# Assessing the performance of the CREWES Project: 1989-2005

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## ABSTRACT

We define an output metric for The CREWES Project that reflects our goal of educating students and engaging in geophysical research. To measure this, we assign weights to each of the elements we consider best reflect progress towards these. Graduates are weighted most heavily, field surveys and awards are the next most important indicators, followed by refereed papers and patents, and finally by research reports, software modules and conference presentations and citations of published work. We attempt to measure productivity by normalizing this output measure by personnel and by inflation adjusted revenue.

Over the project's 17-years revenue, personnel, and output have all steadily increased. Annualized increases in revenue and output are respectively 4.7% and 5.6%. The slightly slower growth in output is attributed to decreased financial support from the university. During this time, the number of people contributing to the project (faculty, staff, and students) has roughly tripled.


## INTRODUCTION

In the 2003 research report (Thurston and Stewart, 2003) we presented a measure for defining and measuring the output and productivity of The CREWES Project. These metrics capture the projects two main goals: to mentor and graduate well-educated students with practical experience, and to be a primary research and development leader in supplying new exploration ideas and recovery technologies.

We are trying to provide some guidance to our sponsoring organizations about the effectiveness of their support, and also provide an internal instrument to improve the Project.

In this paper, we review and update the measurements. This provides a 17-year record documenting relative performance by CREWES faculty, staff and students.

## DESIGNING A PERFORMANCE MEASURE

We attempt to measure elements of output that are proportional to the complementary goals of training and researching. We do this by assuming that productivity can be represented as a weighted sum of individual contributions to each (or both) of these goals. In the following, we describe our scheme for selecting and weighting these individual contributions.

Counting publications as a method for measuring research productivity was first suggested by Nobel Laureate William Shockley (Shockley, 1954). This was done as the basis for comparing productivity of individual scientists. Later studies noted that

publication counts are also a reliable metric for evaluating a research organization collectively (see e.g. Quinn, 1960, and Hodge, 1963). Thus, an important component of our performance measure is the number of publications, in which we include refereed journal papers, non-refereed papers, CREWES research reports, patents, and software distributed to sponsors. Each of these types of publications is weighted according to an estimate of its impact. The primary measure of educational output is the number of graduates. Additionally, there are two outputs that encompass both education and research. The first of these is data acquisition which typically involves student participation in survey design, acquisition, processing and interpretation, as well as some experimentation regarding sources, receivers and layout. The second of these is awards, which represents successful collaboration between students, staff, and faculty collaboration. We seek a quantitative indicator and suggest that output (education and research combined) might be measured as:

$$Output = 1.5 \times (N_{surveys\ shot} + N_{awards}) + 1 \times (N_{refereed\ publications} + N_{patents}) + 3 \times N_{students\ graduated} + 1/3 \times (N_{non\text{-}refereed\ publications} + N_{conference\ presentations} + N_{research\ reports} + N_{programs\ released}) + N_{citations}/5. \quad (1)$$

The weights are derived somewhat subjectively; however, it should be noted that this weighting scheme follows the NSERC framework for rating professional contributions (see e.g. www.nserc.ca/forms/instructions/100/080_e.asp), in which refereed publications, awards and training of highly qualified people are weighted heavily, followed by non-refereed publications, and other research contributions (e.g. software). The raw data used to compute the output measure (equation 1) are provided in the Appendix.

## RESULTS

The output measure (equation 1) was computed for every year that the project has been in existence (1989-2005). This is shown in Figure 1. There is a general increase in output with time, with an almost three-fold increase over the history of the project.

In addition to raw output, it is also useful to normalize the output to the input. The CREWES project has two important inputs. These are revenue and personnel. The personnel are subdivided into two groups, the workforce (comprising faculty members and staff) and students. These inputs are shown in Figure 2. The number of students is constrained by the number of available supervising professors. The number of CREWES faculty (university and adjunct professors) is limited by overall university and CREWES funding. Note that only cash contributions are counted as revenue. Non-cash contributions, such as software and data donations are excluded. As well, the revenue numbers have been adjusted for inflation using the Consumer Price Index.

Figure 2 further illustrates the declining revenues we have experienced since 1997. This reflects a general trend of consolidation in the industry and less spending on research (Thurston and Stewart, 2005). Solutions to this problematic funding trend are to increase fees and sponsorship levels.

