A Comparative Analysis of Engineering Research Expenditures in Selected Big 12 Universities

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Abstract

A comparative analysis of engineering annual research expenditures for four selected Big 12 universities, over a seven year period (2001 – 2007), is reported. The four universities selected for this study are: University of Oklahoma (OU), Oklahoma State University (OSU), University of Colorado at Boulder (UC), and University of Texas at Austin (UT). The American Society of Engineering Education (ASEE) public domain database is utilized as the source of data used in this study. In addition to a comparative analysis of the overall annual research expenditures of these schools, some program specific comparisons are made. Specifically, the following programs are considered: Aerospace and Mechanical Engineering, Chemical Engineering, Civil Engineering and Environmental Science, Electrical and Computer Engineering, Computer Science, and Industrial Engineering. In spite of steady increase in nation-wide competition for federal funding for engineering research, the Big 12 universities considered in this study have done fairly well in terms of annual research expenditures in engineering. In terms of overall annual research expenditures, UT dominated the group, followed by UC.

I. Introduction

U.S. research structure after World War II consists of three major components: industry, academia, and government. Since the initial phase of Industrial Revolution, the nation's economic development is believed to be closely tied to scientific research, technological innovations, and practical implementations of novel ideas[1, 2]. According to Popper and Wagner[3], daily life in the United States and other industrial nations is influenced by the investments in research and education, specifically in science and engineering related to such areas as transportation, telecommunications, food, health, and defense. Scientific innovations and research products aim to protect common people from fatal diseases, harsh working environment, and threats to lives and properties. For example, the revolution in medical research has led to better vaccinations against infectious diseases such as smallpox, tuberculosis, polio, diphtheria, cholera, and typhoid[4]. Life expectancy in the United States increased from 47.3 years[5] in 1900 to 77 years[6] in 1999. Medical research and technology, including advances in biomedical research, is believed to be an important element of the increased life expectancy[4].

According to a study by Scott et al.[7], the enhancement of returns on investment (ROI) for publicly funded research and development (R&D) range from 20% to 67% depending upon the area[7] (engineering, agriculture and pharmaceuticals, etc.). A recent study on "social rates of return"[8] indicates that graduates from a single university in the United States established 4,000 companies, created 1.1 million jobs across the world, and generated annual sales of $232 billion[9]. The tremendous influence of scientific and engineering research, including university-based research, towards homeland security is demonstrated by the Hart-Rudman Commission[10], and the Department of Defense report[1, 2].

One of the key elements of university-based R&D is its doctoral students and post-doctoral researchers. In 1975, 59% of the world's total doctoral degrees in science and engineering were granted in the United States. By 2001 that share was reduced to 41%, whereas China's share grew by 12%[11]. The national debt of $8.9 trillion in 2007 due to continued budget deficit poses a serious problem for U.S. economy[12] and for university-based research. According to a recent survey by Concord Coalition[13], if the current economic trend continues, by the year 2020, interest payments on national debt and other expenses like Social Security, Medicare, and Medicaid would consume most of our national revenues. Under such a scenario, availability of federal funds for university-based research is expected to go down substantially. Changes in budgetary policies and priorities may be needed to retain the nation's lead in higher education and university-based cutting-edge research[16] while competing with other economically developed countries.

Federal Budget Scenarios

The federal government funding is the main source of support for science and engineering research[14, 15]. Out of the 700 laboratories that are funded directly by the federal government, about 100 are considered most significant investments in the nation's R&D[16]. The increase in total U.S. R&D budget from $70 billion in 1976 to $140 billion in 2008 is mainly influenced by the increment of defense R&D budget[17]. According to an AAAS report[18], legislative efforts are being made to boost federal support for basic research in the physical sciences (broadly defined to include engineering, computer sciences, and other disciplines, but narrowly defined as NSF, DOE Office of Science, and NIST laboratories) through the American Competitiveness Initiative (ACI) act. Although United States is still leading as the science and technology superpower in R&D investments, comparing the ratio of R&D to Gross Domestic Product (GDP) of other developed economies like European Union (EU), Korea, and China, the lead seems to be shrinking with time[24]. EU plans to use 3% of its GDP for research by 2010[24]. In recent years, R&D expenses in Korea have grown annually by 10%. Although the basic R&D is small compared to its GDP, China has shown significant increases in investment in these areas. With respect to university-based research in the U.S., competition for federal funds continue to increase steadily as more and more universities emphasize federally funded research.

