quality of a department after 1992.

Equation 4.1 was composed after the analysis from Louis J. Clavelli, a Professor of Physis at the University of Alabama. It is mainly focused on the number of faculty members in the physics department. This equation implies that the quality of the physics department is directly proportional to the number of faculty members.

EQUATION 4-1

$$Q = 1.04 + .266\sqrt{N_{sub}} + .205\sqrt{N_{other}} + .288\sqrt{N_{Nobel}} + .318\sqrt{N_{NAS}}$$

where

$\mathbf{N_{sub}}$ is the number of faculty in the various areas of subatomic phyics (Nuclear/Particle physics plus related areas)
$\mathbf{N_{other}}$ is the number of faculty in all other areas including astronomy.
$\mathbf{N_{Nobel}}$ is the number of faculty who have received a Nobel price.
$\mathbf{N_{NAS}}$ is the number of faculty who belong to the National Academy of Sciences.

Table 4.1 shows the distribution of the NRC rank, NRC calculated quality, rank calculated using Equation 4.1 and the quality using Equation 4.1. The NRC rank and NRC quality are based on the ranking for the physics department for 1992. There are 147 schools ranked in the NRC report. For this new ranking analyzes 175 schools. The schools that were not ranked by the NRC report will show an NRC rank and quality of zero.

TABLE 4.1

NAME	NRC RANK	EQUATION 1-1 RANK	NRC QUALITY	EQUATION 1-1 QUALITY
MIT	3.5	1	4.87	5.527
U. OF ROCHESTER	26.5	47	3.6	2.948
BRANDEIS U.	42.5	90	3.25	2.52
RPI	68.5	80	2.88	2.661
LEHIGH U.	98	117	2.39	2.324
STEVENS INST.	109	153	2.23	2.021
CLARK U.	130	165	1.82	1.914
WPI	137.5	168	1.48	1.811
MICHIGAN TECH.	139	118	1.47	2.324
TEXAS CHRISTIAN U.	146	174	0.67	1.586

In this chart, the schools are ranked in descending order of the raking calculated by the NRC back in 1992. There is a slight difference between the NRC calculated quality for the physics program and the quality calculating using Equation 4.1. This difference is much larger between the rank given by the NRC report and the rank given by the study at the University of Alabama. This means that a little change in the quality of a physics department affects the rank of the school immensely.

Figure 4.1 is the comparison between the quality of the physics programs calculated by the NRC with the quality of the PhD program calculated using Equation 4.1. The quality of the department calculated by the NRC is shown in the vertical axis and the quality calculated by Clavelli is in the horizontal axis.

The physics PhD program for the Massachusetts Institute of Technology has the highest quality for both calculations, when compared with the other 9 schools. There is a big similarity between the quality of the PhD programs calculated by the NRC and the quality calculated using Equation 4.1. The closest calculated quality for both rankings is for the physics program in Lehigh University and Clark University. On the contrary, the biggest difference between both qualities is for the Massachusetts Institute of Technology and the Michigan Technological Institute. With MIT as a major exception, most schools obtained a similar ranking through the NRC report and applying Equation 4-1.

