U.S. Universities and Industry's Human Resource Needs

A Report to NEDO

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PREFACE

The study underlying this report was commissioned by the Washington, D.C., office of Japan's New Energy and Industrial Technology Development Organization (NEDO).

The report's authors, working together as the firm of Technology Policy International, LLC (TPI), have undertaken the study as independent consultants, although it should be noted that each has other professional affiliations and activities (see "About the Authors"). The opinions expressed in this report do not necessarily reflect the views of NEDO or the institutions with which the authors are affiliated.

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Introduction

This report addresses two principal questions:

1. Are there significant gaps between the human resource needs of U.S. industry and the graduates of U.S. universities[1]?
2. What mechanisms are used in the United States to close such gaps as may exist?

We address the question of whether there is a gap by, first, seeking to define what a "gap" might mean and, second, noting the evident resources being devoted to closing such gaps.

Discussions of gaps between the graduates of higher education and the needs of industry typically address four issues:

1. Are there enough graduates of higher education institutions to meet industry's quantitative needs?
2. Do the graduates have the skills needed to meet industry's needs?
3. Are the graduates of sufficiently high quality to meet needs of industrial employers?
4. Do jobs in industry offer sufficient challenges, opportunities, and compensation to attract and retain graduates from higher educational institutions?

That is, to consider the alleged gaps thoroughly, one must consider the number, the skills, the quality, and the expectations of university graduates.

Representatives of industry in the United States have repeatedly called on universities to "do something" to close what they assert are gaps between their needs and the graduates available to them. Generally, university leaders have embraced this challenge enthusiastically and have looked for ways to meet industry's expectations.

Less frequently, calls have been heard from some university leaders for industry to make itself more attractive to recent graduates by, for example, improving working conditions or offering greater opportunities for advancement or raising salaries. In the public sphere, at least, industry has not evinced the same enthusiasm for change as shown by academia.

The main part of this report is devoted to discussing responses by universities to the perceived gaps.

This report is based heavily on contemporary literature regarding the adequacy of highly-educated human resources for American industry. [2] It also reflects the authors' many years working in higher

[1] Throughout this report, we use the term "universities" to include all higher education institutions that offer bachelors or higher degrees, including colleges, universities, institutes of technology, and schools. We do this for convenience to avoid repeated use of the cumbersome phrase, "higher education institutions." Where it is important to distinguish between these categories of institutions, the differences will be made explicit.

[2] Appendix A provides a list of recent studies and reports that assert that there are important gaps between the supply of qualified workers with university-level education and the needs of industry, as well as studies that raise serious questions about the reality of the claimed gaps.

education and related fields where they have first-hand experience with programs intended to better meet the needs of industry.

The report begins with a brief overview of the nature of the various gaps. It turns next to a discussion of higher education in the United States, highlighting the flexibility and dynamism of the higher education system and its implications for how students are prepared to meet industry needs. Then the report analyzes an array of both formal and informal mechanisms that play roles in helping to address the gaps between graduates and industry needs.

The Nature of the Gap(s) Between University Graduates and Industry Needs

All too often, the public debate about the alleged gaps is overly focused on whether the number of graduates is high enough, which naturally leads to prescriptions for increasing the number of such graduates. To a lesser extent, the discussion focuses on whether the students have the right skills. A few analysts have offered data that suggest that the gap may actually reflect a shift in where the very best students choose to work. And, on occasion, attention is paid to whether industrial jobs are seen as desirable by recent graduates.

The discussion about the numbers and skills of graduates typically addresses whether enough young people are choosing professions of interest to industrial employers, especially those professions that build skills in the "STEM" fields (science, technology, engineering and mathematics). More recently, increased attention is being paid to whether university graduates have the "soft" skills needed to succeed in industry, such as the ability to write and speak correctly, clearly and convincingly; the capacity to work in teams and groups across disciplinary and functional lines; the human skills to work effectively in organizations; the judgment to make good decisions; the focus to carry out projects to completion; and the ability to lead and inspire others.

The question of whether graduates who are interested in industrial careers are of sufficiently high quality is an important and subtle issue. Some analysts have found that there is no shortage of STEM-trained scientists and engineers, but also that the very best graduates in these fields, as measured by academic performance, have chosen careers outside the traditional areas of academia and industry and have opted instead for careers in such fields as finance, technology-based media services, and international business.

Along these same lines, it seems clear that the typical career pathways of recent university graduates are quite different from those followed by students a few decades ago. When today's generation of industrial leaders graduated from universities in the 1960s through the 1980s, many graduates—especially those with degrees in engineering and physical sciences—took jobs in large manufacturing firms in such functional areas as engineering support, manufacturing operations, research and development, and marketing. Very few graduates thought of starting their own companies fresh out of school or of joining new, technology-based firms as their first jobs. Today, however, many graduates with strong STEM preparation, as well as an increasing number with backgrounds in the liberal arts and humanities, look to small, entrepreneurial and/or hi-tech firms, often supported by venture capital. These graduates prefer the greater flexibility and autonomy of such companies and the opportunity, or at least the hope, of earning very high compensation packages if their employers, or their own firms,

"get lucky" in the marketplace and enjoy rapid growth with stock price appreciation and/or a lucrative acquisition event. While some large manufacturing firms have made efforts to match at least the working conditions, if not the financial promise, of the venture-capital funded start-up world, they find it difficult to compete with the romance of entrepreneurism and the lure of potentially lucrative stock options and ownership stakes.

The Evolving Roles of Universities in the United States

While preparing their graduates for jobs in industry is an important role for universities in the United States, it is only one of several important roles they play. In this section, we discuss these roles and how they have changed over time.

What is higher education?

For purposes of this report, we define higher education as the institutions and services provided to students who have completed studies at the K-12 level and who nearly all have an earned high school diploma. Higher education typically is offered in institutions that award degrees at the associates, bachelors, masters and/or doctoral levels. In this report, we exclude institutions that teach high school graduates specific skills and trades, such a vocational education, apprentice programs, certificates not associated with degrees, and other forms of post-secondary education not leading to formal academic degrees. We further limit most of the discussion to institutions that offer degrees at the bachelor's level and above, which we refer to for convenience as "universities."[3] Our definition of universities includes several thousand institutions which enroll millions of students and award millions of degrees each year.

Universities can be categorized in a variety of ways which we review next to show the great diversity of higher education institutions in the Unites States.

A primary distinction among institutions of higher education is between those that are owned by a government authority (the so-called "public" institutions") and those that are governed by a private entity (the "private institutions"). Public institutions are typically governed by a board of trustees appointed by a senior government official or elected by the people. Among the private institutions, the vast majority operate as non-profit charitable corporations that are chartered by the states and that enjoy certain advantages under the federal, state and local tax codes. These non-profit corporations are governed by self-renewing boards of trustees. A few privates are operated as profit-making institutions and seek to earn a profit on the services they offer. For historical reasons, quite a few private institutions are closely associated with or even governed by religious denominations, reflecting their historical establishment to prepare graduates for service as clergy or other staff members of the sponsoring denominations.

Another categorization is based on differentiating institutions by the level of the degrees they offer. So-called "community colleges" usually offer two-year, post-secondary education, leading to an "associates" degree. Some of their programs have a decidedly vocational character, whereas others are quite academic and are intended to prepare their graduates for admission as advanced undergraduates in four-year institutions. "Four year" colleges and universities offer programs leading to bachelor's

[3] See footnote number one.

degrees in variety of fields. "Comprehensive" colleges and universities offer bachelor's, master's, and doctoral degrees in a wide array of fields and specialties.

The designations of college, university, and institute also are used to categorize institutions, although the distinctions are not always sharp. Colleges are usually four-year institutions that offer the bachelor of arts degree. They usually focus on the liberal arts and humanities and often include the natural sciences but rarely engineering or business. Universities typically offer education at the bachelors, masters and doctoral levels, as well as in professional fields such as engineering, law and medicine. Institutes typically are focused in the sciences and engineering, although rarely exclusively so, and may offer only the bachelors or, in many cases, masters and doctoral degrees as well. Other designations appear in the names of some institutions, such as school or institution.

