

As Goes California, So Goes the Nation: A Precautionary Tale for American Public Research Universities

by Marye Anne Fox

Even the most casual observer of higher education can see that major challenges are in the wings for American public research universities. These institutions are the sites for the post-secondary education of 85% Americans holding bachelor degrees and, as a result, are major determinants of expected educational attainment. Currently, college graduates enjoy an unemployment rate that is less than half of that of otherwise comparable high school graduates. Adult Americans still perceive that college is worth a substantial financial investment for themselves and their children. With the implication that college completion is not optional for an average middle class American student, it is interesting to speculate on trends faced in confronting the brave new world of public higher education.

In this article, I will discuss major themes likely to be addressed in managing 21st century research universities as they face troubled financial times. A disclaimer is in order: this is a simplified view, albeit an informed one, derived from an inside seat for 14 years of service as chancellor at two important research universities.

Given that there are many common financial challenges facing public institutions, we can probably best understand the driving forces for change if we focus on one of the nation's public flagship campuses or systems in detail. More than half of the nation's research universities are now operating under financial distress, including nearly all of the western states, e.g., California, Oregon, Washington, Arizona, Nevada, Texas, New Mexico, etc. Inarguably, the ten universities that comprise the University of California (UC) together constitute one of the world's strongest public research institutions, and predictions about UC decision-making should provide compelling insight on the future of higher education elsewhere in the U.S.

Ten institutions comprise UC, i.e., those at Berkeley, Davis, Irvine, Los Angeles, Merced, Riverside, San Diego, San Francisco, Santa Barbara, and Santa Cruz. All are, or aspire to be, world-class, each focused on different societal problems. Six are members of AAU (American Association of Universities) and all admit only highly motivated students capable of serious intellectual attainment. UC is often looked to as one of the prototypical American research universities when solving academic or administrative problems in the U.S. As a result, UC schools should be an excellent bell-weather for changes to come.

As a hallmark of demonstrated excellence, each UC campus strives to offer programs that are of top quality and diverse intellectually and demographically, but also accessible and affordable to the students it serves. This is consistent with its long accepted mission of pursuing excellence in research, teaching, community service, and patient care. Decisions about UC's financial challenges are likely to be adopted by other universities. Because UC San Diego (UCSD) is my home institution, I will often report its data because I know it best.

Principles Guiding Budget Decisions

Several important principles guide strategic planning and government investment on each campus. These are the goals embodied in: the Morrill Act of 1862 which established land-grant universities in every state of the U.S.; the G.I. Bill of 1944 that threw open the doors of public and private colleges to soldiers returning from WW II; the publication in 1945 of "Science, the Endless Frontier," by Vannevar Bush, shifting primary responsibility for basic research to universities instead of national laboratories; and then-President Clark Kerr's UC Master Plan of 1960, producing a three-tiered system of higher education institutions. The division of labor in the Master Plan assigned generation and application of new knowledge to UC; workforce development to state colleges (CSU, California State Universities); and preparation in two-year community colleges for the practical trades, for correction of deficiency of required skills, or for preparation leading to academic transfer to a UC or CSU.

For over fifty years, the Master Plan, expressed through the policies mentioned above, provided for California a workforce second to none in the world. Over the last two years, however, in the face of double digit unemployment in California, the budget allocated to UC by the California legislature has shrunk, from \$3.4 B to \$2.3 B, with an additional mid-year cut of \$100 M likely within the current academic year. This gives a net reduction of approximately 30% of allocated state funds.

Most of the budget at the best research universities comes from sources other than state legislative appropriation: UCSD, for example, derives only eight per cent of its annual budget from the state. The remainder comes from tuition, fees, philanthropy, research projects, patient care, and return on investments, including intellectual property.

California is not the only governmental entity to face such bleak economic news, but it is clear that financial stress has made the California state legislature an unreliable partner with regard to University support. And California's elected officials are not alone: similar cut-backs and responses have been endured by more than half of U.S. flagship institutions, despite the major success of the university systems in creating and driving economic growth.