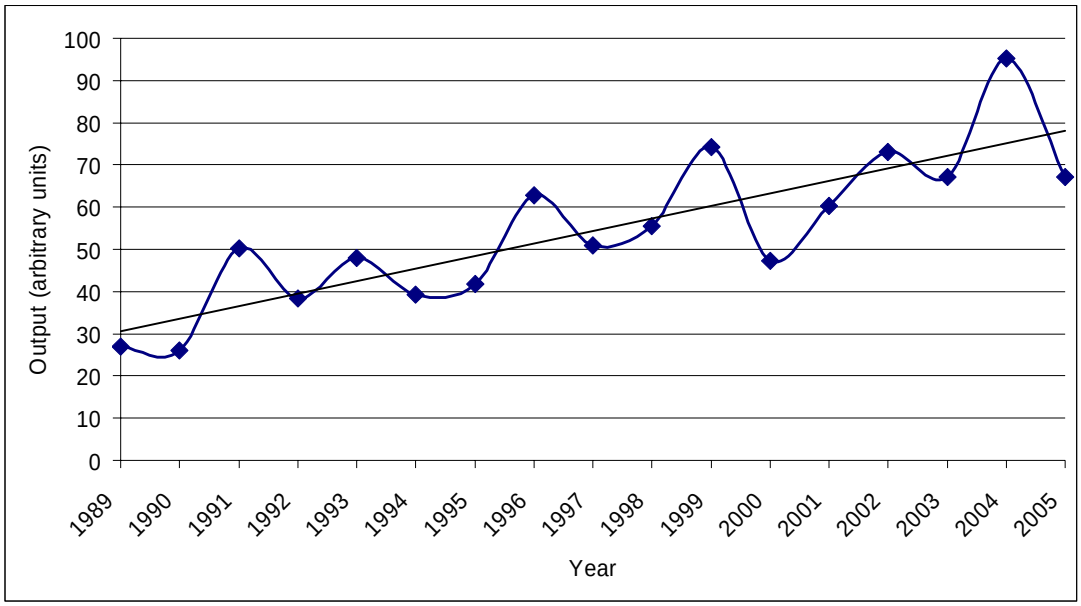



FIG. 1. Output by CREWES personnel over the lifetime of the project. The straight line is the least-squares best-fit. Output has grown ay an average annual rate of 5.6%.