A somewhat less objective categorization is based on the institution's ambition for the geographic region it serves; that is, the scope of the region from which it expects to draw students and of employers whose needs it expects to meet. The scope at the lower end is for "local" institutions that tend to draw on and serve a single community or region of a few miles in extent. "Regional" institutions may seek to serve a part of a large state or perhaps portions of several contiguous states. "National" institutions seek to draw students from all across the country and to meet the needs of leading employers anywhere in the country. Increasingly, universities have ambitions to be international or even "global" in scope, drawing students and serving employers from all around the world.

Institutions are also categorized by the level and complexity of their engagement with research and scholarly inquiry. Some are devoted almost exclusively to teaching, whereas at the other extreme some are devoted almost exclusively to graduate education and research. The Carnegie Foundation for the Advancement of Teaching pioneered this sort of classification system in the early 1970s and it continues in use today.[4]

Finally, various efforts are made to categorize higher education institutions by various measures or indicators of quality. The best known of these is the annual rankings of higher education institutions in the United States by the news magazine, US News and World Report.[5] Perhaps better known internationally are the annual rankings by The Times Higher Education Supplement and by Shanghai Jiang-tao University and joined recently by a separate ranking initiative by US News and World Report.[6]

To reiterate, these categorizations of institutions illustrate the breadth and complexity of the higher education landscape in the United States.

Historical changes in the goals of higher education

There is a profound tension in U.S. higher education between two historical goals: preparation for life and preparation for a career.

By preparation for life is meant that the goal of a higher education institution should be to prepare its graduates to think critically and to engage fully with humanity's highest and best knowledge. In line with this goal, students should learn to think and reflect analytically and from a base of deep understanding about life's major and minor challenges. They should have a foundation of knowledge

[4] https://en.wikipedia.org/wiki/Carnegie_Classification_of_Institutions_of_Higher_Education
[5] http://colleges.usnews.rankingsandreviews.com/best-colleges
[6] https://www.insidehighered.com/quicktakes/2014/10/10/us-news-issue-new-global-university-rankings

about our culture and society—its history, its values, its contributions. They should develop a solid knowledge of themselves and their relationships to others as individuals, communities and society and should learn how to communicate clearly and empathically through the spoken and written word, as well as through imagery and emotion. Education toward such goals should emphasize mastering broad, fundamental knowledge of the arts and humanities. This approach represents the essence of a "liberal education."

The goal of higher education as preparation for a career is quite different. In line with this goal, students should learn bodies of specialized knowledge and analytical techniques. They should learn an array of skills specific to their expected career, as well as skills in working with individuals and groups of people in organizations, skills in problem solving, and methods for developing creative initiatives that can result in new ways and new contributions. Students in career-oriented educational activities should become expert in the norms and values of their chosen profession or field. In the contemporary globalized and information-saturated world, career-oriented students should also learn how to work effectively across cultures and languages and should develop competence in operating in the world of information technology.

Clearly, when industry asks higher education to produce students who can meet its staffing needs, it is usually thinking about higher education in terms of its role in helping students prepare for success in a career. Potential employers want to know that new graduates have analytical skills, bodies of knowledge, and social attitudes that will enable them to work harmoniously in large market-oriented organizations.

It is important to recognize that industry is not always looking for highly-skilled, technically-proficient team players. It has long been recognized that individuals who rise to senior positions in industry are often those whose education combined aspects related to both goals as stated above. Increasingly, there is evidence that established industrial firms have come to realize that a liberal education is often a strong asset among those who offer both managerial and substantive leadership to the firm.[7]

Nevertheless, much of the debate in the United States about the gap between higher education and industrial need has its origins in the conviction that U.S. industrial firms are unable to hire enough recent graduates who have been prepared appropriately for successful careers in industry.

Long-term trends in societal expectations from higher education

The expectations of higher education institutions have changed greatly since the founding of the very first such institution in what became the United States; namely, Harvard, in 1636. In the very early days, colleges and universities were expected to serve the privileged classes and to produce graduates who could take up posts as members of the clergy or teachers and/or who could become world-wise leaders of the communities in which they lived. In the 19th century some institutions, especially the military academies, began to graduate men who would serve as military engineers or leaders of the newly emerging manufacturing and transport industries. The early 20th century saw a growing need for more educated persons to lead cultural institutions, enter the diplomatic services, practice science-based medicine or work in industrial laboratories. In the second half of the 20th century, a college or university degree became essential for those who worked as engineers, architects, managers of large companies,

[7] See, for example, Christopher T. Hill, "The Post-Scientific Society," Issues in Science and Technology, Fall 2007, pp. 78-84. http://issues.org/24-1/c_hill/

accountants, attorneys and in a wide range of other positions. In fact, a college degree, and often an advanced degree as well, became the *de facto* required credential for a host of middle management and service-oriented professions.

Throughout its nearly 400-year history, U.S. higher education have adapted to the needs of the rapidly developing and increasingly sophisticated American society and economy by creating new fields and new disciplines, and by teaching students what they need to know to be successful participants in their increasingly complex world. Thus, there is nothing new about demands for university graduates who can meet the needs of industry and other parts of society.

However, this constant evolution of the world of higher education was resisted at every stage. The introduction of each new domain of teaching and learning was opposed by those who had built the earlier versions of the institutions. At various points in time, many faculty and institutional leaders were opposed to adding such fields as engineering, animal husbandry, medicine, law, sociology, and business to the previously established traditional fields such as languages, history, classics, literature, philosophy, mathematics, and chemistry. One of the reasons for the great diversity of institutional types in American higher education is that new institutions were regularly established to accommodate to changing societal expectations.

The contemporary situation

Today, U.S. higher education is characterized by a very wide variety of institutions that, collectively, offer degrees in hundreds of discipline, fields, and professions. Nearly 5,000 higher education institutions[8] enroll more than 20 million students[9] and award more than 2 million degrees[10] each year. Almost no matter the specifics of their interests and no matter the level of their skills and capabilities, students can find a place to learn somewhere in the higher education system. They can also find institutions whose governing values align with theirs, whether they are secular humanists or are practitioners of main-line or non-traditional Protestant, Catholic, Jewish, Moslem or other faiths and value systems.

Diversity and Flexibility—The Hallmarks of U.S. Higher Education

In keeping with much of American culture, higher education in the United States is characterized by a high degree of diversity along many dimensions as well as by great flexibility, again along many dimensions. In this section, we comment on a few of these dimensions of diversity and flexibility, with a focus on how those dimensions condition the abilities of higher education to meet the ever-changing needs of industry for an educated work force.

Diversity of institutional types

We have already commented at length above on the great diversity of types of higher education institutions and on how this variety facilities students' searches for institutions that meet their needs.

Similarly, the diversity of institutional types facilitates more or less direct linkages between the organizations that hire graduates, including industry, and higher education institutions. Almost no matter the needs a firm has for specific skills or interests on the part of recent graduates, somewhere

[8] https://nces.ed.gov/fastfacts/display.asp?id=84
[9] http://nces.ed.gov/programs/digest/d13/tables/dt13_303.10.asp
[10] https://nces.ed.gov/programs/digest/d07/tables/dt07_258.asp

The Roles of Market Forces in Higher Education and Career Choice

Markets and market-like phenomena are omnipresent in U.S. higher education. Students compete for entrance to universities; universities compete for excellent students. Departments compete for students within institutions. Students choose majors, and within majors can often choose which professors to study with. Institutions compete to attract the best faculty members, who compete with each other for grants and recognition.