Dealing with the Allocation Shortfall

Because personnel costs, i.e., salaries, health benefits, and pension reserves, constitute over 80% of a typical academic budget, a list of proportionally large reduction of expenditures would demand some or all of

(continued on next page)

What does it mean to be a public research university? Does American public higher education serve the public, by definition, by subsidizing available educational offerings and by expecting innovation and job creation in return?

the following: vacant faculty positions going unfilled, cutting or freezing pay, eliminating middle management positions, imposing furloughs and layoffs, switching to a semester-based academic year, turning to information technology (IT) for many functions, and/or restructuring pensions. In parallel, it is possible, although certainly not desirable, to identify new and recurring revenues, while drastically reducing expenditures by introducing operational efficiencies. For example, we could increase class size, reduce the number of

other UC institutions to achieve common, discounted procurement procedures for goods and business travel; by enhancing the efficiency of routine IT procedures, *e.g.*, payroll; and by renegotiating variable interest rates.

Defining the Public Research University

Under such conditions, we ask ourselves: What does it mean to be a public research university? Does American public higher education serve the public, by definition, by subsidizing available educational offerings

Is the current global financial crisis causing the American middle class to be squeezed out of access to a college degree?

hours required for a degree or for a major, drop sections of required courses thereby slowing graduation, eliminate numbers of electives and requirements for major fields of study, increase the time served between sabbaticals, and/or require professors to teach additional classes. We have already pursued efficiencies such as a flat tuition rather than cost per term hour or productivity incentives that enable graduation in four years or less.

But irrespective of such efforts, the most direct way to generate necessary income short-term is, unfortunately, raising tuition. Tuition has increased and legislative support has decreased over the last decade, with the curves crossing this fall (2011) for the first time in UC history. That is, for the first time, UC revenue billed to students as increased tuition and fees exceeds that allocated by legislative appropriation.

Widely distributed budget cuts also lead inevitably to identification of new sources of income. Philanthropy and directed income from a very small number of successful pursuits based on generated intellectual property have indeed created a number of high-payout sites. Such increases in higher education costs increase debt load to a degree that it inhibits free choice of careers for some students. That is, it may no longer be economically feasible to choose to be a public interest attorney, an elementary school teacher, or a practitioner of other low-paid professions. This situation clearly is not optimal for our society.

Large cuts in the legislative allocation for the university base budget have, in turn, caused universities to reconsider reallocation of assets held by the many internal campus units. For example, at UC, pointed efforts have been made to restructure debt by selling bonds; by readjusting the ratio of long- and short-term interest derived from endowments; by reassigning priorities for investments from the administrative pool; by cooperating with

and by expecting innovation and job creation in return? Or is it a private benefit, with costs covered by need-based financial aid for the poor, subsidized loans for the middle class, and itemized bills for the well-off, thereby raising the lifetime income of the typical graduate? Is it an egalitarian enterprise capable of changing the world? Or has it become an inward-looking athletics-motivated body, able to admit preferentially those who can afford to pay rapidly accelerating tuition and fees?

Is the current global financial crisis causing the American middle class to be squeezed out of access to a college degree? Is post-secondary education a meritocratic public good requiring nurture and investment, or is it a private entity closed to all except those with the resources to keep up with constantly increasing costs? Is it possible any longer to offer a wide range of programs, particularly in low enrollment specialties, offered in state-supported schools? Does the global debt crisis diminish the capacity of the arts, humanities, and social sciences to civilize world citizens and to engage in civil discourse?

Affordability: Paying the Bill for College

These questions defy simple responses, but making college affordable is the responsibility of any academic administration. Need-based financial aid is available from federal sources (Pell grants and subsidized loans) and from state sources (Cal grants). Small amounts are available for recognized scholastic attainment (as a Regent Scholar) and the system-wide Blue and Gold Initiative guarantees full coverage of tuition and fees for families with incomes lower than \$80K. Students are expected to include self-help in their plans. Financial aid was not explicitly included in itemized cuts in the University budget.