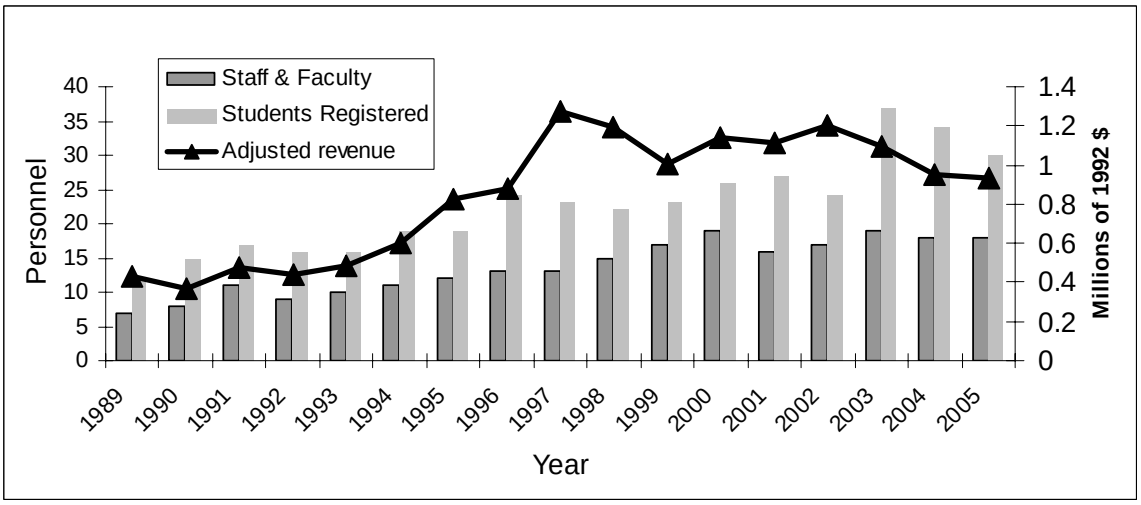


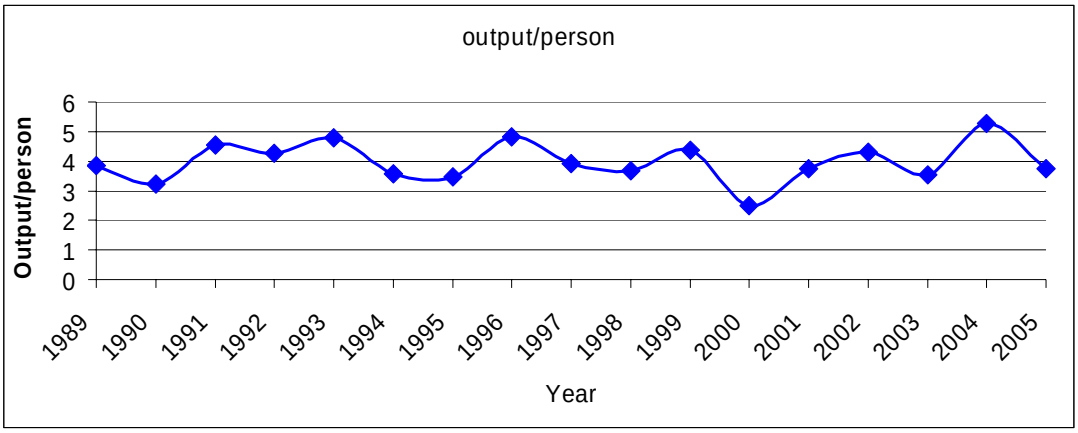

FIG. 2. Counts of personnel (staff and faculty) and students, overlain with inflation-adjusted revenue (revenue is inflation adjusted to 1992). Revenue has experienced real growth of 4.7%.

## Productivity

The ratios of outputs to inputs are useful for placing recent results in a historical context. It is also useful to illustrate how the consumption of resources (i.e. sponsorship revenue) has evolved over time.

The ratios shown in Figure 3 suggest that Project growth, with the attendant increased managerial demands on the directors, has not degraded productivity. In fact, it appears that faculty and staff have increased their productivity. On the other

hand, there may be a slight decrease in output/$ (Fig. 3). We attach this to the shift of costs from the University to funded projects (i.e. increasing tuition costs which must be borne by the Project, and by increasing overhead costs due to reduction on the University's operating expenditures). (Figure 5).



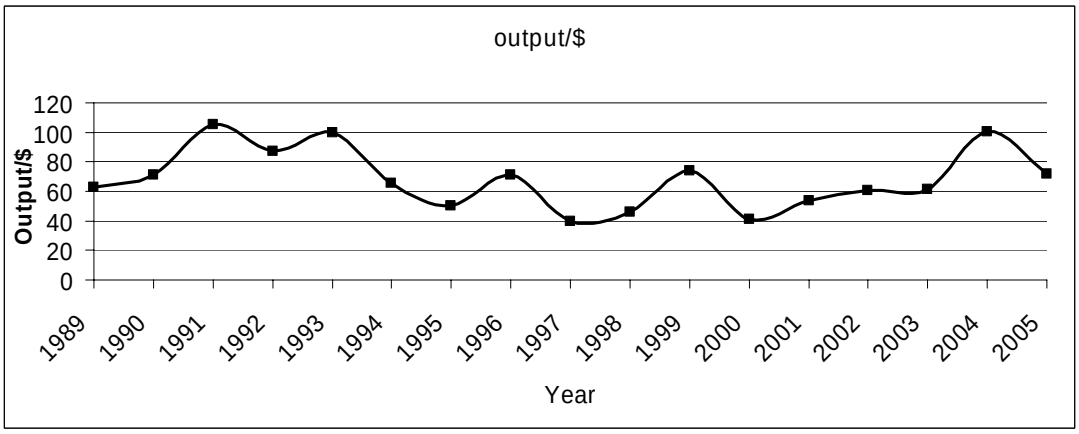




FIG. 3. a) Output normalized by personnel (staff and faculty) and b) by revenue (revenue is inflation adjusted to 1992).