Scope

In view of the aforementioned political, social and economic scenarios, it would be beneficial to study the recent changes in university annual research expenditures (ARE). To this end, this paper examines the changes in the engineering ARE for selected Big 12 universities. The following universities are included: University of Oklahoma (OU), Oklahoma State University (OSU), University of Colorado at Boulder (UC), and University of Texas at Austin (UT). Selection of these schools s based on several factors, including program size (faculty and student population), funding source (public vs private) and geographic location. Among the four universities selected, UT is the largest based on the faculty and student size, followed by UC. The other two schools (OU and OSU) are of similar size and representative of typical programs across the country. All the selected schools are public institutions. Data for this comparative study are obtained from the public domain database, ASEE web site[19]. The analysis is conducted under two major categories: (1) total distribution of ARE for selected engineering programs, and (2) overall ARE for the college. In spite of increased competition, overall the selected Big 12 universities have done fairly well in terms of annual research expenditures.

II. Total Research Expenditures Dynamics

The distribution of annual research expenditures (ARE) for the past seven years (2001 to 2007) for the selected schools is shown in Fig. 1. In terms of overall annual research expenditures, UT led the group, followed by UC. Following a decline in 2002 (the expenditures in 2002 was $24.7 million), UC maintained a fairly constant annual research expenditures of about $57 million for four years (2003 – 2006). In 2007, the annual expenditures dropped to approximately $51 million. Both OU and OSU maintained a more of progressive increase in research expenditures during the same period. Specifically, OU's annual research expenditures increased from about $10 million in 2001 to $22.7 million in 2007. During the same period, the OSU's annual expenditures increased from $12.8 million to $19.2 million. Among the four universities considered here, UT exhibited almost a 3-fold increase in its ARE, from $49.8 million in 2001 to $135.2 million in 2007.

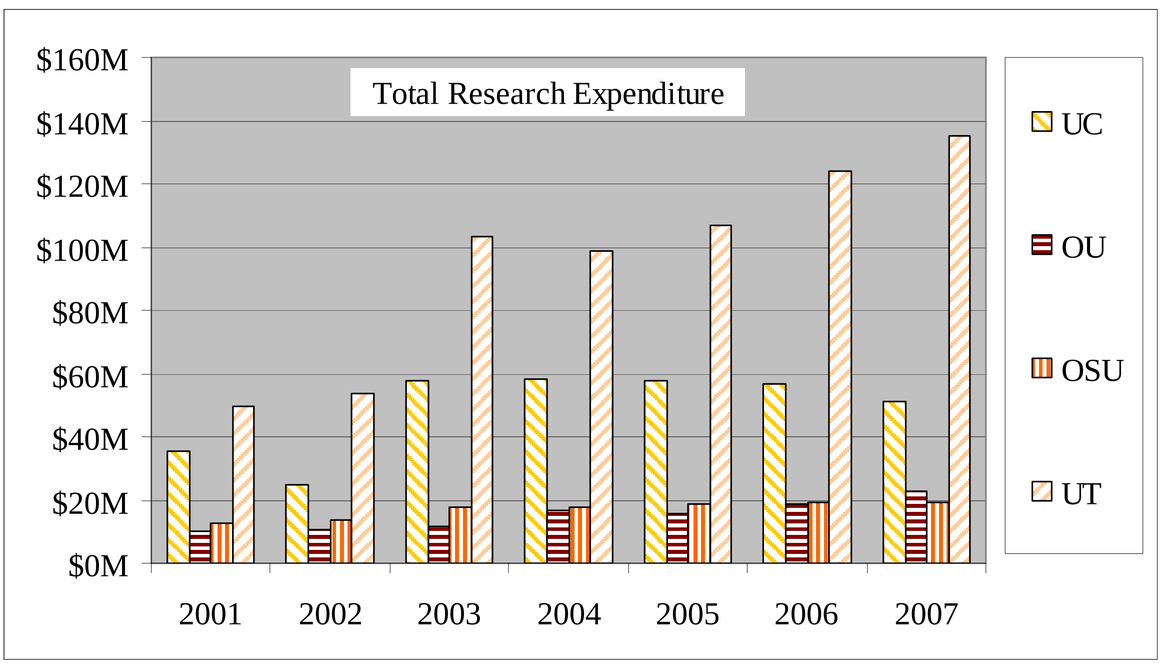

Fig. 1. Total R&D expenditures of four selected universities from 2001-2007.

In order to put these data in context, one needs to examine the ARE of each school in terms of faculty size and discipline. To this end, we have considered six selected engineering majors, namely: Aerospace and Mechanical Engineering (AME), Chemical Engineering (CE), Civil Engineering and Environmental Science (CEES), and Electrical and Computer Engineering (ECE) , Computer Science (CS), Industrial Engineering (IE), and a separate "Other" category.