Recently the proportional fractions of students studying at UCSD show significantly more students in the top two income quintiles than in the bottom two quintiles, indicating differential income as one important contributor affecting enrollment and degree completion. And, the demographic differential is growing, not shrinking.

For example, 2/3 of graduating UC students completed their studies in debt. Of those who did so, the average payback period for an average of about \$17K debt was 25 years. And tuition and fees constitute only about 1/3 of expenses incurred: students and their families must somehow cover housing and dining, books, transportation, and health care and insurance. The availability of financial support, whether through grants, scholarships, or fellowships is inadequate or barely adequate, but remains vitally important to student success.

Having a reliable source for the increasing price of a BA/BS is growing more and more difficult. Gone are the days when a needy student could work a part-time job for a few hours each week to cover tuitions and living costs, which are also rapidly accelerating. And gone as well is a rapid pay-back to the state for the state-determined subsidy through taxes paid by graduates consequent to prompt completion of degrees and attainment of stable employment.

These cost/price observations predict profound monetary effects on excellence in university operations and demonstrate an evolving picture of priority-setting in many public research universities. Constantly networked with fellow students for social, personal, or educational purposes, the new student emerging from our best U.S. research institutions will be required, in my opinion, to deal with a different economic reality than faced by their parents a generation earlier.

Fields of Study: Growing Attention to STEM Disciplines

Integrated creativity has come to be valued over rote-style processing of information. The new "normal" student will therefore be more likely to choose his or her institution based on the quality of the typical learning experience. STEM (Science, Technology, Engineering, and Mathematics) disciplines offer a challenging environment, along with the prospect of gainful employment, and the new student will likely develop greater interests in these fields than heretofore. (Let's hope so!)

But our universities also play a significant role in preserving and extending our civilization, as we probe the human condition more deeply. Such considerations underlie the importance of the continuing contributions of the arts, social sciences, and humanities. And pursuit of the professions remains vital to modern life. All courses of study will continue to define the well-educated person as one capable of critical thinking, of working in teams, experienced in problem solving, skilled in communication, both oral and written, and able to take intellectual risks from a platform indicating depth of study within one or more fields.

New students will also observe that many of their fellow students who pursue a STEM major, at least for the present are not native-born U.S. students. The UK, for example, produces per capita 3-5 times the number of STEM graduates than does the U.S., and China produces 10 times absolute number of engineers as does the U.S. It is a simple statement of fact that 3/4 of the citizen recipients of the 2010 U.S. National Medal of Science and Technology were born outside the U.S. The global implication for top quality academic STEM research and instruction is obvious.

High levels of creativity can be turned into major innovation centers when researchers with STEM expertise interface with those conducting medical research, collaborating through models designed by excellent business and engineering schools. Such an aggregation/cooperation/collaboration of experts, broadly dispersed throughout the world is required, if the U.S. is to use its intellectual strength to identify the next wave of products. It is unavoidably true that STEM will contribute dramatically to national prosperity and well-being. U.S. students must be at the table where critical decisions are made.

Because a firm foundation in STEM advances will be necessary for next-generation job creation, scientific literacy will become increasingly important in informing public policy decisions. Federal support for basic research must continue on the upward projection that has transpired within the past several decades. Increasingly frequently, well-educated people will no longer feel comfortable being uninformed about scientific advances. As a result, formal credentialing will supplement the awarding of degrees in STEM fields. Since the time-to-degree will be shortened, net costs will go down, with expected rising tuition costs being fully disclosed to each prospective student in a legally binding letter/contract offered each student at the beginning of his/her post-secondary study.

Increasing Emphasis on Quality by Program Ranking

Next generation students will continue to chase the American dream, sometimes described as owning a house, a car, and a college degree, each with sufficient cachet to be admired by one's friends. Academic quality is important to this path, not only because of the real and perceived value of completing a degree at a highly rated institution. The successful completion of a bachelor's, master's, or doctoral degree is also associated with high intelligence and superior performance.

