The Importance to Economic Development of Improved University-Industry Engagement in Research and Professional Education

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Abstract

The key to the strength of the U.S. economy has been industry's ability to capitalize on technological innovation. At American research universities, an inherent objective of Ph.D. programs in engineering is innovation related to new or existing technologies. Despite such an obvious mutuality of interest, industry has typically not looked to universities to fulfill its applied research needs. This paper examines some of the reasons behind this condition, including the continued emphasis some universities place on traditional Ph.D. programs that are geared to the preparation of students for faculty positions rather than entry into industrial careers. The economic downturn has forced industry to cut back on internal R&D expenditures, making it even more important to find ways of encouraging industry to partner with academe to help meet the continuing need for technological innovation. This paper focuses on some new developments in engineering doctoral education that meet this need while continuing to satisfy academic program requirements. The new approach calls for a systemic change that will couple the resources of research universities and industry in a cooperative effort to produce the technological innovation that supports the continued growth of the economy.

Introduction

In June 1999, Federal Reserve Chairman Alan Greenspan appeared before the Joint Economic Committee of Congress and stated that “something special has happened to the American economy in recent years. An economy that twenty years ago seemed to have seen its better days, is displaying a remarkable run of economic growth that appears to have its roots in ongoing advances in technology.”

Just several days before Mr. Greenspan’s appearance, the U.S. Department of Commerce issued a statement noting that although the information technology industry accounts for only about 8
percent of the U.S. gross domestic product, it generated more than one-third of the nation’s economic growth from 1995 to 1998 \(^1\).

One of the primary sources of economic growth lies in the creation of new products and processes. The innovation of new products is built upon technological advances that stem from basic and applied scientific research. It is this connection between R&D and the economy that provides a common bond of interest between universities and industry. Universities not only directly contribute to basic scientific knowledge, but also supply industry with the human talent necessary to take innovative concepts and turn them into practical and profitable products.

This paper examines the current state of the interaction between industry and the university with regard to its effect on technological innovation and identifies some of the factors that encourage that cooperation and others that impede it.

The Changing Role of the University

In the introduction to “Capitalizing Knowledge”, the editors H. Etzkowitz, A. Webster, and P. Healy \(^2\), in addressing industrial/academic relations, state that: “The knowledge flows thesis is based on the assumption of a linear model, with a one-way flow from basic research to innovation. Alternatively, a spiral model has been suggested with a reverse flow from industry to academia, as well. Such an iterative effect, in which industrial innovation opens up new basic research questions, suggests that academic involvement in industrial innovation enhances the performance of basic research.” They go on to point out that a third player in the innovation system, government, encourages universities to contribute to regional and national economic development, resulting in a triumvirate of interaction that defines a new model that they refer to as “the triple helix”.

One point brought out clearly by the book’s contributors is that the roles played by industry, government, and academe in technology development have not only changed, but have become more complex. Industry has developed educational programs to train their employees in skills that directly impact their job responsibilities, universities have placed more emphasis on the generation and capitalization of intellectual property rights, and government has encouraged industry-academic partnerships that are intended to address the needs of local and national economies.

The ability of research universities to commercialize new developments through technology transfer has shown a significant increase. This point is addressed in a brochure prepared by the Technology Transfer and Research Ethics Committee of the Council on Governmental Relations (COGR) \(^3\). It states that: “The university sector has been highly successful in its technology transfer efforts since it was given the right to own and license university inventions under the Bayh-Dole Act in 1980. Prior to 1980 when university patents were generally owned by the federal government, no more than 10% of those patents were licensed to industry for commercialization. Data for FY98 on university licensing activities show that universities are filing in excess of 4,000 patent applications a year and issuing more than 3,500 licenses or options to license annually. Trend data show a cumulative total of licenses and options issued since 1991 standing at over 20,000 and that the percentage of licensing activity has doubled.
between 1991 and 1998. It goes on to make the point that “Recent data and the application of impact models show a return to the U.S. government and the national economy from university licensing of $33.7 billion, and supported 280,000 jobs during the university fiscal year ending June 30, 1999.”