FIGURE 4.1

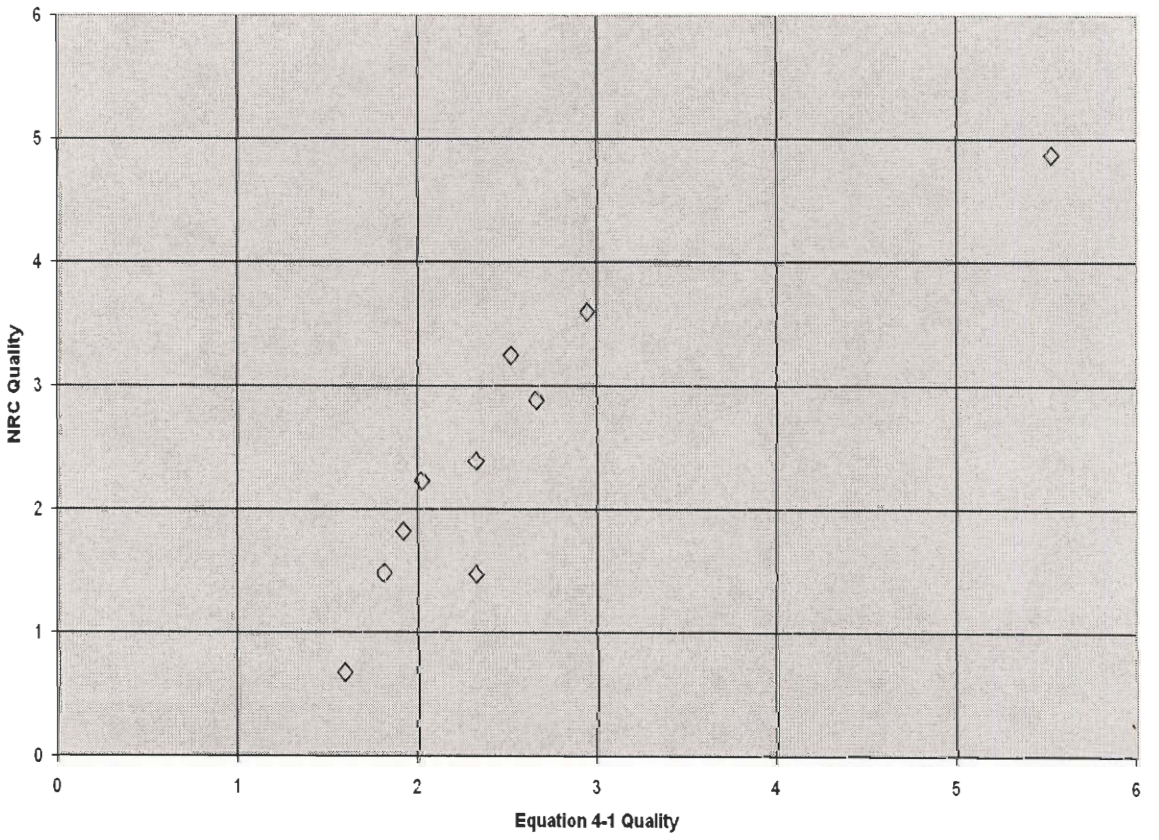
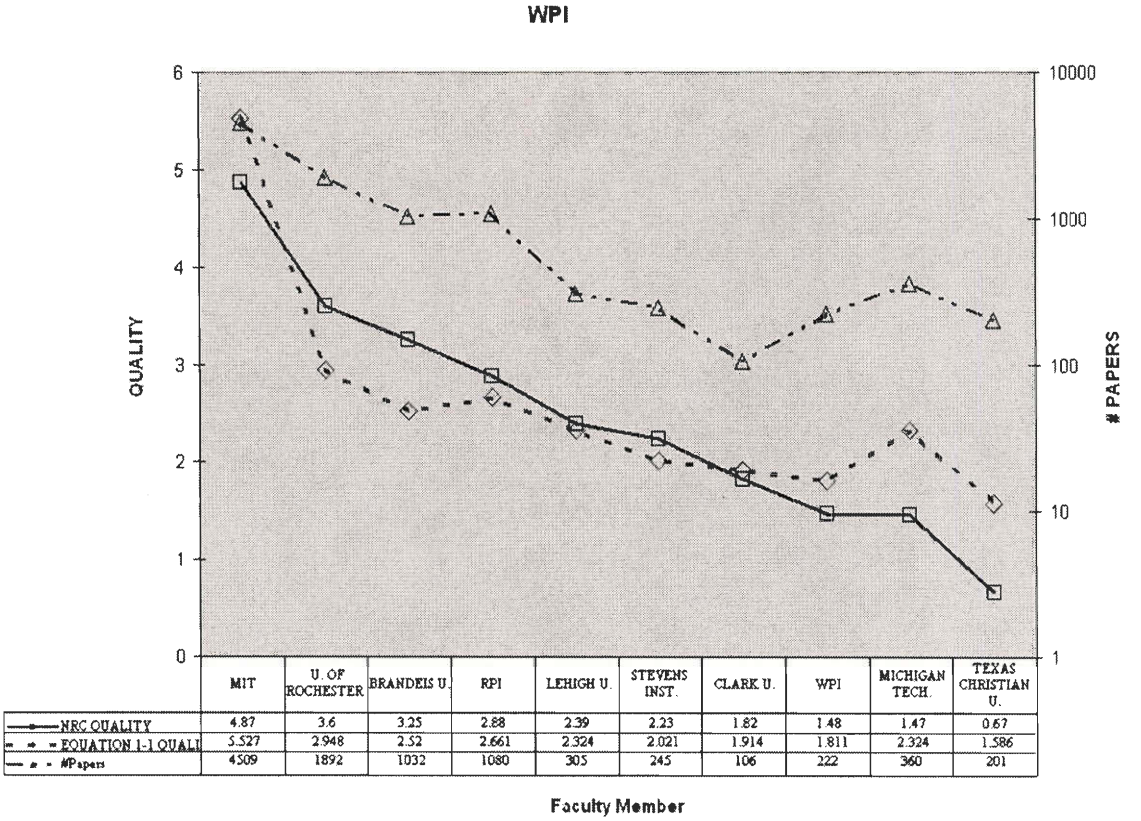


Figure 4.2 (next page) shows the comparison between the quality calculated by the NRC, the quality calculated using Equation 4.1 and the total number of published papers. The number of published papers follows almost an exact pattern than the quality calculated by Equation 4.1. The quality is represented in the left vertical axis, the number of papers in the right vertical axis and the schools are listed in the horizontal axis. The schools are ranked in descending order of the quality calculated by the NRC report. As he quality calculated with Equation 4.1 decreases the number of published papers decrease as well. This relationship occurs because the number of published papers is directly related to the number of faculty members.