Publishing rankings of American research universities has become a lucrative cottage industry for magazines and professional societies. Accurate rankings, however, have been proven to be difficult as the missions and priorities of each institution become more complex. Often, the criteria for rankings are ill-defined and may or may not agree with what a particular student thinks most important for his or her course of study.

The most interesting academic problems will address real world problems, and will probably be conducted in units outside the department. For example, in the future, organized research units, often including co-workers from private industry, will sometimes provide an alternative academic home. Faculty will more frequently be hired in clusters of three to five or more instead of by divisions. Frequently, these clusters will likely also include industrial partners, with pre-arranged agreements for well-defined student support and ownership of intellectual property. Thus, private-public partnerships may focus on product output rather than input.

The composition of these clusters will be in near constant flux, on an academic time-scale. Thus, relatively rapid bundling and unbundling of the clusters will produce new combinations of expertise, with strong faculty coming and going. Involved students will tend to work for shorter periods on several different research problems, with thesis requirements being completed in shorter periods, perhaps three years for a BA or BS degree, three plus one and three plus two or three for the MS or PhD, respectively. It is also likely that a sequence of professional master's degrees will be pursued more frequently, and with faster completion times, than in the typical PhD, as the Sloan Foundation has projected.

Recent advances in information technology make it plausible that OLI can transform both teaching and learning as hybrid methods of pedagogy are developed. Classroom instruction will be altered by soon-to-be accessible tools that remove some of the time constraints inherent in traditional classroom-base, thereby blending conventional and digitized information. Across the nation, digitization of libraries and special collections is proceeding apace. Just as the case study method was developed for law instruction, new courses with different styles will be redesigned and made available recognizing the enhanced opportunity for visualization and audio elaborations.

This is true whether delivered as a free good, as in the Massachusetts Institute of Technology's (MIT) posting of all course materials on the Internet, or as a commoditized course, such as that offered by the University of Phoenix. The MIT Open Courseware experience, which put every course syllabus at MIT online free, however, argues that the value of an MIT degree is not conveyed by the online materials themselves. Instead, commoditized content does not equate with the rich experience of relationships between a faculty member and bright, driven students. This continued value of 1:1 interaction may allay some faculty skepticism about wide adoption of online courses.

Recent advances in information technology make it plausible that online instruction can transform both teaching and learning as hybrid methods of pedagogy are developed.

On-line Instruction

By all counts, the new student will be networked globally. The largest global change in post-secondary education will involve the facilitation of education through IT, both inside and outside the Academy. As we have seen, tuition rates for standard higher education have risen at a rate greater than inflation for over two decades as the state-allocation of support for public institutions has declined. Technology instruction, while considered disruptive within a conventional classroom, may enable adult (over age 25) post-secondary education, or facilitate focused training leading to certificates. For example, certificates in business, education, accounting, or as a health science technician are very valuable. But On-line Instruction (OLI) is not likely to reduce costs significantly. In many cases, adult students will appreciate being fully time-adapted to the module approach typically offered to adult learners as more consistent with an adult's responsibilities.

There may be no financially viable alternative to the broad use of technology, but the reduced flexibility of a two year transfer route may demand a shift in the ratio of asynchronous online courses to hands-on recitations or lectures. This shift illustrates divergence of priorities for different groups of students, e.g., cost vs. convenience or individualized counseling. In this way, educational programs for global citizens must use technology if quality comparisons by current assessments are to be attained, irrespective of cost or added value.

Although the effectiveness of learning with these techniques has been controversial, a strong independent authority, i.e., the Sloan Colloquium, has found that online methodology is as effective, or more so, than conventional lectures for motivated student learning. Indeed, William Wulf and I argued nearly a decade ago at a conference at the National Research Council that adoption of this disruptive networked methodology was likely

(continued on next page)

to be “rapid, profound, and ubiquitous.” The timing for this prediction proved to be incorrect, probably with interested students awaiting the availability of dependable mobile hardware to become more universally available.