The “Other” category of engineering research expenditures is obtained by subtracting the combined ARE of the selected six engineering majors from the total ARE of the college of engineering.

III. Distribution of Annual Research Expenditures by Disciplines

The annual research expenditures (ARE) dynamics for the Aerospace and Mechanical engineering (AME) discipline for the past seven years is shown in Fig. 2. For UC, this discipline appears to be the most productive discipline with respect to relative ARE. Specifically, the AME faculty and researchers generated 42.5% of the overall UC funding in 2003. The share reduced to 23.2% in 2002, but bounced back to about 35.4% for the past four years (2004 – 2007)[19]. Comparatively, the AME share of OU’s overall ARE exhibited a reduction from12.7% in 2001 to 9% in 2007. The OSU research expenditures for the AME program were fairly stable (~ $2.7 million/year) during those seven years. The AME program at UT, reported a steady increase in its ARE from $5.2 million in 2001 to $8.7 million in 2004. Following that period, research expenditures reduced to $7.8 million in 2005. The growth was reestablished during 2006 and 2007, reaching a level of $8.6 million per year.

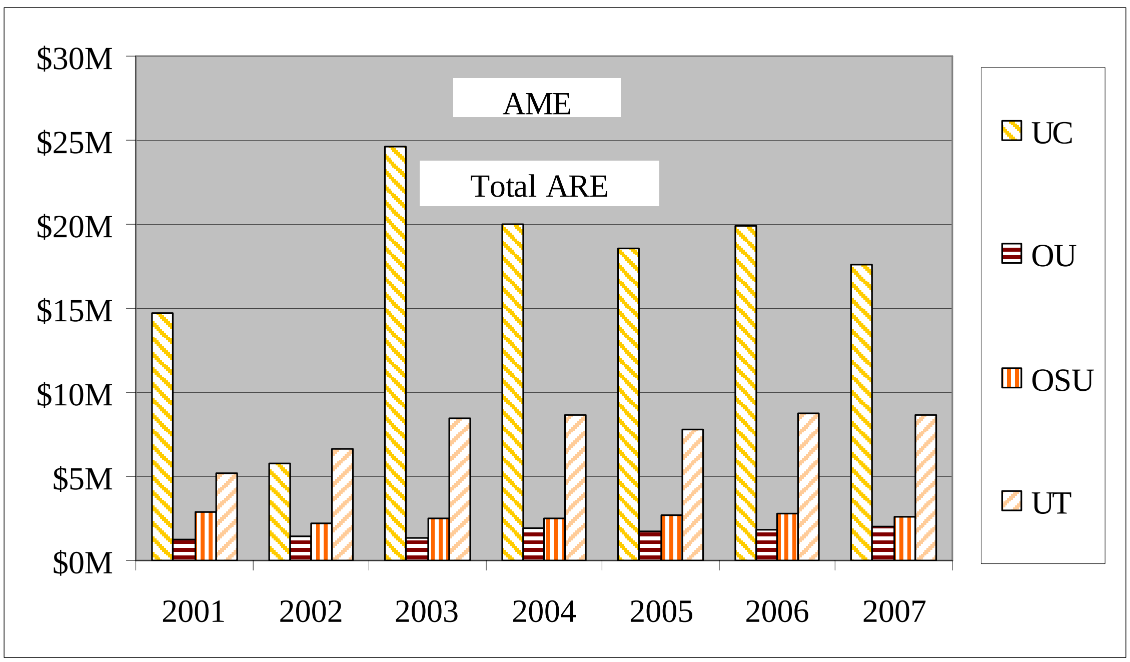

Fig. 2. R&D expenditures dynamics for AME of four Selected Universities from 2001-2007 based on total ARE.

The distribution of annual expenditures in Chemical Engineering (CE) for the past seven years for the selected schools is illustrated in Fig. 3. It is interesting to note that UC’s annual research expenditures of the CE program increased substantially from $3.4 million in 2001 to $12.9 million in 2007 (Fig. 3). The CE program at OU generated $1.5 million annually during 2001 - 2003. The ARE increased to $2.1 million in 2004 and remained fairly constant since then. Comparatively, the OSU’s annual research expenditures for this program reached a maximum of

~ $1 million in 2003 and then underwent a reduction in the following years, reaching the lowest level ($502K) in 2007. The CE program at UT, on the other hand, demonstrated a gradual increase in ARE from $5.5 million in 2001 to $9.7 million in 2005. Thereafter, the ARE reduced to ~ $7.7 million in 2006 and 2007.