Upon graduation, students compete for available jobs and employers compete to hire the best students. Students choose from among available jobs based in part on salary offers, job location, the promise of interesting work, future prospects, and so on. Employers make job and salary offers to potential employees with awareness of what other employers may be offering. Students may decide to forego working for others and instead establish their own companies alone or in partnership, sometimes with financial support from other investors.

None of these markets are "perfect" in a technical sense. Information is always incomplete and often "asymmetric." Institutions and employers may collude to try to restrict student choice and limit the impact of high demand on salaries.

Nonetheless, the American system prefers to use market forces to drive these kinds of decisions by students, institutions and employers rather than to use centrally administered processes to control enrollment patterns, the costs of education, or job opportunities.

among the thousands of institutions and tens of thousands of programs, a match can usually be found, although not without a great deal of effort in some cases.

The absence of a grand national strategy and guidance for higher education

Also in keeping with American culture in general, the United States has no grand national strategy for the management and development of higher education. This is not to say that there is not a plethora of independent organizations and accreditation bodies that seek to impose some degree of order and regularity on the institutions. However, there is no comprehensive national (read "Federal") strategy for higher education. There are certainly strategies for elements of higher education, such as Federal student financial aid programs, investments in STEM education, and uniform requirements for doing research on human subjects. But, there is no "ministry of higher education" that can impose requirements on the institutions.[11] The absence of national strategy with its associated central control leaves U.S. academic institutions a great deal of latitude to experiment with new programs, new teaching modes, new forms of financing, and new kinds of relationships with industry and other partners.

Curriculum coordination among institutions is weak

A key element of the flexibility and dynamism of U.S. higher education institutions is that curriculum coordination among institutions is weak. Such coordination as there is flows in large part from accreditation requirements levied on both institutions and certain disciplines, from continual benchmarking and best-practice analyses carried out by institutions and disciplines, and by the influence of a few textbook authors who successfully capture an approach to teaching and learning that becomes widely adopted. Despite these influences, however, curriculum offerings and requirements differ greatly

[11] There is an Office of Postsecondary Education in the U.S. Department of Education, headed by an Assistant Secretary for Postsecondary Education. http://www2.ed.gov/about/offices/list/ope/index.html However, the powers and responsibilities of that Office and of the Assistant Secretary are quite limited relative to the powers held by higher education ministries in some other countries.

among institutions. Even within a single department of a single university, professors may prepare the same course offering using different texts and with different expectations of students.

Flexibility of student selection of major fields of study

American students typically enter the higher education system after completing a secondary education and earning a high school diploma. Often, students have poorly developed understanding of the disciplines and fields of study that might be open to them and even less understanding of the implications of studying and then working in those fields. To accommodate to such poorly formed student preferences, institutions often admit students to the institution as first year students in "undeclared" status; some institutions even refuse to recognize student majors in the first year. Students are encouraged to explore their interests through both course work and non-course activities in the first year in order to better understand their interests and options. Even after declaring and pursuing a major for a few semesters, students are usually permitted to change their majors while in school. Of course, if they choose majors with highly structured curricula that are constrained by requirements for completion of pre-requisites, changing majors may prolong the total time required to earn a bachelor's degree from the standard four years to five or six years, depending on when the student decides to change majors.

This flexibility in selection of courses of study is in sharp contrast to the practices of higher education in many other countries, where selection of a major is essentially irrevocable (and even admission to an institution is often, in fact, admission to a major field of study with little or no option to change majors within the institution).

Continuing on the theme of flexibility in selection of major, it is common in the U.S. for students to earn a bachelor's degree in one discipline or field and then go on to earn a graduate degree or degrees in an entirely different field. Depending on the divergence between the undergraduate and graduate major, such students may be required by their chosen graduate field of study to take remedial undergraduate courses in the graduate major to strengthen the foundations of their knowledge. Nonetheless, it is not uncommon to encounter a person who holds a bachelor's degree in, say, physics and a masters and doctorate in history or music. It is less common for a person to earn a liberal arts undergraduate degree and then follow that up with, say an engineering or applied science degree, but it does occur.

Consequences of the Diversity and Flexibility of the U.S. Higher Education System

In the above we have demonstrated how diverse and flexible U.S. higher education can be. Of course, in this brief review, we have touched on only a few salient aspects of this diversity and flexibility; there are many others.

An important consequence of this diversity and flexibility is that the set of higher education institutions, taken as a whole, can be highly responsive to changes in both student interests and employer needs. If for example, the market for petroleum engineers, or computer scientists and engineers, or neuroscientists, or psychologists or historians unexpectedly strengthens, or weakens, in a short time, the system of institutions can adjust to meet the new market conditions. Programs can be expanded or shrunk in the time frame of a year or two. Students can change majors to take advantage of new opportunities or withdraw from fields for which employer demand has suddenly shrunk. Institutions can set up new curricula using existing faculty members or by adding part-time faculty hired on short notice to create new fields of study as needs arise. Appendix B includes more details on how this can happen.

Petroleum Engineering – An Example of the Dynamics of Higher Education and the Demand for Graduates

Petroleum engineering is an example of a field for which employer needs fluctuate wildly as the market for crude oil experiences its usual volatility. Over the past few years, the boom in "fracking" to produce oil and gas from unconventional sources stimulated a rapid increase in opportunities for petroleum engineers. During the year just completed, however, the collapse in the price of crude world-wide has brought on a sharp contraction in drilling and production activity, and this will undoubtedly cause the need for new petroleum engineers to contract just as sharply. Undoubtedly, many students now in this major will have a difficult time finding employment in their chosen field upon graduation. If history is any guide, starting salaries will decline. Further, students currently enrolled in the field may try to change their majors to fields that they find less interesting but that are in greater demand, such as computer science or environmental engineering, and new enrollments can be expected to drop sharply.

The dynamics of the market for petroleum engineers have been explored in depth by Lynn, Salzman and Kuehn, who found, *inter alia*, that both the supply of petroleum engineers graduating from universities and their starting salaries were very responsive to changes in the demand for such graduates in the petroleum industry. See: Leonard Lynn, Hal Salzman and Daniel Kuehn, "Dynamics of Engineering Labor Markets: Petroleum Engineering and Responsive Supply," paper presented at a conference on "U.S. Engineering in the Global Economy," September 26-27, 2011 , The National Bureau of Economic Research , Cambridge, MA http://conference.nber.org/confer/2011/SEWPf11/Lynn_Salzman.pdf

Computer Science – An Example of the Dynamics of Higher Education and the Demand for Graduates

The field of computer science has experienced a great deal of volatility as the fortunes of the computer and information technology fields have waxed and waned. During the "dot-com" boom of the late 1990s, enrollments in computer science soared; they fell just as quickly after the "dot-com" bust of 1999. Many students, both enrolled students and applicants, dropped out of the field. Some educational institutions, wishing to retain their former computer science majors, moved with alacrity to create new majors and/or new minor areas of specialty such as "information technology" or "digital humanities." Subsequently, many employers outside the ITC sector discovered that graduates with hybrid educations could make key contributions to the myriad fields of application of ITC technologies in such industries as entertainment, travel, and retail and wholesale trade. Now even Stanford, arguably the top computer science institution in the country, has recently announced establishment of a new program that combines computer science and any of a number of liberal arts disciplines into a Joint Major called "CS-X." https://undergrad.stanford.edu/academic-planning/majors-minors/joint-majors-csx

The ways in which the supply of new engineering graduates is affected by changes in market demand have been elucidated at length in the work of the labor economist Richard Freeman and others. This work was brought together in a symposium in 2009 under the auspices of the National Bureau of

Economic Research.[12] A key finding of such work is there is a problem of lack of synchronicity in the education market and the labor markets for the graduates who are its product. That is, there is a typical time lag of 4 to 6 years between when a high school student elects to enter high education and when he or she graduates and seeks a job. So, it is not uncommon for high school students to become very interested in a field that is "hot" when they are 16-year-old high school juniors, but that has turned "cold" by the time they graduate from college or university five or six years later. In the absence of a national strategy or coordinating body that can try to anticipate such delays and mismatches, some students do find themselves unable to find employment in their major in bad times. Likewise, when employment opportunities in a field suddenly expand, it can take a number of years for the pipeline of students to yield suitable graduates, leaving some employers frustrated at the apparent "shortage" of appropriate graduates. Another key finding is that changes in the level of Federal R&D investment in a field can heavily influence graduate student enrollment in that field, which only adds to the volatility in the match of supply and demand for graduates that results from the workings of the marketplace absent other government intervention.