University Support

The total support for R&D expenditures in U.S. universities is reflective of the industry/academe/government partnership. The greatest contributors to this support are the federal government, state and local governments, industry, and the institutions themselves (Source: National Science Foundation, 1999). The total expenditures from all sources compared to that supplied by industry alone for the last two ten year periods for which data is available are given as follows:

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Support*</th>
<th>Industry Support*</th>
<th>Industry Percentage of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1979</td>
<td>5,366,105</td>
<td>193,214</td>
<td>3.6</td>
</tr>
<tr>
<td>1989</td>
<td>14,976,508</td>
<td>993,715</td>
<td>6.6</td>
</tr>
<tr>
<td>1999</td>
<td>27,489,061</td>
<td>2,047,722</td>
<td>7.4</td>
</tr>
</tbody>
</table>

* In thousands of dollars

While the percentage of total support provided by industry is modest, it nevertheless shows a steady increase in last two decades, more than doubling over that time span. This is indicative not only of an expanding level of cooperation between the university and industry, but also of an increased awareness by industry of the value of such partnerships. Perhaps this is an indicator of the expanding role of universities in contributing to technological advancement and economic development.

How to Encourage Industry -University Partnerships

Given the potential gain to be realized by encouraging cooperative efforts between industry and the university, it is instructive to examine the factors that either contribute to or impede partnering activities.

A survey was taken of 64 firms that have significant interaction with university faculty. Citing about 320 researchers whose work in the 70s and 80s contributed most significantly to the firm’s new product and process development, the respondents listed the following factors as important to that success:

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• quality of the faculty;
• scale of activities in a relevant area - a critical mass of researchers and equipment is regarded as essential to achieve high productivity in particular aspects of academic research;
• geographical proximity.

In an NSF workshop discussing the international reform of graduate education, the participants brought up the following concerns:

• making doctoral training relevant to a wider range of occupations than just academic careers;
• graduate programs [are] too long, too narrow, and too campus-centered;
• doctoral training (previously focused on specialized research) [should] be broadened in a variety of ways. These include doctoral programs providing off-campus internships, opportunities for interdisciplinary research experience, teaching and mentoring skills, complementary course work, and awareness of changing career opportunities and emerging employment categories.

The following concerns of industry also need to be considered:

• secrecy;
• control of intellectual property;
• timeliness of technological development.

Universities, too, have interests that in some cases impede industrial partnerships. These include:

• retention of intellectual property rights;
• encouragement of entrepreneurial efforts;
• maintenance of traditional academic standards.

The following concerns of the faculty members themselves must also be addressed:

• need to publish research results;
• the increase of stature and standing in their field;
• development of funding sources;
• need to keep abreast of recent technological advances.

Finally, another stakeholder not often mentioned is the graduate student. Ph.D. programs are typically structured to prepare graduates to enter an academic career. However, this objective does not meet the needs of the majority of graduate students in engineering. Data published by the National Science Foundation show that in the year 2000 there were 5,330 engineering doctorates were awarded by universities in the U.S. Of these, a total of 2,556 were awarded to U.S. citizens or non-U.S. citizens with permanent visas. A survey of the latter group of graduates that focused on their plans after graduation showed that 14.4% of the total wanted to pursue academic careers while 49.9% planned for employment in industry. Thus, an educational program that includes partnering with industry would better meet the needs of one-half of the doctoral students in the study group. One can only speculate on the effect that such a program
would have on the total number of students interested in entering an engineering doctoral program.

Future Potential

A surprising outcome of a study by Mansfield of firms that account for about 15 percent of the total R&D expenditures in the chemical, computer, petroleum, and pharmaceutical industries showed that “…while university departments with highly rated faculties are more likely to receive industry support than those with lower rated faculties, the differences frequently are not large, and a substantial proportion of the academic research findings that industry regarded as most important in the 1980s came from modestly rated departments.” He goes on to point out that “a wide range of colleges and universities, not just the prestigious ones, play an important role in fostering industrial innovation.”

If this outcome is typical of all technologically oriented industries, it bodes well for that majority of U.S. engineering universities not included in the Carnegie Foundation’s Research I category. More importantly, it represents a significant resource that could make a substantial contribution to national and local economic development.

Conclusions

Engineering universities in the U.S. have begun to change from predominantly upstream, basic research oriented institutions to interactive partners with industry and government as contributors to U.S. economic development based upon technological innovation. This change in the role of universities requires an examination of the content and process of graduate education. The traditional doctoral training geared to the preparation of students for faculty positions does not meet the needs of the majority of participants, their future employers, or national goals. A broader program that includes interaction with industrial partners, fundamental research driven by identified needs, and experience in the technical and economic aspects of innovative product design would be a valuable supplement to these existing programs.

The current structure must also be examined from the point of view of the future needs of the university itself. Adaptation may be a necessary step to the future growth of the university by stimulating increased enrollment, increasing revenue through research and commercialization of intellectual property, and, perhaps most importantly, contributing to local and national economic growth.

Bibliography


5. Ibid. Survey Table S-12.


8. NSF Workshop on Graduate Education Reform in Europe, Asia, and the Americas, Division of Science Resources, National Science Foundation, Nov. 17, 1998.

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