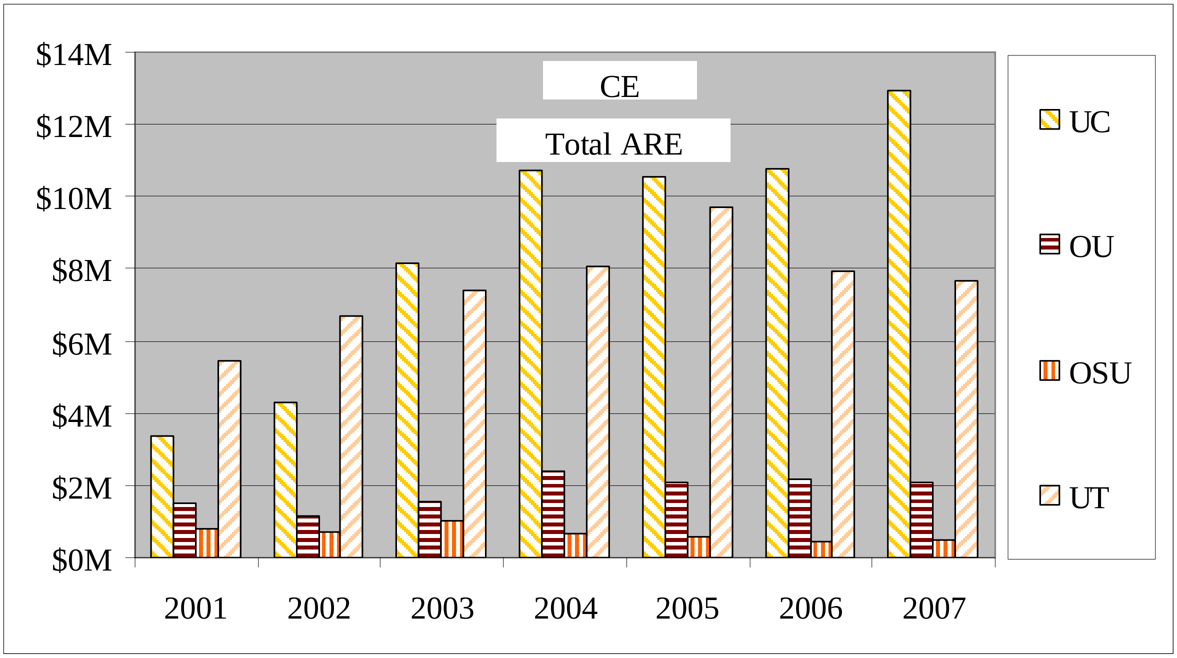

Fig. 3. R&D expenditures dynamics for CE of four Selected Universities from 2001-2007 based on total ARE.

From the ARE distribution dynamics in Fig. 4, it can be inferred that the annual research expenditures in Civil Engineering and Environmental Science (CEES) for UC reached a maximum of $8.6 million in 2003 from $6.7 million in 2001 after suffering a decline to $4.5 million in 2002. Then the ARE again increased to $7.6 million in 2005. In 2007, the ARE again fell to $5.5 million. On the other hand, OU's ARE in that major exhibited a consistent improvement during the reporting period. In particular, the ARE for CEES increased from $2.1 million in 2001 to $4.8 million in 2007. Comparatively, OSU had a gradual improvement in ARE for the CEES program for the same reporting period (from $334K in 2001 to $1.2 million in 2007). Comparatively, UT showed an evidence of steady rise, from $1.1 million in 2001 to $2.5 million in 2003. The ARE in the following year shrank to $1.4 million, and then improved steadily to $2.9 million in 2007.