Recognition that quality is even more important in OLI than in traditional modes for content delivery has been nearly enthusiastically accepted, although the need for detailed scrutiny of independent offerings will have to be continued by highly respected accrediting agencies. As a result, for-profit schools may, in fact, produce excellent classes ahead of at least some offerings from research universities.

One public not-for-profit online school that is attracting broad attention is the Western Governors’ University (WGU), started as the name implies by the sitting governors of many western U.S. states as a virtual degree-granting entity. So successful has been WGU that other states have joined in their offerings, *e.g.* Indiana. These programs mirror the highly successful Open University, which has developed in the UK to include a wide range of academic options over several decades. The ability of students to communicate with professors through inexpensive mobile devices implies that such tools can be transformative in how students study and learn. It is likely that such tools will invigorate professorial inclusion of IT within their regular courses. These so-called hybrid interactions, irrespective of whether or not they are used in online instruction, are only now beginning to reach their full potential.

And yet such efforts continue to generate academic skepticism. In a recent article in their trade publication, *Educause* has addressed and debunked many of the historic myths that have become associated with online delivery. Issues addressed include: purported excessive time commitment; major cost over-runs, particularly in the first several offering years; need for broad investment in acquiring fluency in new media IT; threats of termination of teaching assistants and lecturers; interference with brand; faculty desires that offerings be free; assumptions that scale will permit only those options in which faculty at School X be asked only to interact with students at the same institution; and excessive cheating, leading to artificially

elevated, and unearned, GPAs. There is also a wide nagging worry that students simply do not learn as well unless the infrastructure is arranged for face-to-face tutoring.

In contrast, a multi-year study sponsored by the Alfred P. Sloan Foundation has shown clearly that students who choose online education show strong motivation and no clear evidence for the stated concerns. A definitive pilot study at UC, to be conducted in the 2012-2013 academic year, should go far in resolving these concerns. It is quite likely that an optimal delivery system will be a hybrid, incorporating IT as a classroom and recital supplement.

Building Diversity: A Mandate for an Inclusive Future

Admitting a highly talented entering class at the graduate or undergraduate level defines intellectual program quality. It endorses change, as the natural consequence of discovery. Given the importance of inclusion in support of national diversity goals, it is likely that in the next several years, research universities will confront continued focus on diversity relevant to admissions and hiring: (1) when under-represented groups will predictably constitute a majority of STEM scholars; (2) when rules affecting class and ethnic diversity are reconsidered; and (3) when out-of-state and international students are admitted as a larger fraction of the student body.

Several states are already minority/majority states, and U.S. core values have always included immigrants. But attracting students from under-represented groups has proven to be difficult. Substantial outreach efforts must be undertaken at all of the UC universities, for example. In addition, California’s Proposition 209 makes it illegal to consider race, ethnic origin, or minority status in admission decisions. And the recent Supreme Court rulings concerning the University of Michigan’s affirmative action continues to be challenged.

The positives of a STEM career are emphasized by most universities in promoting diversification of the student body. Because these changes will affect student attitudes and modes of interaction with professors, they will significantly influence student participation in foundational departments. Out-of-state

admissions generally face much higher tuition (sometimes more than double in-state rates), and, as a result, are vital financial sources, but they grow at the expense of state legislative/political commitments to state citizens. Whether to admit undocumented students at in-state tuition rates remains unresolved. As other countries develop their own scientific infrastructure, STEM graduates become objects of high interest: non-native scientists and engineers attract high salaries and bright careers. We must be more aggressive in retaining such men and women.

Women in STEM Disciplines

Qualifications for faculty appointments and student admissions continue to be debated and reexamined at both the faculty, graduate, and undergraduate levels. To the extent that a particular group presents credentials different from their demographic presence in the U.S. population, university administrations recognize under-representation and lack of inclusiveness. For example, females remain under-represented on chemistry and physics faculties nationwide, despite their obvious presence in our nation’s best graduate schools. Why? The next section focuses on women, but the same situation pertains also for other under-represented groups.