From the employer perspective, the diversity and flexibility of higher education as a whole offers the promise that nearly every firm can find a way to meet its needs for new people with specific training. This is not necessarily an easy process. Subsequent sections of this report will describe a number of ways in which industry's needs have been responded to by universities.

Formal Mechanisms that Encourage Universities to Prepare Graduates for Employment in Industry

Expert Advisory Boards

It is common for higher education institutions to establish expert advisory boards at the departmental (e.g., electrical engineering) and school (e.g. school of engineering, school of business) levels. The boards have no direct managerial responsibilities but advise and offer feedback to faculty and university administrators on such matters as curriculum, research, career opportunities for students and emerging areas of industrial interest. Board members can provide a "reality check" for the faculty about which subjects in the curriculum should be emphasized and how they should be taught as well as on which subjects are no longer needed by graduates working in industry.

Such boards are usually composed of leaders in the fields they are advising, with a heavy emphasis in the more technical and applied fields on those who work in industry. Alumni of the department or school who have been successful in industry are often asked to serve on such boards. Members serve on a *pro bono* basis and usually meet formally with the institution's faculty and administrators once or twice each year. Board membership usually reflects the geographic and other ambitions of the institution. Therefore, institutions that serve local needs for graduates will draw most advisory board members from the region, whereas institutions with national or international ambitions will correspondingly draw advisors from around the country or even from other countries.

[12] Richard B. Freeman and Daniel L. Goroff, editors, Science and Engineering Careers in the United States: An Analysis of Markets and Employment, University of Chicago Press, 2009. Also available on line at: http://papers.nber.org/books/free09-1. See especially Chapter 1," Introduction," by the editors.

Institutional Boards of Trustees

At a higher level, universities and colleges typically are governed by appointed or elected boards of trustees.[13] Such boards have a stewardship responsibility to ensure that the institution is led by the best available academic leader/manager/administrators, that it is on a sound financial footing, and that it has a clear mission, vision and strategic direction that it seeks to implement. Boards at this level do not typically involve themselves in advising the institution regarding which disciplines or fields it should offer or how the curriculum should be designed.[14] They may, however, comment substantively on the strategic direction of the institution (for example, whether to pursue partnerships with industry) and may from time to time suggest new areas that the institution should establish (e.g., a medical school, a business school, or different emphases in engineering and applied sciences.) In the United States, the members of institutional boards are usually people who have posted substantial accomplishments in life outside academia such as corporate officials, leading citizen activists, religious leaders, and outstanding faculty or administrators of other universities. The presence of leading industrialists on such boards ensures that the views of industry are heard and taken into account at the highest levels of the institution, if not on the specifics of the curriculum then surely on the more strategic questions of attitudes and approaches toward meeting industrial needs. Boards of public institutions are usually elected by the people of the state or locality served by the institution or appointed by the governor and/or legislative leadership of the state.[15] Boards of private institutions are usually self-replicating, with incumbent board members choosing new members through a voting process involving the incumbents as voters.

Accreditation

Accreditation of institutions and of programs in some disciplines and fields is a prominent part of the American higher education landscape. In principle, institutions and disciplines voluntarily organize accrediting bodies to examine each of their members on a recurring basis to ensure that they have fulfilled consensus expectations regarding both their processes of governance and administration, that their curriculum is generally in line with the expectations of peers, and that their faculty are qualified to teach the subjects they teach. While the origins of accreditation bodies are as voluntary associations, increasingly governments, including the Federal government, have used accreditation as a tool for determining which institutions and fields are eligible to receive various kinds of government financial assistance. The Federal government has a very heavy presence in higher education today through its programs of direct financial assistance to students through loans, grants, and work-study subsidies. Generally, such assistance is only available to students who attend institutions and programs that have

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[13] Profit-making institutions may be governed by officers or board members of the parent private corporation.

[14] From time to time, boards get involved in trying to shape the curriculum directly. This is usually the result of the efforts of board members who have a political or social agenda that they seek to promote through the institution. For the most part, such efforts are discouraged by university officials and are frowned upon by faculty members.

[15] Public universities regularly experience efforts by political leaders in their states (such as governors or members of state legislatures) to oversee or influence the contents of the academic curriculum for political reasons. Institutions usually try to resist such political pressure, but since political leaders usually control the state's financial contributions to university operations and to capital construction, institutions sometimes find themselves with little choice but to accede to the preferences of powerful politicians. In egregious cases of political pressure on institutions, the American Association of University Professors may do an investigation of the situation and, if it finds evidence of undue political pressure, the AAUP may censure the institution; an act that can make it difficult to hire good faculty and attract top students.

been accredited by accreditation organizations that are recognized by the government. In turn, such recognition has increasingly been dependent on the accreditors requiring certain standards of their members. This linkage of accountability of institutions through accreditors to government has become increasingly contentious in the United States.[16]

Industrial influence may be more strongly felt at the discipline and school level. Most fields within engineering, business, and chemistry, for example, have strong accreditation or "certification" programs that expect certain subjects and contents to be included in the curricula they oversee. The accreditation process may take into account whether those programs offer students what they need to succeed in their careers in industry. So, for example, the Accreditation Board for Engineering and Technology (ABET) requires that students complete the study not only of their chosen field but also of fundamental sciences and mathematics, the humanities and social sciences, ethics, and non-academic skills such as working in teams, public speaking, and writing. ABET standards evolve over time in part to improve the fit of engineering graduates with changing industrial career demands.

Professional Licensing

In the United States, each state requires that practitioners of various professions and trades that affect the public obtain a license from the state that is intended to ensure that the person meets the qualifications of a professional in that field. These kinds of professional licensing requirements are imposed on a number of the more sophisticated professions such as medicine, law, engineering, and social work, as well as on members of trades such as barbers and electricians. Usually, the licensing process is overseen by boards of practitioners in each field who are appointed by the governor of the state, while licensing standards are set by state laws adopted with the advice of the oversight boards. To be awarded a license, a professional must usually pass a series of examinations on both theory and practical problem solving, accumulate a minimum period of professional practice under the supervision of a licensed professional, and undergo a personal background check. While it may be waived in certain circumstances, the applicant for a license should have graduated from an accredited university.

In fields of interest to industry, such as engineering, architecture and geology, many if not most of the board members are employed in industry. In that capacity, the industrial representatives can influence the licensing requirements. For higher education institutions, curricula in the fields of interest to industry are designed, in part, to help ensure that the institution's graduates can fulfill the licensing requirements. Clearly, then, industry can influence the content of the higher education curriculum by encouraging the boards to require demonstration of competencies in certain areas as a condition of receiving a license to practice.

Career Counseling and Job Placement Services

In certain fields, especially the technical professions such as engineering and management, universities offer their students professional counseling on career opportunities and direct assistance in locating, applying for, and interviewing for job openings. Career counselors and job placement officials must be knowledgeable about the industries and even about the specific firms in which their graduates might be able to find employment. In the ordinary course of their professional activities, the career counselors

[16] Michael Stratford, "Challenges of an Accreditor Crackdown," Inside Higher Ed, November 17, 2015. https://www.insidehighered.com/news/2015/11/17/education-department-faces-challenges-cracking-down-college-accreditors

and job placement officers meet frequently with industrial representatives to learn what skills potential employers are seeking and the types of individuals they hope to hire. In the short run, this helps the counselors match employer needs with the skills of individual students. In the longer run, their dialogue with employers can provide valuable intelligence about industry's needs to the faculty and administration of the institution and can thus help shape the curricula in fields for which employers and seeking new employees.