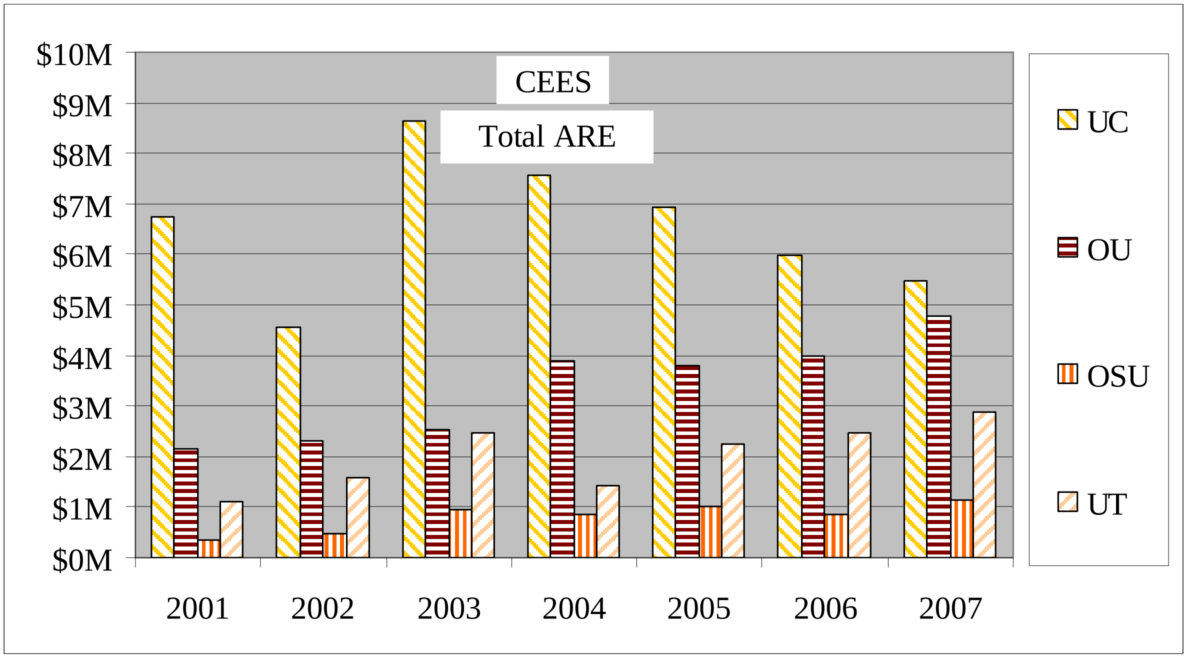

Fig. 4. R&D expenditures dynamics for CEES of four Selected Universities from 2001-2007 based on total ARE.

The distribution of annual expenditures in Computer Science (CS) for the past seven years for the selected schools is illustrated in Fig. 5. Amongst the four selected universities, OSU and UT do not have separate CS division in the college of engineering. It is interesting to note that the UC's annual research expenditures of the CS program fluctuated over the years. In 2002, UC reached an ARE level of $7.3 million, after a level of $4.5 million in 2001. In the following year the ARE reduced to $5.3 million per year, and again increased to around $10.8 million in 2004 and 2005. After that, the CS annual research expenditures steadily reduced to a level of $3.9 million in 2007. Comparatively, the OU's annual research expenditures for this program produced more or less a steady increase for the seven-year period. Specifically, the ARE was only $960K in 2001, which afterwards steadily increased to a level of $3.3 million in 2007.

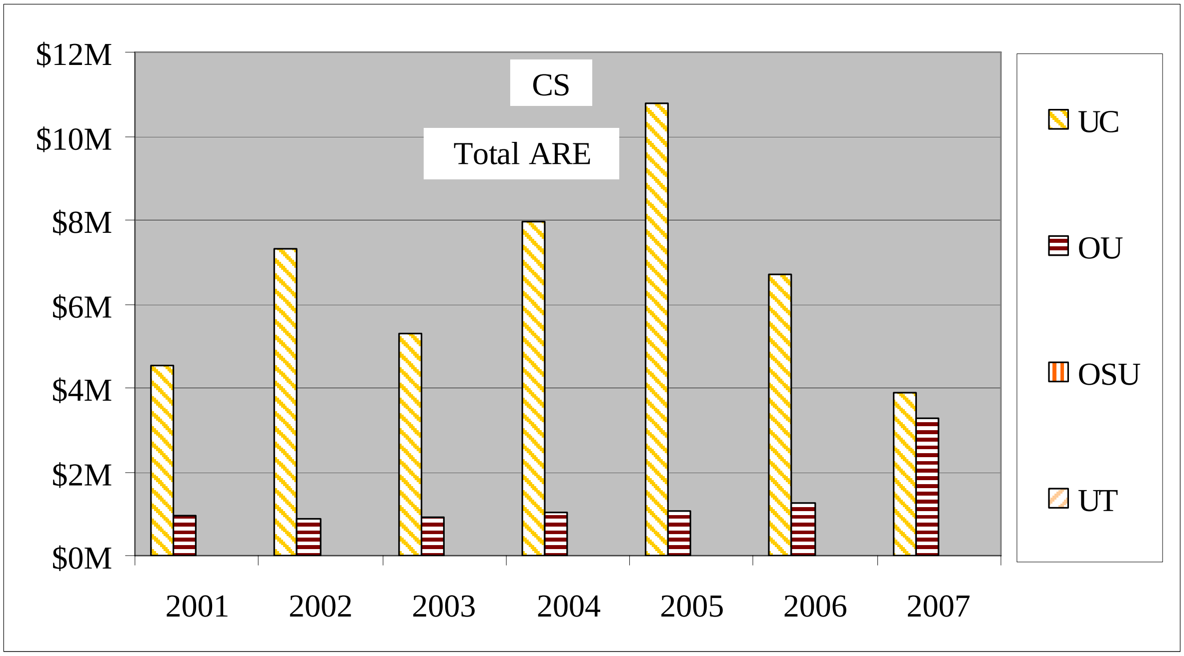

Fig. 5. R&D expenditures dynamics for CS of four Selected Universities from 2001-2007 based on total ARE.