Consider the following interesting observations about the academic records of U.S. women. Last year, 72% of the nation’s high school valedictorians were female and the number of PhD degrees granted to women was 10% higher than in the previous year. Yet, with 41% of all doctoral recipients being female, women represent only 26% of the U.S. science and engineering workforce, and only 17 per cent of chemistry faculties. Similar trends will also be observed with members of other under-represented groups. A study by American Women in Science concluded that by attaining or exceeding a population threshold of about 25 percent, many issues concerning women’s status simply disappear. Unfortunately, this threshold is rarely exceeded in academic science and engineering departments.

Most universities have responded to minority workforce climate issues by focusing on attaining a supportive environment that is responsive to the personal and family needs of faculty and prospective faculty. At UC, for example, recruitment notices include statements upholding diversity and faculty are encouraged to establish supportive affinity groups. Applicants are also encouraged to describe their own commitments to diversity, and applications containing such statements are circulated widely to multiple search committees. Provisions can be routinely made for lactation; child care; family accommodations, including parental and eldercare needs; extension of the probationary period, if requested because of pregnancy or adoption; deferral of merit reviews, if requested; and periods of flexible workload scheduling.

Despite such interventions, inequities continue to exist and women who are absent from tenure-track positions are also under-

Faculty will more frequently be hired in clusters of three to five or more instead of by divisions. Frequently, these clusters will likely also include industrial partners, with pre-arranged agreements for well-defined student support and ownership of intellectual property.

represented in competing industrial positions. Where are the women and members of minority groups? What interventions are needed to achieve full parity? The answer is complex but worthy of continued investigation.

Financial Support Sufficient for Access and Affordability

As core values, excellence/high quality, access, and affordability support the California Master Plan for higher education. Until recently, UC tuition was very low, but recent economic uncertainty has caused further pressure on the low tuition/low aid model. The University of Michigan (UM) has long sponsored a high tuition/high aid model, in which substantial financial aid is made readily available to low income families. In the fall of 2011, for example, Michigan's tuition and fees were \$12.6K, close to UC San Diego's at \$13.2K, both at in-state rates. The UC figure was reached only after a 30% rise over the previous two years, whereas the UM figure represented a small increase on an already high sticker price for a UM education.

At both institutions, out-of-state tuitions were much higher: \$37.8K at UM and \$36.1K at UC. Clearly, admitted non-residents without need for financial aid contribute significantly toward solving financial shortfalls. In the high fee/high aid model, students from high income families pay full fare, with the difference between cost and stated price becoming even larger than in the past. That is, with low tuition it was generally possible to meet the needs of families with lower income from a revenue stream originating from high income students.

Squeezing Low- and Middle-Class Students

The economic downturn, however, has squeezed middle class students and forced new levels of cost consciousness in choosing a college. Many students are working long hours to afford attendance at the best research universities, and are unable to find sufficient study or social time. The federal government has responded by increasing Pell grants, and many states have provided partial grant relief for in-state students. Subsidized loans for those with low-to-middle family income are being provided at a low net interest rate, along with generous loan forgiveness packages. Although default rates are at an historic high, the federal government has recently proposed reduction of the repayment rate for low income borrowers and a reduction of repayment at a renegotiated rate for those willing to consolidate loans into a government direct loan program. New and stricter academic requirements must also be met in this proposal, with the government demanding enrollment of at least 36 units per year and a GPA of 2.0 for continued eligibility.

With this cost structure, are middle income students able to enroll? Or will the enrollment of middle income students continue to decline? So far, there is some limited proof of decline

The economic return arising from scientific discoveries provides one important payback to the nation for the confidence reflected in federal support of research.

in enrollment of middle class students, but diverging levels for cost vs. price for a 2 plus 2 community college or bachelor's degrees do represent a cost-effective alternative. Broader use of articulation agreements to assure transfer students of timely admission to a four year undergraduate college permits longer range planning, typically over two to four years. This approach thus provides a heavily discounted option for graduates of community colleges, but the 2 plus 2 approach also restricts available electives and present student with fewer undergraduate research opportunities. This general approach also applies to recent proposals, first suggested by Texas governor Rick Perry, in which a three year time requirement for a university degree is completed by counting courses taken in the twelfth year of high school in lieu of first year college courses.