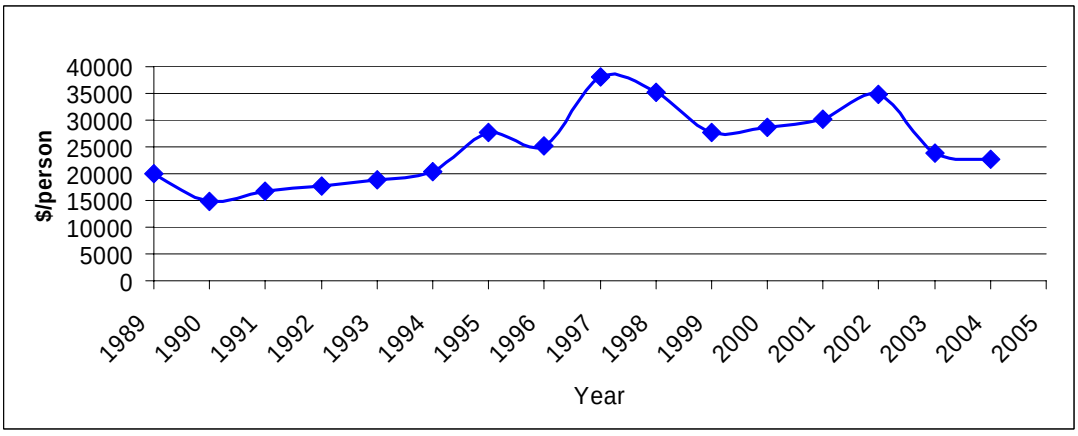



FIG. 4. Revenue (in 1992 $) on a per person (including staff students and faculty) basis.

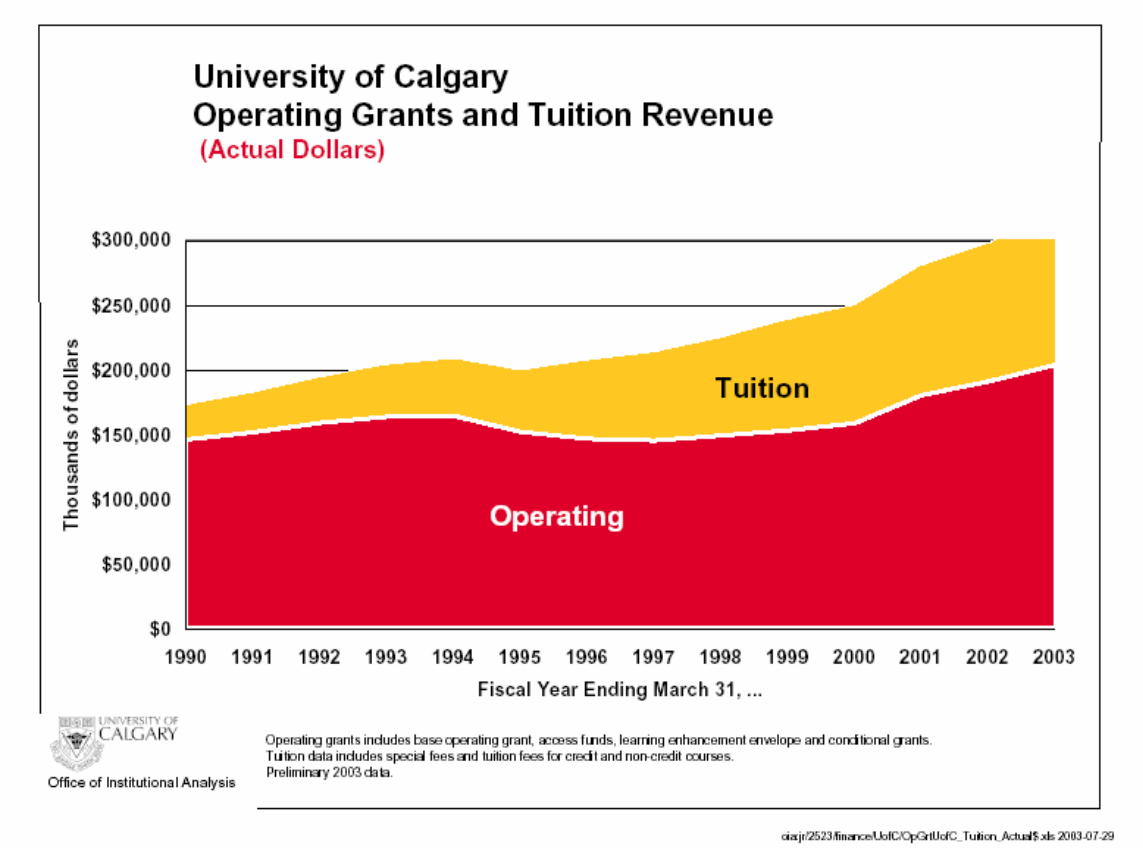



FIG. 5. University of Calgary operating grants and tuition revenue.