The variation of Electrical and Computer Engineering (ECE) ARE for the past seven years (2001 to 2007) is shown in Fig. 6. It is seen that UC's ARE fluctuated during 2001 – 2002, and becoming fairly stable (~ $6.3 million to $7.2 million per year) over the next five years (2003 – 2007). The annual research expenditures of the ECE program at OU exhibited a consistent increase, by reaching a level of $5.9 million in 2007 after starting from $1.9 million in 2001. Comparatively, during the initial four years (from 2001 to 2004), OSU posted an increase from $1.5 million in 2001 to $2.9 million in 2004. Then it reduced during the next three years (2005 – 2007), reaching an annual level of $1.8 million in 2007. UT also followed a trend similar to OSU's research expenditures in ECE; the ARE underwent an increase from $3 million in 2001 to $5.6 million in 2004. During the following years, however, the ARE suffered a gradual reduction, reaching $3.9 million/year level in 2007.

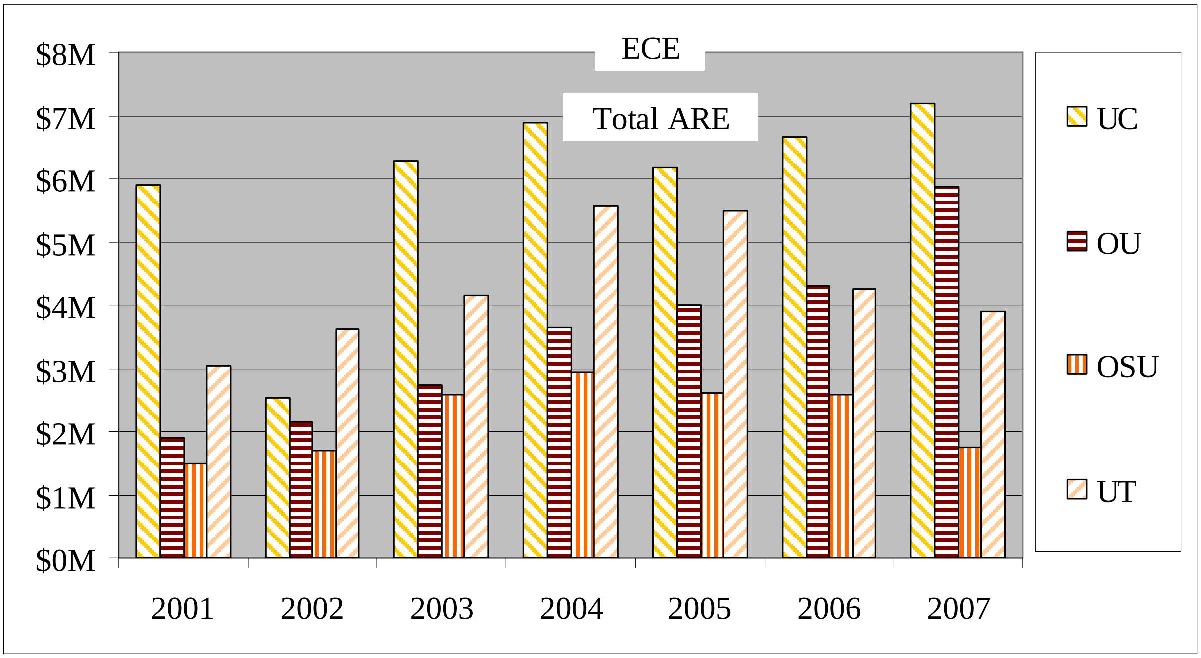

Fig. 6. R&D expenditures dynamics for ECE of four Selected Universities from 2001-2007 based on total ARE.

As in the case of CS, only two universities (namely OU and OSU) have separate Industrial Engineering (IE) schools in the college of engineering. From the ARE distribution dynamics in Fig. 7, it can be seen that the annual research expenditures in IE for OU reached a level of $2 million in 2007 from $1.1 million in 2001. However, the ARE for this major underwent a reduction to $1.3 million in 2005. Comparatively, OSU's annual research expenditures exhibited an improvement in the period 2001 - 2003 by reaching a level of $1.1 million in 2003 from $453K in 2001. However, in the following four years (2004 – 2007) the ARE underwent a gradual reduction to reach a level of $543.7K in 2007.