Periodically universities organize "career days" or "career fairs" where companies are invited to send representatives to meet students in informal settings to discuss student interests and company needs. Faculty members are usually on hand to talk with industry as well. This arrangement is another valuable channel through which the faculty become aware of what industry is looking for in its new employees.

NRC Studies of Human Resource Needs in Certain Fields

The National Research Council (NRC) of the National Academies frequently does national-level studies of opportunities and human resource needs in various fields of science or engineering or in specific industries.[17] These studies are often sponsored by Federal agencies that have some responsibilities in the field of need. For example, the Department of Energy might fund the NRC to do a study of human resource needs related to emerging energy sources such as solar or wind, or the Department of Homeland Security or the Federal intelligence agencies might commission a study of human resource needs in cybersecurity.

NRC studies usually "paint with a broad brush" and tend to be focused on near-term future needs (say, one to five years into the future). Nevertheless, the NRC study panels typically try to identify specific roles for technical talent, numbers of new professionals who are expected to be needed in a field, major bodies of knowledge and skills those professionals should possess, and recommendations for government, industry and higher education actions to help fulfill the need.

NRC studies do not have the force of law and cannot compel action on anyone's part. However, they often serve as "touchstones" or benchmarks of what leaders in the field are thinking about education and human resource requirements to meet certain national needs, including the needs of industry. As such, the NRC reports can provide valuable guidance to both students and faculty about what the curriculum should incorporate to maximize the employability of newly graduated professionals.

Bureau of Labor Statistics Forecasts of Future Needs in Certain Fields

The Bureau of Labor Statistics (BLS) in the United States Department of Labor periodically issues reports that provide an "outlook" on the future needs of industry for professionals in various fields and industries, as well as on salaries in various fields. The BLS reports receive substantial attention in both the business and professional press as well as in educational circles. BLS focuses on the numbers of such professionals rather than on their characteristics and quality and does not break down its forecasts by job specialties or narrow industry classes. The BLS forecasts are driven by static models of the economy and do not attempt to anticipate how the changing structure of the economy or how major technological innovations might affect future needs for professionals in certain fields. Therefore, while

[17] For a recent study of the NRC and some of its work, see: George R. Heaton, Jr., Christopher T. Hill and Patrick H. Windham, "The Roles of the U.S. National Academies in Influencing Federal S&T Initiatives," a report to NEDO by Technology Policy International, December 2014.
www.technopoli.net/yahoo_site_admin1/assets/docs/National_Academies_and_ST_Initiatives.25281253.pdf

the BLS projections can be useful in helping to set national policies for the support of certain fields, they are too coarse to be of much use to students looking for career guidance or industry looking for opportunities to promote reforms to higher education.

Government Fellowships, Assistantships and Training Grants in Priority Fields

The Federal government has offered competitive fellowships and training grants to graduate students in fields of national interest since the 1950s, and it has also supported such students as participants in research grants and contracts to faculty members for nearly as long. Some programs have been very general, such as the long-standing NSF graduate fellowships that are awarded in all fields included in the very broad NSF research agenda. Others, such as NASA's graduate traineeships and NOAA's Sea Grant funding, have been focused on more narrow fields; in these cases, space and oceans sciences respectively. While the primary goal of these programs has been to educate students at the highest levels of research and scholarship, they have also played a major role in supporting preparation of students for careers in industrial research. By and large, however, industry input into the design and foci of such programs has been quite limited.

The U.S. Selective Service System and its Effects on Universities and Industry – A Historical Perspective

Many countries have conscripted ("drafted") young men, and increasingly, young women to serve for a period of time in their armed forces. The United States is no exception. It has used the draft repeatedly in time of war to compel men to take up arms. The precise nature of the draft, the obligations inherent in service, and exemptions to such service have varied greatly over the decades.

The modern day system had its origins in the Selective Service and Training Act adopted in 1940 and subsequently amended numerous times. For purposes of this discussion, the most important changes occurred with passage of the Selective Service Act of 1948, which was in effect until 1969. This act codified the practice of creating categories of exemptions for men (women were not subject to the draft at the time) who were, for example, married with children, enrolled full-time in a higher education institution, or employed in industries deemed critical to national defense. See: https://en.wikipedia.org/wiki/Selective_Service_System

During the era of the conflict in Vietnam (~1965-1975) the exemption process was relatively generously applied to men enrolled in higher education, including those in graduate school. Similarly, it was liberally applied to men who were employed by firms that served the defense industries, even if the positions that they filled were not directly related to national defense. The result of these policies and practices (combined, of course, with with-spread opposition to the United States engagement in Vietnam) was to create an incentive for young men to enroll in higher education immediately upon graduation from secondary school, to remain enrolled and to enter into graduate degree programs immediately after receiving a bachelor's degree, to prolong their period of study for the masters and/or doctoral degrees as long as possible, and then to take a job immediately upon graduation working for a defense-related company. Furthermore, such a pathway was most likely to succeed in keeping the person from being drafted if he were enrolled and then working in a technical field such as engineering, mathematics or the physical sciences. Overall enrollments in those fields quickly reached record highs in the late 1960s and early 1970s and contributed to the oversupply of such graduates in the recession of the late 1960s and continuing into the 1970s. In addition, the incentives also worked to sustain high enrollments in such fields as history, philosophy, languages and the social sciences. For a comprehensive analysis of factors, including the Selective Service system, that influence production of PhDs, see, Barry R. Chiswick, Nicholas Larsen, and Paul Pieper, "The Production of PhDs in the United States and Canada," Discussion Paper IZA DP No. 5367, Institute for the Study of Labor, Bonn, German, December 2010. http://ftp.iza.org/dp5367.pdf

Informal Mechanisms that Encourage Universities to Prepare Graduates for Employment in Industry

A variety of practices and activities serve as informal mechanisms that encourage universities to conduct educational programs that meet the needs of industry. Often these mechanisms have other, complementary purposes, so that strengthening the capacities of program graduates to meet industry needs can be viewed more as a side effect of the mechanism rather than as a deliberate part of its design. Collectively, however, these mechanisms play an important role in focusing higher education on industry needs.

Participation in Professional, Scientific and Technical Societies

Technical and scientific professionals in both industry and higher education institutions, as well as those who work in government laboratories, often participate together in the activities of their professional societies, such as the American Chemical Society, the Society of Automotive Engineers, the Institute of Electronic and Electrical Engineers, and many others. Through such engagement, personnel from industry and higher education come to know and understand each other's strengths and needs. The informal discussions that take place in these contexts help keep educators up to date on what industry is doing and needs, while industrial professionals are kept up to date on promising new areas of research and especially about students who faculty judge to be excellent prospects for industry.

One part of the programming of some such associations is a focus on academic curricula and industry needs. The Council for Chemical Research, for example, is an association of senior administrators from universities and colleges who lead departments in fields like chemistry, chemical engineering, materials science, and biotechnology, along with senior technical personnel and management from industrial firms that are highly dependent on chemical technology and chemically-trained personnel. The Council addresses areas of mutual interest in research and graduate education.[18]

Personal Networks

Personal, individual ties between university and college faculty members and their alumni who are employed in industry is of inestimable value in building rich and enduring links between the sectors. Universities and colleges cultivate the continued interest of their alumni in their institutions for a number of reasons, not the least of which is that alumni are sometimes in a position to make major financial donations to the places from which they graduated. (U.S. higher education is very dependent on alumni contributions in general.) In addition, however, faculty members reach out to individuals and groups of alumni for advice on departmental operations, curriculum, research directions, consulting opportunities and other matters. Not infrequently, department heads, deans and even institutional presidents meet with groups of alumni in major cities around the country to promote the interests of the institution and to solicit advice on what the institution should be doing. These networks serve to

[18] See: https://www.ccrhq.org/

keep both sides informed on a timely manner about needs and opportunities for students, curricula, and research.