Revenue Streams

We have also reevaluated accounts within the endowment to ascertain donor intent for restricted and unrestricted uses and have renegotiated uses of fees from university-associated auxiliaries. The Office of the UC President has also pledged to minimize claims against campus-controlled tuition and fees and indirect research costs through deep administrative cuts. UC has also created a "Work Smarter" initiative that seeks to redirect \$500M annually in five years from business administration to academic and research enterprises. So far, 24 projects have been evaluated as good ideas and opportunities, and implementation strategies have begun.

After careful discussion about alternative revenue sources, we have also initiated partial payout of reserves as recoverable inside income over a three to ten year pay-down period and have begun to explore means to enhance security of private equity investments derived from intellectual property discovered or created by faculty and research staff. We have actively worked with experts on our Foundation Board to be judicious in making such allocations, as well as with CONNECT and with the Kaufmann and von Liebig Foundations, all of whom have specialized in commercialization of intellectual property. We do recognize, however, that successful partnering for private/public commercialization requires faculty acceptance of unfamiliar levels of responsiveness and risk-taking. Nonetheless,

the Davos World Economic Forum has concluded that "a world without risk taking is a world without innovation." Clearly, university processes will have to adapt to the *modus operandi* of our partnering industries.

The economic return arising from scientific discoveries provides one important payback to the nation for the confidence reflected in federal support of research. Universities have also long benefitted from the Bayh-Dole Act of 1982. This legislation provides for university ownership of IP (intellectual property) generated by principal investigators sponsored by one or more federal agencies. Application of this law has proven to be exceedingly positive for the creation of wealth and in encouraging follow-up for derivative work. Some public-private partnerships have expressed frustration with the Act, usually because of time delays encountered in negotiating shared returns for jointly owned IP. Increasingly, such shared income is negotiated before the relevant work is conducted. Continued and expanded cooperation in handling IP is anticipated to improve as more federal attention is devoted to improving other challenges of American patent policy, e.g., being first to file vs. first to discover in patent filing.

Innovation as an Economic Engine

President Obama has challenged us to recognize that "The first step for winning the future is encouraging American innovation." He acknowledges, as well, that Americans must be resolute in our pursuit of creative new industries that define new jobs and new industries. Exactly how to proceed is likely to be a "big tent issue," in which all relevant expertise must come together to formulate an effective division of labor. Research universities also add significantly to national prosperity: for example, UCSD annually contributes over \$7B to the California economy.

The spirit of cooperation reflected in evolving IP standards also extends to use of shared facilities. More frequent investments in research infrastructure are expected to be played out by sharing instrumentation that is too expensive for single investigators, e.g., gene sequencers, cyclotrons, large animal facilities, or banks of servers capable of high security cloud computing. Collaborations following from shared infrastructure are

(continued on next page)

likely to promote closer interactions on other new scientific problems that need expensive instrumentation, and should open pathways for better inter-personal relationships and, hence, higher productivity. As an example, consider a new program sponsored by the U.S. National Science Foundation, which directly supports innovation teams from multiple institutions based on their record for enhancing commercial viability.

Global Research and Development

Greater international competition will become common as international mergers and acquisitions become increasingly important. National prosperity and the creation of well-paying jobs can be directly correlated with achievement in STEM disciplines, success in international innovation will, in turn, depend on the high quality of graduate students. But outstanding preparation is also required in elementary and secondary schools if the next generation is to succeed. It is for this reason that Americans are shocked by the plummeting rankings of U.S. schools. Over the last decade, the U.S. fell in ranking of achievement in K-12 education from 1st to 38th.

Cambridge and the University of Michigan. One such collaboration, the Asia Pacific Rim Universities (APRU), sponsor an array of annual conferences that foster inter-institutional cooperation. At the same time, medical centers are being constructed by Cornell, Duke, and UC San Diego in Qatar, Singapore, and Abu Dhabi, respectively, and other smaller ventures are targeted on the arts and humanities, such as the UC San Diego's art restoration project in Florence or Notre Dame's program in architecture in Rome and in Irish Studies in Dublin.