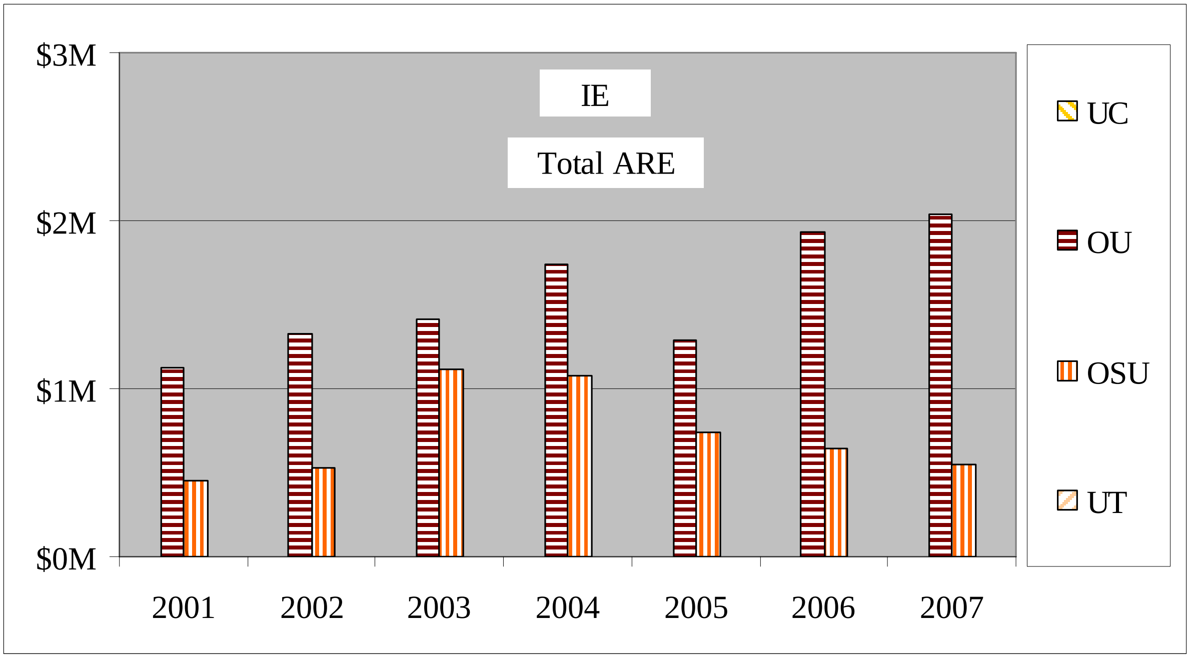

Fig. 7. R&D expenditures dynamics for IE of four Selected Universities from 2001-2007 based on total ARE.

The dynamics of annual research expenditures in the “Other” category for the past seven years is described in Fig. 8. UC has specifically four such “Other” categories of CoE funding sources namely Interdisciplinary Telecommunications Department (ITD), Engineering Administrative Dean’s Office (EADO), Engineering Management (EM), and university Research Centers (RC). Among these, the funding level for ITD was $425.8K in 2001. It reached a maximum level of $706.4K in 2006 and then reduced to a level of $44.1K in 2007. Comparatively, the ARE for EADO was $3.6 million in 2003 and it increased steadily to $6 million in 2006 and then reduced to $4.1 million in 2007. The EM contribution in this regard was $17.6K only for 2003. The ARE in the RC category reached a level of $764.6K and $837.6K in 2003 and 2004, respectively. Comparatively, three engineering programs at OU, namely Engineering Physics (EP), General Engineering (GE), and Petroleum and Geological Engineering (PGE), are considered in the “Other” category. Of these, the annual research expenditures of PE was $518.2K in 2004 and it increased to $1.1 million in 2007. GE’s part of the ARE was steady ($200K – $300K) during 2001-2005, and then dropped to $101K in 2006 and again increase to $733K in 2007. The PGE contribution reached a maximum level of $2.3 million in 2006 and then reduced to $822K in 2007. Comparatively OSU’s ARE in this area include contributions from Architecture and Architectural Engineering (AAE), Biosystems and Agricultural Engineering (BAE), and Research Centers (RC). The AAE’s part in the ARE was fairly constant (around $50K) during 2002 – 2007, after the level of $9K. The BAE’s share was $1.6 million in 2001, and it steadily increased to $3.9 million in 2007. The RC’s share reached a maximum level of $9.2 million in 2006 and then reduced to $8.7 million in 2007. The UT’s annual research expenditures generated from its Research Centers (RC), Biomedical Engineering (BE), and Petroleum and Geosystems Engineering (PGSE) were significant. For example, the RC’s contribution was $34.7 million in

2001 and in 2007 it reached $106.2 million. BE's contribution in ARE was around $4 - $5 million for the period 2002 – 2007.