Personnel Exchanges

It is common in the United States for faculty members to spend a summer working at an industrial firm in R&D or other functional area, both to earn a salary during the traditional period when U.S. faculty are not paid by their employing institutions and to improve their understanding of current and emerging industrial practices. Some faculty members even spend one or two semesters of a sabbatical year working for a company, for the same reasons. Other more complex but less common relationships exist, including faculty leaves of absence to help start a new firm or to take on a significant managerial responsibility in a firm for a limited time.

Conversely, industrial scientists and engineers, especially those who work in R&D, may spend a limited time (a month, a semester, a year) as a visiting industrial fellow at a higher education institution. While the main purpose of such visits is to improve the knowledge base of the industrial fellow, their presence on campus provides a convenient channel for sharing industrial needs and opportunities with faculty members.

Faculty Hiring from Industry

The careers of scientists and engineers in the United States are known to be quite non-linear; that is, such professionals can readily change their employers and even the sectors in which they work relatively easily. Universities often seek out senior industrial scientists and engineers from industry to serve as "professors of practice," to take up regular faculty appointments, or to fill administrative positions such as dean, department head, technology transfer officer, or even university president. At the more junior level, in many applied fields of interest to industry, spending a few years after earning one's doctorate working in industry is viewed very positively by faculty recruiting committees. Each such relationship serves to bridge the gap between industry and academia and strengthen the institution's capability to provide educational opportunities to their students that will be valued by industry.

University-Industry Research Collaboration and Technology Commercialization

Higher education institutions in the United States are deeply engaged both in R&D collaboration with industry and in commercializing technologies invented in the institution to industrial companies. These phenomena have been widely described and analyzed and need no further elaboration here.

What does bear mentioning, however, is that both collaborative R&D and technology transfer bring industrial leaders into frequent and substantive contact with their counterparts in the university, from the level of individual students and faculty up to the president and even members of the board of trustees. Informally, these contacts provide a convenient channel for discussions of industry needs and exploration of potential university responses.

More recently, some companies and universities have formed strategic alliances that go beyond single instances of R&D collaboration or technology transfer. Instead, a company may identify a university that has multiple strengths of interest to it for a continuing, strategic relationship that may involve multiple research projects, training and continuing education of company staff members, participation by company representatives in advisory boards, visits back and forth by faculty and company staff, and so on. Companies naturally seek out institutions that offer both a wide array of possibilities and a

willingness to engage on a sustained basis. Institutions seek out companies that similarly are willing to invest heavily in the institution and that respect the needs of the institution to remain committed to an academic agenda.

Regardless of the intensity of the interactions over time, disciplines, projects and activities, however, the existence of collaborative relationships between universities and companies offers a myriad of possibilities for ensuring the university's graduates have the skills and capabilities industry needs.[19]

Some Specific Activities of Higher Education that Help Ensure that Graduates Meet Industry Needs

Having discussed a wide array of mechanisms and pathways by which higher education institutions can improve their linkages to industry and can thereby help ensure that their graduates meet industry needs, we turn now to describing a few more specific examples of concrete activities that contribute to this purpose.

Industry-focused Academic Programs in Regional Economic Development Strategies

Regional economic development programs at the local and state level across the United States frequently incorporate commitments by regional universities to establish educational programs intended to provide the specialized talent required by companies that have or might make investments in the region. Often companies need a mix of both skilled tradespeople and those with university-level education in fields like engineering, marketing, and operations management.

For example, the School of Engineering at the University of Tennessee very recently announced that it is establishing a set of concentrations in automotive technology for students in mechanical, electrical and materials engineering to help meet the needs of the more than 900 companies in Tennessee that are in or serve the automotive industry.[20] The automotive sector has been one of the key industries in Tennessee's economic development strategy for a number of years.

Also in Tennessee, the state legislature set up a grant program implemented in 2014 entitled the Labor Education Alignment Program to be administered by the Tennessee Higher Education Commission. According to the Commission's 2016 report on the program, "LEAP's primary goal is to close skills gaps by ensuring that students enrolled in courses provided by Tennessee Colleges of Applied Technology (TCATs) and community colleges gain the necessary skills to meet the requirements of high-skill and high-technology jobs demanded by industry leaders in the state."[21]

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[19] Graduates of the NSF-sponsored Engineering Research Centers at universities, which require industrial co-funding and participation as a condition of universities receiving NSF funds, were found to be a valuable output of those centers. See: J. David Roessner, David W. Cheney and H.R. Coward, "Impact on Industry of Interactions with Engineering Research Centers – Repeat Study," Report to NSF by SRI Int'l., December 2004. http://erc-assoc.org/sites/default/files/studies_reports/Impact%20on%20Industry%20of%20ERC%20Interactions_SRI_12-04.pdf

[20] http://www.knoxnews.com/news/education/ut-engineering-adds-automotive-concentrations-28d6cf61-e0e3-6c7d-e053-0100007fec89-364686661.html

[21] https://www.tn.gov/assets/entities/thec/attachments/LEAPReport2016.pdf

These examples from Tennessee are illustrative of what is happening all over the country—academic institutions, including universities as well as community colleges, are collaborating with local officials and local business in efforts to ensure that the skilled workforce industry requires will be available.

Part-time Educational Programs for Industry

In addition to seeking recent graduates who can rapidly and effectively meet their needs for new talent, companies also have a broad need for continuing education for their existing technical staff members. Employees may, of course, pursue advanced degrees on a part-time basis while continuing to work full-time for the company. However, this approach requires a deep commitment by the employee over a period of several years and may result in earning a degree that has become partially obsolete in the interim and which may include a lot of material not relevant to the job.

For this reason, some companies have turned to local colleges and universities and asked that they offer specialized courses tailored to the needs of their employees, often given at times that are convenient for employees and, in some cases, even offered on the company premises. This approach makes a lot of sense for large companies that have enough employees needing the same educational experience that inviting the university onto the company's property is financially viable for the company. At the extreme, companies in very fast moving fields may actually hire students who have not yet completed their degrees and then invest in their completing their degrees on the company's premises.

This approach is not without its challenges. It is important that the principles of academic freedom and fairness be sustained for faculty members who are teaching for companies under university sponsorship. Pricing such custom offerings should ensure that the company is paying as much of the cost of its employee's education as it would pay if the employee were enrolled as a regular student, plus enough additional to cover the extra cost of faculty travel and special preparation.

Nevertheless, this approach can be an excellent way to ensure that students learn what the employer needs them to know, at least in the near term. Longer term, the company should be sure that its employees get a sufficiently broad education that they do not rapidly become obsolete again soon after the course is completed.

Distance Education and On-line Learning

Closely related to on-premises education as described immediately above is provision of specialized courses to company employees via various forms of synchronous and asynchronous distance and on-line education offerings. While they obviously differ considerably in the way they are offered, such courses can provide the same kinds of opportunities to people already employed in industry that part-time, on-premises programs can offer. An important difference is that on-line course participation need not be limited to the employees of one firm or to people gathered at one location.

Cooperative Educational Programs

So-called cooperative education programs have been a presence in U.S. higher education for decades, but have involved relatively few institutions.[22] The basic idea of cooperative education was for students to alternate classroom education with on-the-job learning throughout their undergraduate years. In some programs, students spend alternate semesters in the classroom and in employment. In others, the student divides each day between classroom and employment. These models were predicated on

[22] https://en.wikipedia.org/wiki/Cooperative_education

the view that, especially in technical fields, learning from hands-on experience was as important to personal development as learning in school. For students with limited finances, this style of education offers a financially viable way to earn while they learn.