Another measure we have been looking at is the behavior of productivity with respect to the number of people. For instance, the output/person as a function of the number of people is shown in Figure 6. A positive slope suggests per person productivity increases as the size of the workforce increase. Likewise, a negative slope points towards a decrease as the project acquires additional personnel.

Figure 6 shows there is some fluctuation in productivity around the long term mean as the number of people changes; however in general there is no indication, from these data, that either growing or contracting the project will positively or negatively affect productivity.

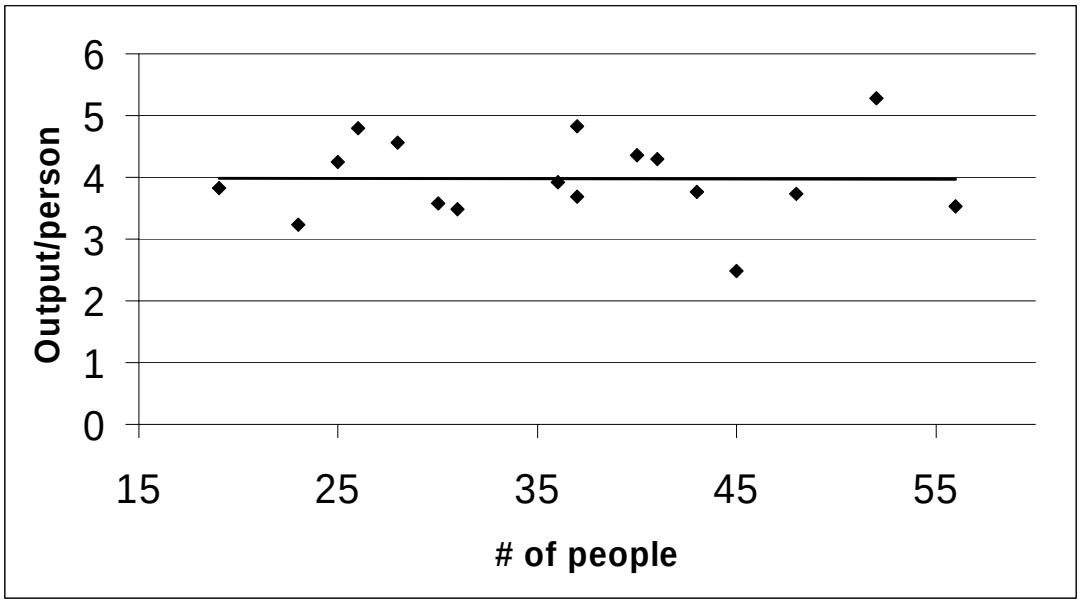



FIG. 6. The behavior of productivity with respect to the size of the project's workforce. Positive, negative, or zero slopes of this function indicate respectively that productivity improves, degrades, or is immune to the number of employees.

## A LOOK TO THE FUTURE

The breadth of research documented in this research volume has entailed an attendant increase in the complexity of the project's activities and operations. In order to maintain our productivity levels we seek greater efficiencies in report production and organization. Of concern has been the recent loss of faculty to retirement and job changes.

## SUMMARY

Performance measurements are a useful tool for evaluating the performance of an organization (vis-a-vis desired goals), and for encouraging desired results. CREWES has a two-fold mandate to educate students, and to undertake meaningful research. Thus, we have developed a performance measurement that incorporates these two aims. Research results are evaluated primarily on the basis of publication counts, as documented studies of research organizations indicate that this can be a reliable indicator of output.

Our analysis indicates the CREWES Project is succeeding in its mandate to produce research results and to educate students. Additional analysis of revenue growth suggests that diffusion of CREWES technology has followed a pattern typical for new technology offerings in the marketplace. Further, output has risen steadily over the lifetime of the project, and productivity has seen an increase.

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