FIGURE 4.2



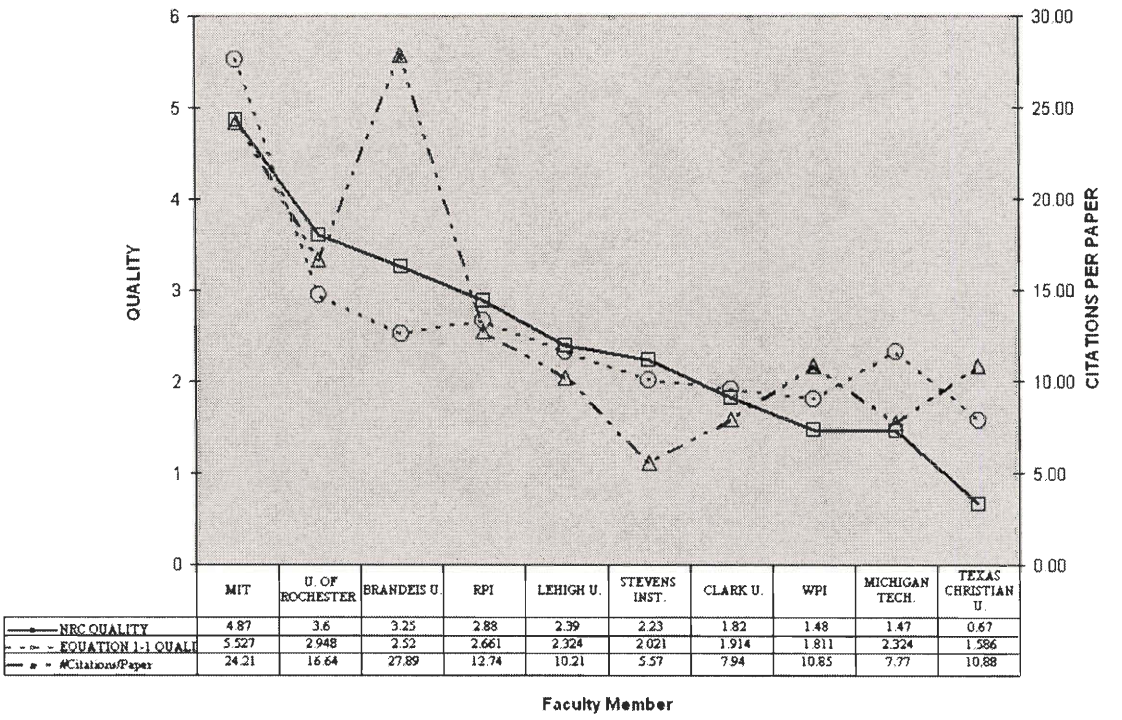
	MIT	U. OF ROCHESTER	BRANDEIS U.	RPI	LEHIGH U.	STEVENS INST.	CLARK U.	WPI	MICHIGAN TECH.	TEXAS CHRISTIAN U.
NRC QUALITY	4.87	3.6	3.25	2.88	2.39	2.23	1.82	1.48	1.47	0.67
EQUATION 1-1 QUALI	5.527	2.948	2.52	2.661	2.324	2.021	1.914	1.811	2.324	1.586
#Papers	4509	1892	1032	1080	305	245	106	222	360	201

The quality and the number of published papers have the same two exceptions to this rule: Rensselaer Polytechnic Institute and Michigan Technological Institute. These

two schools have a larger number of papers and a higher quality calculated by Equation 4.1 than the previous school with a higher NRC calculated quality. The number of published papers is related more closely to the quality calculated using Equation 4.1 than to the quality calculated in the NRC report.

Figure 4.3 shows the distribution of the calculated NRC quality for the physics PhD programs, the quality calculated by Equation 4.1 and the number of citations per paper for the ten schools being analyzed. The quality is shown in the left vertical axis, the number of citations per paper in the right vertical axis and the schools are listed in the horizontal axis. The schools are ranked by descending order of the NRC calculated quality.