These collaborations are but samples of many such agreements from a list too lengthy for this opinion. Partnerships are commonly encountered in the best, evolving entrepreneurial research institutions, but are encountered only less frequently in liberal arts colleges, largely because of scale. The best of American students, here identified as those most eager and able to contribute to innovative improvements of the human condition, will likely choose to attend a school where such collaborations are encouraged.

Building an infrastructure at home and abroad that produces a better educated workforce will be essential. Indeed, college graduates with advanced IT skills will be in great demand. Stretch goals will be adopted as private companies join with public universities and public national laboratories in offering

Business School who maintain that process engineering and engineering research cannot be maintained in the U.S. if manufacturing is sent off-shore.

Innovation must encompass the entire range from discovery/design through optimization and patent protection to marketing and branding. All parts of this process must be included in American engineering sequencing and each must find its way into both the American research strategy and the instructional leadership, if we are to retain a global leadership position in manufacturing.

Summary

The current shortfall in projected allocations from state legislatures will place unprecedented pressure on the budgets of research universities and will test our definition of American public research universities. Economic realities are likely to spark new interest in the STEM disciplines. The future success of research institutions will depend on insisting on high quality programs that are accessible and affordable to American middle class students. In turn, achieving high institutional rankings will require identification of new revenue streams and highly efficient management processes, even as operational austerity becomes more and more evident. A new emphasis on information technology, mobile instruction, intellectual property, and international collaboration will be essential for us as Americans.

Innovation must encompass the entire range from discovery/design through optimization and patent protection to marketing and branding.

The immediate consequence of such interactions is the blossoming of branch campuses and targeted programs, including international distance education options. Some of our strongest research schools are active in alliances that produce more than the sum of their component parts. For example, research centers have been opened or are being planned by Stanford and Cornell in New York City; by a consortium of Columbia, New York University, City University of New York, University of Toronto, University of Warwick, IIT Mumbai, and Carnegie Mellon in Brooklyn, along with seven industrial partners; by UC Berkeley and Tsing-hua in Shanghai; and a broad venture in Singapore between Yale and the National University of Singapore.

Other institutions are creating geographically integrated consortia that attracts international expertise from some of the world's strongest universities, e.g.,

continuing education required for prioritized problems at places such as Google Singularity University, Motorola University, or the Clinton Global Initiative University.

Many U.S. companies conduct their R&D abroad because of the insufficient availability of senior scientists and engineers within the U.S. For example, Apple Computers has now hired 700,000 employees in China, where innovation is followed routinely by production within the same factories where the innovation idea had originated, again moving manufacturing away from the U.S. Companies have routinely asked the federal government for larger numbers of H-1 visas so that foreign-born engineers can enter our workforce. So concerned was Andy Grove, the former CEO of Intel, that he is asking repeatedly for a return of manufacturing to the U.S., if necessary through tariffs on off-shore products. This is in accord with the position of Pisano and Shih of the Harvard

About the Author

MARYE ANNE FOX is the seventh chancellor of the University of California, San Diego. She also holds the title of distinguished professor of chemistry and has received honorary degrees from 12 institutions in the U.S. and abroad. In October 2010, President Barack Obama named Fox to receive the National Medal of Science, the highest honor bestowed by the United States government on scientists, engineers, and inventors.

Dr. Fox has been elected to membership in the National Academy of Sciences, the American Association for the Advancement of Science, and to fellowships in both the American Philosophical Society and the American Academy of Arts and Sciences.

Fox has received numerous research and teaching awards. From the American Chemical Society, she received the Garvan Award, the Southwest Regional Award and the Charles Lathrop Parsons Award for 2005, in recognition of outstanding public service. She also is the recipient of the Monie A. Ferst Award, a national award recognizing outstanding mentoring of graduate students. She may be reached at chancellor@ucsd.edu.