The advantages of the cooperative approach to industry are clear—companies are able to get an early look at inexperienced students at low cost, to socialize them to the ways of working in industry and to develop loyalties that will lead students to choose their host companies for permanent employment, if it is offered. Furthermore, university cooperative programs are necessarily developed in close association with companies, which leads automatically to firms being able to help shape the institution's curriculum and educational philosophy. In this way, cooperative programs can be a highly effective mechanism through which universities and companies jointly prepare students who are very well prepared to meet the company's needs.

Student Internships in Industry

Student internship programs are growing rapidly in extent and acceptance. An internship is an educational experience that is organized around a student spending some portion of his or her enrolled time working in a company or other type of organization not associated with the university. An internship is much more than a part-time job for a student. Internships operate much like cooperative education programs except that internships are typically offered for shorter periods of time and as one-time experiences. In order to host interns, companies are expected to offer structured learning experiences within the company, often including cross-training over several different functions. Typically, interns are required to write a report on their experiences to be shared with the host company and to serve as the basis for an evaluation of the internship experience by the faculty.

Internships offer students an opportunity to experience the world of professional practice and to learn both the explicit and tacit skills necessary to succeed in the company world. And, because they involve deep interaction of the host companies with the institution, they offer a rich array of possibilities for mutual learning about needs and opportunities by both.

Student Summer Jobs in Industry

In the United States, most college students attend school for about nine months of the year and do not attend school in the 10-12 weeks that constitute the summer break for institutions. Many students seek summer employment to earn extra money and to gain employment experience. For many students, earning money is a priority, and they often take any sort of job that enables them to work and save money, including relatively menial positions such as hospitality workers at summer vacation resorts. Those who are more competent, more determined and more fortunate hope to find a summer job working in a company in an industry related to the field of their university studies.

Student summer job opportunities in industry are often brokered on behalf of students by members of the faculty or by internship coordinators hired by the university to make such arrangements. As with other personnel sharing activities, creating and overseeing summer jobs can open up channels of communication between faculty and company staff regarding human resource needs and opportunities; that is, the summer job experience becomes an indirect means of guiding the university towards greater focus on the needs of industry.

Hiring Part-time Faculty Members from Industry

U.S. colleges and universities are increasingly making use of part-time or "adjunct" faculty members to teach courses in many fields and at all levels. While educational institutions have their own financial reasons for staffing with part-timers, this practice creates a fertile mechanism for dialogue among faculty, students and industry-based instructors regarding what industry needs its new hires to know. Adjunct faculty are usually expected to teach according to the curriculum and the course syllabi developed by full-time faculty members. At the same time, however, in practice the industry-based part-timers are likely to heavily influence course content in the short run and the curriculum in the longer term as a result of the continued conversation about course teaching.

Entrepreneurs-in-Residence Programs

A relatively new addition to the academic landscape is the presence of entrepreneurs on campus.[23] These are typically people who have been successful in starting companies and have returned to campus to help faculty commercialize their inventions using start-ups and to teach students through practical experiences about how to build companies. With their experience in the venture-backed entrepreneurial world, these new staff members can bring a 21st century small, high-tech business based sensibility and sensitivity to the campus and can thus help shape the curriculum and the expectations of students. Entrepreneurs in residence are usually given contractual appointments lasting from a few months to a few years. Unlikely regular faculty, they are not expected to publish but are expected to serve as mentors for everyone on campus, from first-year students to the senior administration.

Concluding Observations

The diversity and flexibility of U.S. higher education has contributed immensely to its ability, as a system, to meet industry's continually evolving requirements for the skills and capabilities of the staff members it expects to hire as they graduate from the nation's colleges and universities.

American higher education has always had a strong vocational flavor, although this perspective on the purposes of higher education has also always co-existed with a broader, human development perspective. Increasingly, industry needs staff members who have both strong vocational skills and a broad liberal education. Similarly, many of the non-industrial parts of American society increasingly look for their staff members to have the technical and financial skills that were traditionally thought of as the domain of industry. Hence, the drive to improve the match of educational experiences with employer needs may find a grand synthesis as the array of skills necessary to "succeed in business" increasingly encompasses the same skills needed to succeed in human relations and in the community.

Many mechanisms that are in common use in U.S. higher education serve to improve communications and understanding between the academic "suppliers" of talent and the industrial "demanders" of that same talent. Any special efforts to improve communication between the two spheres—academia and industry—must take into account the richness of communication that already exists.

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[23] The Entrepreneur in Residence Program at the Columbia University School of Business is an interesting example. See: http://www8.gsb.columbia.edu/entrepreneurship/programs/entrepreneur-in-residence

Appendix A - Recent U.S. Reports on the "Skills Gap" Between University Graduates and the Needs of Industry

Selection compiled by Technology Policy International, LLC, for NEDO-DC

"Revisiting the STEM Workforce," Report by the National Science Board of the National Science Foundation, February 2015.

> *This is a comprehensive overview of issues with the STEM workforce, including more than 100 citations. The industry-skills gap is emphasized on page 9 and page 20, but the entire report is highly relevant.*
>
> *The National Science Board is the governing body of the National Science Foundation and is chartered by Congress to offer advice on scientific and technical matters to the President and Congress.*

http://www.nsf.gov/pubs/2015/nsb201510/nsb201510.pdf

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"Closing the Skills Gap: companies and colleges collaborating for change," A report from The Economist Intelligence Unit, 2014.

> *This analytical report describes the various dimensions of the skills gap and general approaches to closing it taken by companies in collaboration with universities. It is based, in part, on the results of an extensive survey of industry executives.*

https://www.luminafoundation.org/files/publications/Closing_the_skills_gap.pdf

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"Boiling point? The skills gap in U.S. manufacturing," A report on talent in the manufacturing industry, Sponsored by Deloitte and The Manufacturing Institute, 2011.

> *This report, which is based on a survey of manufacturers, includes data for both college educated and production employees. It emphasizes the skills gap along several dimensions.*
>
> *The Manufacturing Institute is the research arm of the National Association of Manufacturers. Deloitte is a major consulting firm.*

http://www.themanufacturinginstitute.org/~/media/A07730B2A798437D98501E798C2E13AA.ashx

and

"The skills gap in U.S. manufacturing 2015 and beyond," 2015.

> *This is an update of the 2011 report that includes more data and deeper analyses.*

http://www.themanufacturinginstitute.org/~/media/827DBC76533942679A15EF7067A704CD.ashx

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"The U.S. Science and Technology Workforce," Report of the Congressional Research Service to the United States Congress, June 2009.

> *This CRS report was prepared by two senior analysts, Deborah Stine and Christine Matthews. It includes a good overview of issues regarding the STEM workforce, especially regarding demographic data. It also examines the characteristics of the workforce and immigration issues. The report includes a lot of data and numerous references. The report is slightly out of date, with most of its data current only through the year 2000. However, its conceptual framework remains valid.*
>
> *CRS is charged with preparing authoritative, non-partisan background reports for Congress on important national problems and issues. CRS does not ordinarily make its reports available to the general public, but many of them, including this one, have been acquired and posted on its Web site by the Federal of American Scientists, a non-profit organization.*

https://www.fas.org/sgp/crs/misc/RL34539.pdf

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"What Shortages? The Real Evidence About the STEM Workforce," by Hal Salzman, in Issues in Science and Technology, Summer 2013.

> Hal Salzman is a prominent critique of claims of gaps in the supply of scientists and engineers for industry in the United States. This paper summarizes a number of empirical studies that he has done on this topic, often in collaboration with Lindsay Lowell and/or Leonard Lynn.

http://issues.org/29-4/what-shortages-the-real-evidence-about-the-stem-workforce/

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"Is the skills gap real? Economists challenge a politicians' truism," by David Scharfenberg in the Boston Globe, August 02, 2015

> *This is a journalistic but well-informed analysis of the claims that there is a skills gap in manufacturing.*

https://www.bostonglobe.com/ideas/2015/08/01/skills-gap-real/ZKiocRvvwz24jdnY1DaoNK/story.html

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"Falling Behind?" by Elizabeth Redden in Inside Higher Education, May 2014.