FIGURE 4.3



	MIT	U. OF ROCHESTER	BRANDEIS U.	RPI	LEHIGH U.	STEVENS INST.	CLARK U.	WPI	MICHIGAN TECH.	TEXAS CHRISTIAN U.
NRC QUALITY	4.87	3.6	3.25	2.88	2.39	2.23	1.82	1.48	1.47	0.67
EQUATION 1-1 QUALI	5.527	2.948	2.52	2.661	2.324	2.021	1.914	1.811	2.324	1.586
#Citations/Paper	24.21	16.64	27.89	12.74	10.21	5.57	7.94	10.85	7.77	10.88

The major discrepancy between the quality of the PhD programs and the number of citations per paper occurs with Brandeis University. The physics department of the

Massachusetts Institute of Technology has a higher quality of PhD program but the Brandeis physics faculty members have a larger number of citations per paper. The second major discrepancy occurs with the physics programs at the Stevens Institute of Technology. Stevens has a small number of citations per paper when compared with fellow schools with a similar quality of PhD programs. For the Massachusetts Institute of Technology, University of Rochester, Rensselaer Polytechnic Institute, Lehigh University, Michigan Tech. University and Stevens Institute, the number of citations per paper decreases as the quality of the PhD physics program decreases. On the contrary, for Clark University, Worcester Polytechnic Institute and Texas Christian University, the number of citations per paper increases as the quality of the PhD physics programs decreases.

Figure 4.4 shows the comparison between the NRC calculated quality and the number of physics faculty members in each school. The NRC quality of the Physics program is represented in the vertical axis and the number of faculty members in the horizontal axis. There is a small correlation between the NRC quality and the number of faculty members for each school. The number of faculty members decreases as the quality decreases. The Massachusetts Institute of Technology is the only school that has both, the largest number of faculty members and was ranked with the highest quality by the NRC report. For the other nine schools, the quality does not depend on the number of faculty members. The school with the lowest ranked quality is not the school with the fewest faculty members. In the same way, the school with the second highest ranked quality is not the school with the second largest number of faculty members.

FIGURE 4.4

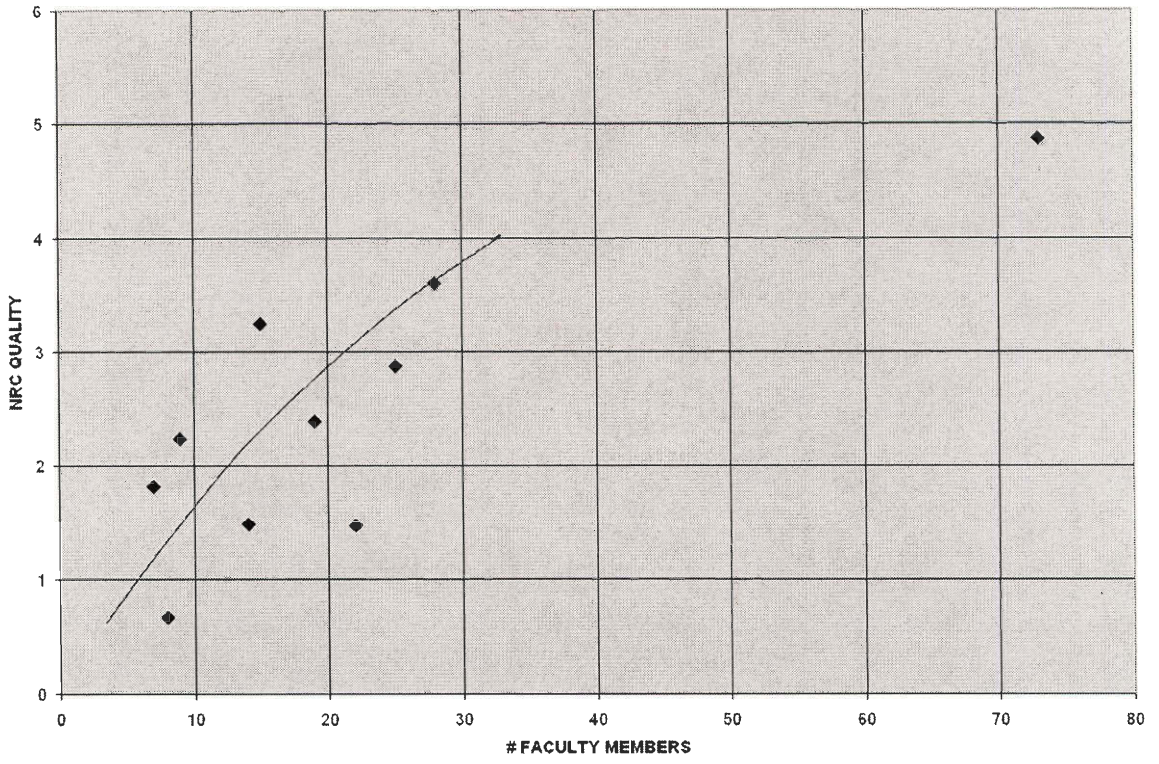


Figure 4.5 shows the distribution of the number of faculty members and the number of papers published after 1990. The Massachusetts Institute of Technology has published the largest number of papers as well as the largest number of faculty members in the physics department. Nine schools have less than 30 faculty members and six schools have published between 100-1000 papers after 1990.