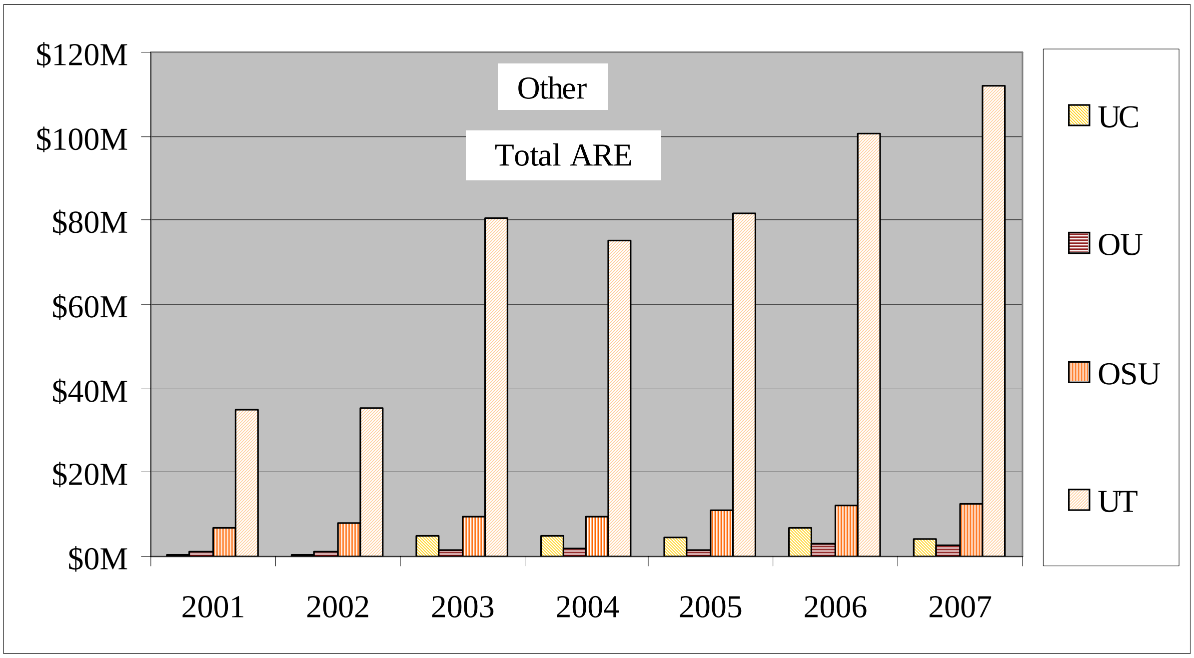

Fig. 8. R&D expenditures dynamics for "Other" of four Selected Universities from 2001-2007 based on total ARE.

IV. Concluding Remarks

This study illustrates the changes in engineering annual research expenditures of four selected Big 12 universities: University of Oklahoma (OU), Oklahoma State University (OSU), University of Colorado at Boulder (UC), and University of Texas at Austin (UT). The study is focused on two major categories: (1) total distribution of annual research expenditures (ARE) for selected programs, and (2) overall annual research expenditures for the college. The analysis for selected programs identifies research centers (RC) as an expenditure category used in different ways among the colleges. ARE for UT (and to a lesser degree, OSU) are concentrated in research centers. Despite steady increase in nation-wide competition for federal funding for engineering research, the Big 12 universities considered in this study have done fairly well in terms of the engineering ARE. In terms of overall research expenditures, UT dominated the group, followed by UC. Comparatively OU and OSU exhibited more of a steady improvement for the seven-year period (2001-2007) considered here. The annual research expenditures of UC's programs, in general, underwent a reduction in 2002 from its corresponding levels in 2001, except for Chemical Engineering (CE). For the remaining period (2003 – 2007), the Aerospace and Mechanical Engineering (AME) and Civil Engineering and Environmental Science (CEES) programs exhibited a steady decline, whereas the CE program showed a gradual increase and the Electrical and Computer Engineering (ECE) program remained relatively constant. OU's annual research expenditures exhibited a steady gain during the study period. The most significant increases are noted in the case of CEES and ECE. Comparatively, UT's annual research expenditures maintained a steady phase for AME. The CE and ECE programs are observed to reach a peak level in 2004 – 2005, and then reduced somewhat in the following years. The CEES program, however, after a decline in 2004 posted an increase in the following years.

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