> *This is an excellent review of Michael Teitelbaum's book, Falling Behind. Teitelbaum calls into question whether there is a shortage in the STEM workforce. Teitelbaum is at Harvard University and before that was with the Alfred P. Sloan Foundation, where he was responsible for an extensive program of grants in the field of the STEM workforce.*

https://www.insidehighered.com/news/2014/05/23/new-book-stem-workforce-needs-and-international-competitiveness-finds-no-evidence

See also: Falling Behind?: Boom, Bust, and the Global Race for Scientific Talent, Michael S. Teitelbaum, Princeton University Press 2014.

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http://www.bhef.com/our-work

BHEF 6-year project: National Higher Education and Workforce Initiative

> *The Business-Higher Education Forum is an association of the chief executive officers of U.S. universities and major companies. It has just begun a series of regionally-focused dialogues between industry and higher education on improving the match of graduates' skills and industry needs, focused on the undergraduate level.*
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> *No reports are yet available on this new project. It is listed here because it is likely to result in interesting reports and data over the next several months.*

Appendix B – How U.S. Universities Adjust to Changing Demands and Expectations

Flexible Adjustment Practices

U.S. universities have considerable ability to adjust quickly to changes in student interests in different fields of study as well as to changes in what students need to know in order to meet the expectations of potential employers. For example, if the market demand for graduates with a particular major (say, computer science, biochemistry, or electrical engineering) is strong, then student interest in that major is usually strong as well. Universities may face relatively sudden increases in enrollments in newly popular majors. They are able to respond, within reasonable limits, to such increases in a period of just a few weeks or a couple of months by adding sections of courses in the major, reallocating faculty effort, hiring part-time or adjunct faculty to teach additional sections, or recruiting advanced graduate students or post-docs to assume teaching responsibilities. While it is more difficult than responding to growth in demand, institutions can also respond to reduced demand for particular majors by combining or eliminating sections of courses in that major, by reassigning faculty to teach other courses, by cutting back on faculty hiring, by encouraging faculty to retire early, by laying off part-time or adjunct faculty, and so on.

University curricula can be updated relatively frequently as the needs of employers change. It is especially easy to respond to new interests in or demand for certain specialized topics in a major by asking faculty members to teach "special topics" courses that cover the new material. A faculty member might be able to create such a course in only a few weeks. Entirely new majors can be developed relatively quickly by reassigning existing faculty to the new topic or by hiring new faculty, both tenure-track and part-time. New majors often emerge as spin-offs from existing majors as radically different material is developed or as two or more disciplines collaborate to create a third hybrid, such as bioinformatics from a combination of biology and computer science. Eliminating obsolete material and majors from the curriculum can be more challenging because of the vested interests some faculty members develop in teaching their favorite subjects. Obsolete courses can be withdrawn over a period of a few months. Eliminating a major can take longer, especially if doing so might entail laying off faculty who have tenure in the department of that major.

Enablers of and Barriers to Flexible Adjustment

A number of aspects of university governance, administration, and budgeting enable U.S. universities to act with such great flexibility. At the same time, other aspects act as barriers to flexible action. Here are a few of the most important aspects that are enablers as well as some that are barriers.

Enablers

Among the key enablers of flexible adjustment to changing demands and conditions are leadership, budgeting, and governance and decision processes.

U.S. university leadership is generally results-oriented. Each institution must compete for students, for resources and for recognition and engagement. Leaders, including boards of trustees, presidents, provosts, deans and department heads, are all oriented toward being responsive to the diverse demands place on them. At the same time, leadership responsibility is typically decentralized and

distributed throughout the leadership ranks. Thus, mid-level leaders have the authority and the responsibility to make key decisions with only limited oversight from higher levels, which makes changes within a department or schools relatively easy and relatively free of bureaucratic opposition.

Budgeting and management of university financial resources is also decentralized. Of course, institutions develop comprehensive budgets on an annual basis to guide overall direction and allocations. Once those allocations are made, however, leaders of "local academic units" (meaning departments and schools/colleges) such as deans and department heads have the responsibility for planning and administering the funds made available to them from the central budget. The latter can decide, with higher level oversight, what courses to offer, who should teach them, how many students are enrolled in a single class, and so on. Some funds from the university's budget are typically set aside and held in central administration accounts as contingency funds to help local academic units financially if they come under unexpected enrollment pressure.

As suggested in the above, decision processes are typically decentralized and distributed as well. There is an important caveat, however—U.S. universities operate under a model of "shared governance." Put simply, this means that the administration and the faculty each have a share in the processes of decision making. The "size" of the faculty share depends on the institution and its history and culture, including whether the faculty have been organized into a faculty labor union. Recognizing that their decisions must be made in consultation with the faculty, nevertheless deans and department heads are delegated the authorities not only to administer but to manage and lead their schools and departments. They can act decisively and quickly to make decisions that enable their local academic units to act to meet changing circumstances.

Barriers

There are also barriers to rapid adjustment by universities in the face of changing interests and needs. These include limited budgets, academic culture, shared governance, and, in the case of public institutions, obtaining official approvals.

University budgets are nearly always inadequate, at least in the eyes of university leaders, administrators and faculty. Most institutions, even those with huge invested endowments, must manage their financial resources carefully. So, even when everyone agrees that a new direction or growth in existing directions would be wise, there is not always enough money to make the adjustments required. Leaders and administrators usually have to pick and choose among the new directions to follow. Deciding to accommodate the growth of student interest will compete with other financial priorities.

Furthermore, when institutions are under pressure to change rapidly, there may not be appropriately trained people in the community who can step in to serve as part-time faculty, students mentors, or in other roles. Many universities, including some very good ones, are located in small communities where it is unlikely that anyone lives who is prepared to take on a teaching role in a specialty on short notice, whereas universities located in major cities are much more likely to be able to draw on a community that includes some real experts in most fields.

Academic culture applies an important brake on rapid adjustment. As noted in the main text, change in academia is often resisted by entrenched intellectual and bureaucratic interests. That said, the intellectual opposition to change is not simply the result of myopic commitments by faculty members to

their parochial interests. Such opposition also reflects, in part, the key social mission of universities to be the compilers, stewards and disseminators of the best of human knowledge and wisdom. Universities, by design, should be "conservative" with respect to changes in courses, curricula and disciplines.

As noted in the prior section, American academia is also committed to the concept of shared governance. How governance is shared between faculty and administrators varies considerably among institutions and between those that are private and those that are public. The faculty as a whole plays a much stronger role in strategic and administrative decision-making in institutions in which faculty members belong to a recognized labor union or where tenure is very strong. Group faculty decision-making tends to be participatory, deliberative, process-oriented, and protective of existing interests, all of which can lead to time delays as faculty members discuss among themselves and then with the administration about what action should be taken.

Finally, public institutions usually have to obtain permission from a high-level official state body before they create a new formal major or close down an existing department or major. In some states, this body is a state cabinet-level Secretary of Education; in others, it is a state council made up of leading citizens appointed by the state's governor. For proposed new programs, such official bodies may require a complete dossier about the new program, an analysis of the potential market for both students and graduates, and an estimate of financial viability. Gaining such approvals can take many months, which obviously introduces delay in adjusting to new needs.

Analysis

A number of factors, including those discussed here, enable or serve as barriers to, rapid adjustment of U.S. university enrollments, majors, and courses in the face of new demands and changing expectations. As with nearly every characteristic of American higher education institutions, circumstances and practices differ greatly from one institution to another, as does the balance of outcomes. Some institutions have a reputation for being dynamic, flexible, responsive, and entrepreneurial regarding changing teaching needs and expectations. Others are said to be stodgy and slow to change, remaining mired in some past golden age or other. As a whole community, however, U.S. higher education is remarkably responsive to the needs of society.