There is a direct relationship between the number of physics faculty and the number of published papers. The number of published papers increases as the number of faculty members increases. For example, the University of Rochester has the second largest number of physics faculty members and has published the second largest number of papers. In a similar way, Clark University has published the smallest number of papers and it has the smallest number of physics faculty members. The physics

department from Brandeis University is the principal exception to this relationship. Brandeis physics faculty members have published an extremely high number of papers compared with other schools with similar number of faculty members.

FIGURE 4.5

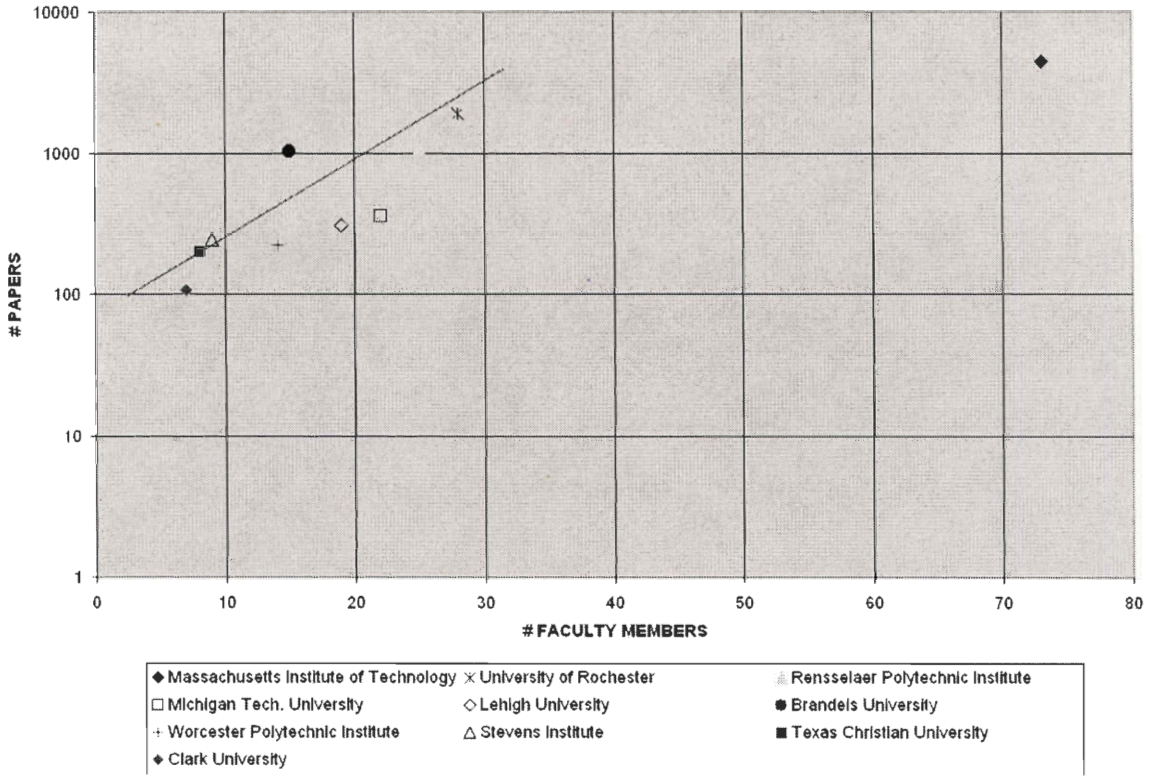


Figure 4.6 (next page) represents the comparison between the number of citations with the number of physics faculty members. The number of citations is shown in the vertical axis and the number of faculty members is shown in the horizontal axis. The number of citations is directly related to the number of published papers. As concluded before, the number of published papers is dependant on the number of faculty members. Therefore, there is a direct correlation between the total number of citations and the number of faculty members. The number of citations increases as the number of faculty

members increases. The MIT faculty members have received the largest number of citations. There are five schools with a number of citations between 1,000 and 10,000, and a number of faculty members ranging from 15-25. All the schools, with the exception of MIT, have less than 30 physics faculty members. Brandeis has an extremely high number of citations when compared with other schools with a similar number of physics faculty members.

FIGURE 4.6

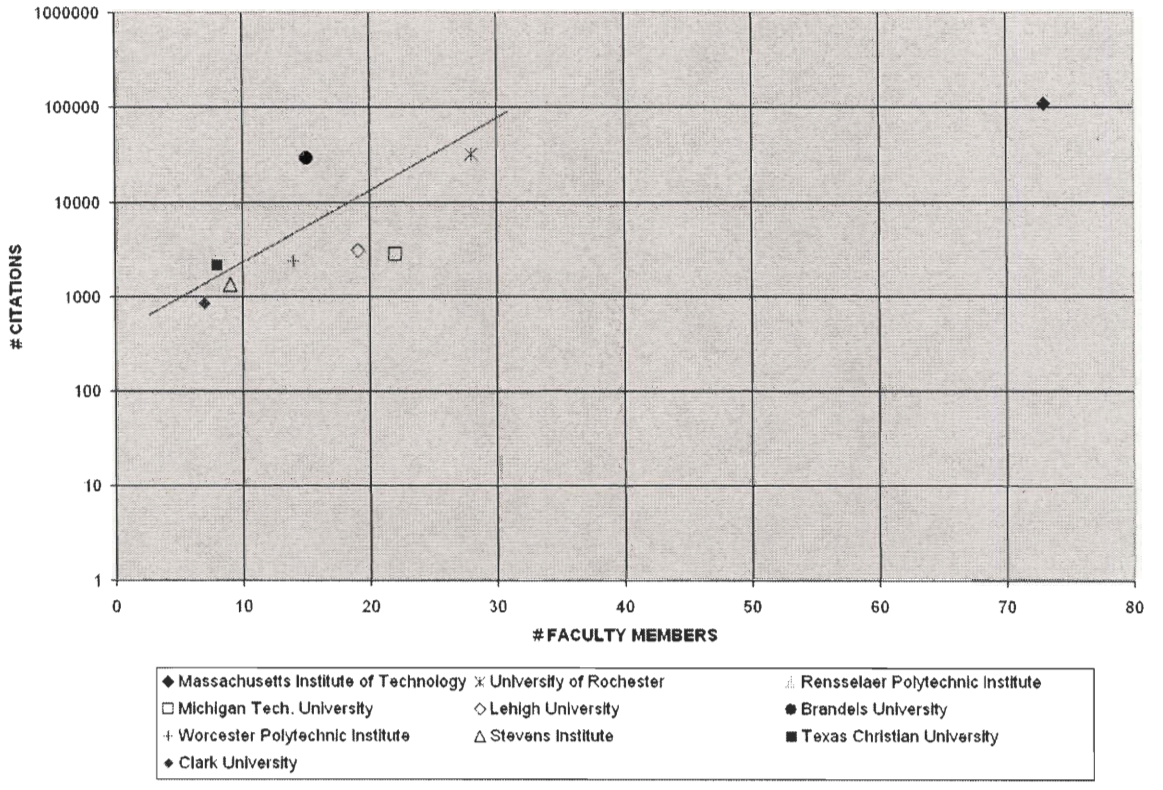


Figure 4.7 (next page) shows the relationship between the number of citations per paper with the number of faculty members. The number of citations per paper is represented in the vertical axis and the number of physics faculty members is represented in the horizontal axis. There is a small correlation between the number of citations and

the number of faculty members. As the number of faculty members increases, the number of citations increases as well. MIT has the largest number of physics faculty members but does not have the largest number of citations per paper. Brandeis has the largest number of citations per paper. This means that the physics faculty members at Brandeis University have received, in average, a greater number of citations for each publication than the faculty members at the Massachusetts Institute of Technology. Clark University has the lowest number of physics faculty members but the Stevens Institute faculty members have received the smallest number of citations per paper. This result shows that the size of the physics department is not directly related with the quality of the school.

FIGURE 4.7

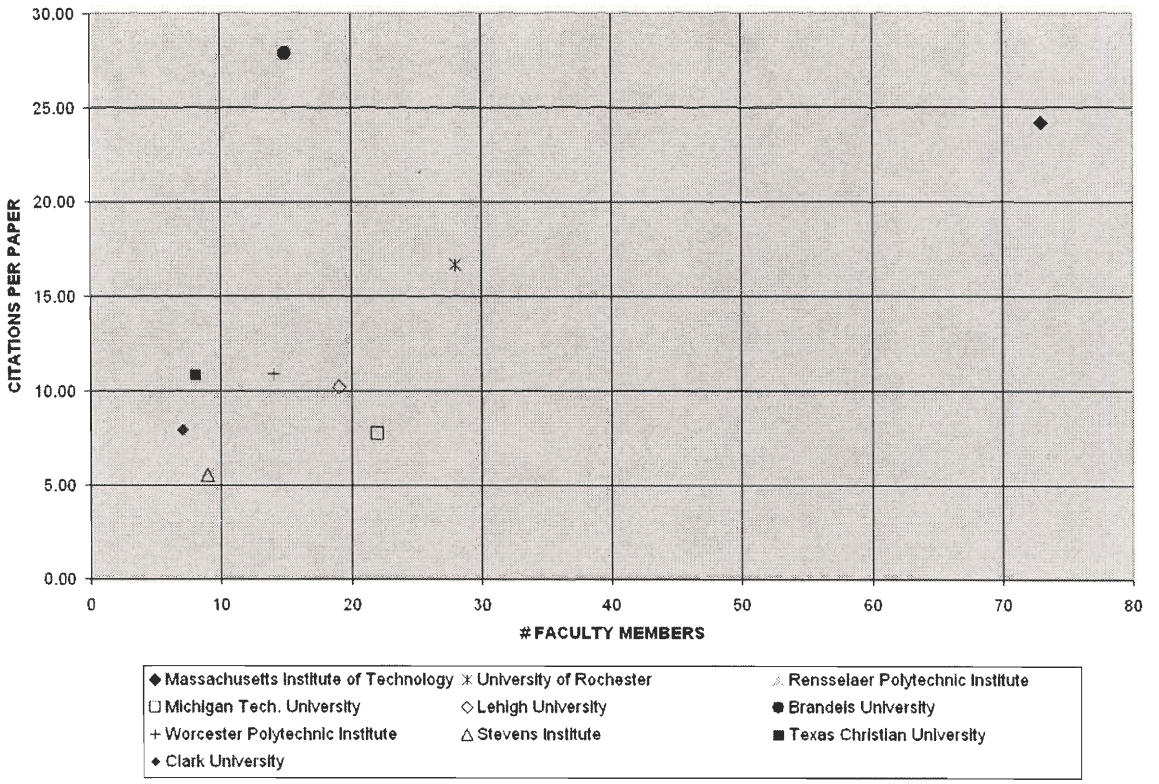


Figure 4.8 shows the number of papers published after 1999 compared with the number of physics faculty members. The number of papers published after 1999 are represented in the vertical axis and the number of faculty members is located in the horizontal axis. There is a direct relationship between the number of published papers and the number of faculty. As the number of faculty increases, the number of papers published after 1999 increases as well. MIT has published the most papers after 1999. Four schools have published between 10 and 100 papers after 1999 and five schools have published between 100 and 1000 papers in the same time period.

FIGURE 4.8

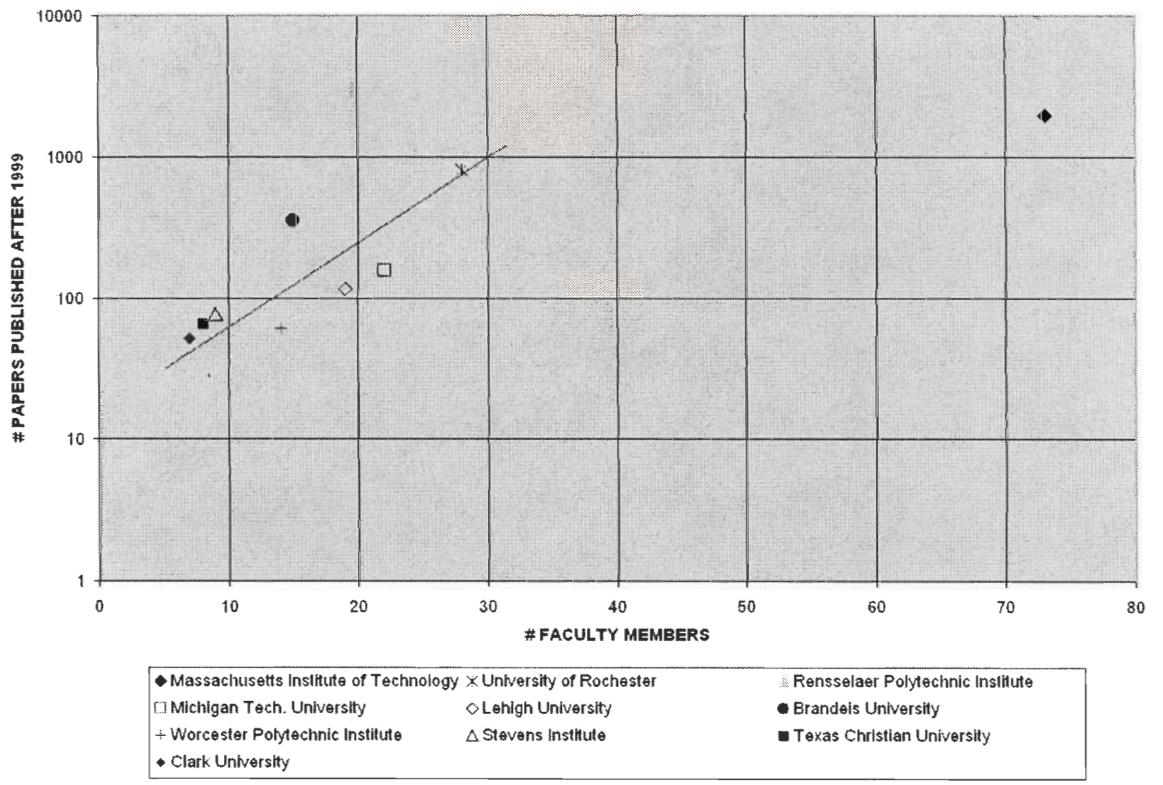
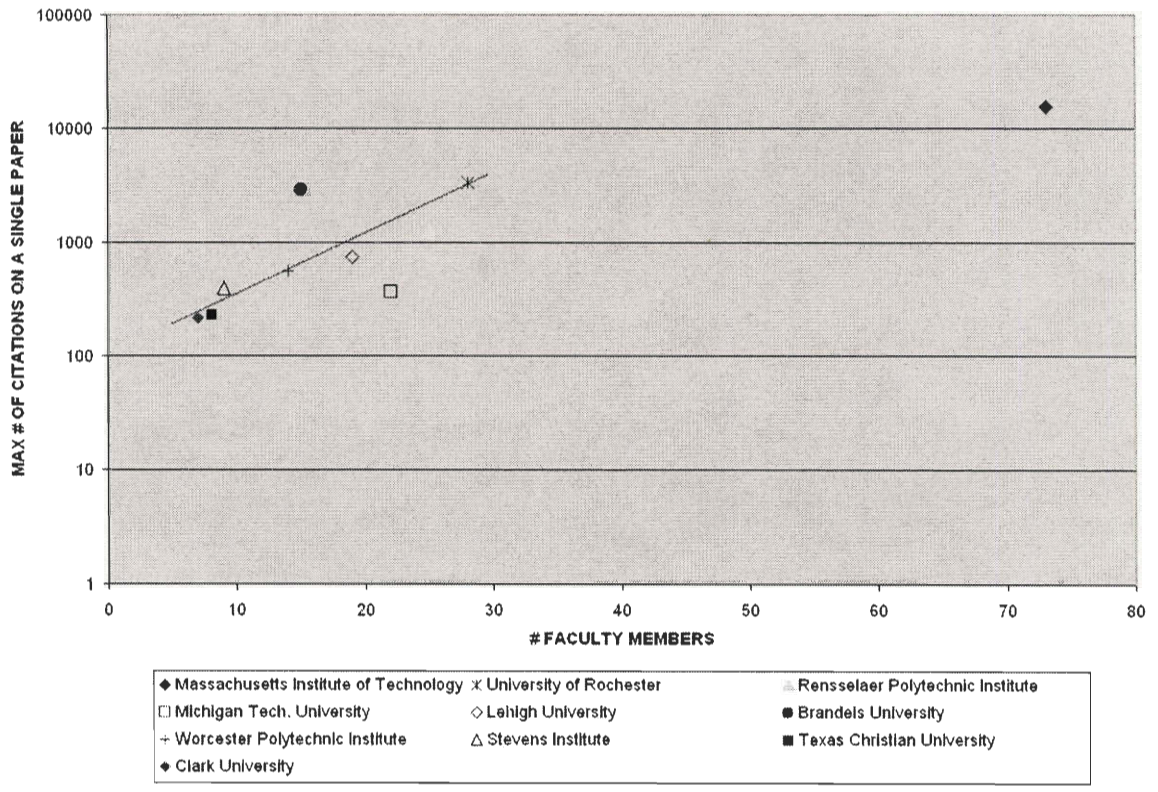


Figure 4.9 (next page) shows the representation of the maximum number of citations on a single publication compared with the number of faculty members. The

maximum number of papers is located in the vertical axis and the number of faculty members is listed in the horizontal axis. MIT has the faculty member who has published the paper that received the most citations. The maximum number of citations on a single paper increases as the number of faculty members increase. The faculty members who have received a large maximum number of citations have a high contribution towards the total number of citations and also increase the number of citations per paper. For example, Brandeis University has less than 20 faculty members but has a maximum number of citations on a single paper much larger than other schools with a much larger number of faculty members.

FIGURE 4.9



CONCLUSIONS

There are five important factors that need to be studied when analyzing the quality of a physics program. This report analyzed the number of papers published after 1990, number of citations, number of citations per paper, number of papers published after 1999 and maximum number of citations on a single publication. All this data was then compared with the number of physics faculty members at each school.

The number of papers published after 1990 and the number of papers published after 1999 have a direct correlation with the number of faculty members. The distribution of the number of published papers increases as the number of faculty members increase. The Massachusetts Institute of Technology physics faculty members published the most papers since 1990.

The number of citations has a direct relationship with the number of published papers. The number of citations increases as the number of papers increase. Therefore, the number of citations is also directly related to the number of faculty members. The physics faculty members from MIT have received the largest number of citations.

The number of citations per paper has a small correlation with the size of the faculty. The MIT physics faculty members have published the most papers and have received the largest number of citations. But the faculty members from Brandeis have the largest number of citations per paper.

Finally, the maximum number of citations on a single paper has a correlation with the total number of papers and with the number of citations. MIT has the faculty member that published the paper with the largest maximum number of citations.

In conclusion the only factor that measures the quality of a physics department analyzed in this report is the number of citations per paper. The quality of a physics program does not depend merely on the number of faculty members but the size of the faculty does have a deep impact in the quality analysis. For example, the number of published papers increases exponentially as the number of faculty members increases. The quality is based on the frequency of publication and on the importance of each published paper.