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The Virginia News Letter

Higher Education as the Engine of the American Economy*

by Teresa A. Sullivan

It's no secret that higher education serves as the engine, or driver, of the American economy, and by extension, the Virginia economy as well. To give an appropriate mental image for this topic, let me begin by describing a news story and photo that appeared on the CNN website recently.[1] The story explained how the American economy had begun to languish in recent months, after promising growth in the earlier part of 2011. The story cited slow economic growth of 1.8 percent in the second quarter and mentioned falling consumer confidence, a slowdown in hiring, a drop in home prices, a reduction in manufacturing, and other symptoms of a sluggish economy.

The headline read: "Economy Still Stuck in the Mud." Under the headline appeared a black-and-white photo from the 1950s or 60s. The photo showed an old bus stuck in the mud, with all of the passengers, women and men in their dresses and suits, lined up behind the bus, trying to push it out of the muck.

Now, if we see the stuck bus as a symbol of the current state of the American economy, and if we think of ourselves and our fellow citizens as the stranded passengers trying to push the bus out of the mud, then all of us might wish for a better engine. We would prefer an efficient, high-powered engine capable of driving the bus forward and getting us out of the mud.

Teresa A. Sullivan

The good news is that we already have a high-powered engine for our economy. This engine has effectively propelled the American economy for the past half-century or more. It has been one of the great success stories in our national narrative, and with proper, prudent investment—the good care that all engines need—it can provide the necessary horsepower now to drive our economy out of the mud.

Of course I refer to our higher education system generally and our research universities in particular. Our colleges and universities have the necessary elements of human talent, a culture of cross-disciplinary collaboration, and a long view perspective, to lead to a new, sustained renaissance in American innovation and economic growth. This article will show how that renaissance can happen.

Before we consider what higher education can do for the economy in the future, however, we should look back at what it has done for the American economy in the past. The past, as we know, holds lessons for the future.

The Success Story

It's a broadly acknowledged fact that federally funded university research has been the driving force in the American economy since World War II. Funding to universities through the National Institutes of Health (NIH), National Science Foundation

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(NSF), Department of Energy (DOE), and other agencies has created jobs, improved health care, and led to the discovery of new technologies, new products, and whole new industries that have enhanced the human condition in every conceivable way.

In our daily lives, we are surrounded by the fruits of this work, but we often forget that many of our everyday things grew out of university-based research. Countless products, technologies and medications are the result of university research. Here are just a few examples culled from an unofficial list compiled by U.Va.'s Patent Foundation:[2]

- The method for fortifying food with Vitamin D was developed at the University of Wisconsin in 1925.
- The first general-purpose electronic computer was invented at the University of Pennsylvania in 1946.
- The development of Fluoride toothpaste that was invented by researchers at Indiana University in 1956.
- The first retractable, locking seat belt for cars was invented at the University of Minnesota in 1963.
- The liquid crystal display, or LCD, that is used in numerous applications including computer monitors, television sets, and instrument panels, was invented at Kent State in 1967.
- The computerized axial tomography scan (better known as the CAT scan) was invented at Georgetown University in 1973.
- The Kentucky bluegrass hybrid, which is now the turf-grass of choice throughout much of the U.S., was invented at Rutgers in 1977.
- The drug Adenocard, commonly used in emergency rooms and emergency rescue vehicles to treat patients who develop dangerously high heart rates, was invented at the University of Virginia in 1985.

Political leaders and policy makers who are searching for a solution to the sluggish American economy are surrounded by clues. The economic and societal impact of higher education should be apparent to them every time they drink a glass of Vitamin D-fortified milk, every time they brush their teeth, every time they buckle a seatbelt, and every time they walk across a plush expanse of Kentucky bluegrass in their back yards.

In the last half-century, the impact of university research on the pharmaceutical industry alone has been remarkable. A recent study found that during the past 40 years, 153 new FDA-approved drugs, vaccines, or new uses for existing drugs were discovered through research carried out at public sector research institutions.[3] In addition to making rapid advances within existing industries, university research has given birth to entire new fields and industries, like biotechnology and the Internet.

In recent years, university based research projects have produced countless companies that are creating jobs and improving lives across the nation. Here are a few examples:[4]

- North Carolina-based SAS, today a major provider of business software, began as a U.S. Department of Agriculture-supported research project to analyze agricultural data at NC State University. Today, SAS employs more than 11,000 people, and *Money* magazine ranked it as the #1 best U.S. company to work for in 2010.
- A123 Systems, founded by MIT researchers in 2001 with support from the Department of Energy, has helped lead development of the advanced battery manufacturing industry in the U.S. A123 Systems now makes millions of batteries each year for hybrid electric cars and buses and large-scale energy storage systems. The company employs about 1,000 people.
- An NSF grant supported the basic research at Stanford that led to the creation of Google, which now employs more than 24,000 people. That investment cycle came full circle last year, when Google announced that it would begin investing in university research through its Focused Research Awards program.[5] (Incidentally, if you search the Internet for the CNN article that I mentioned earlier, Google will find the article for you in 0.16 seconds, along with a quarter of a million other closely related search results.) Next time Google brings precisely the right information to your fingertips in just a few milliseconds, remember to say thanks for university-based research.

Another success came to life at U.Va. when two faculty members, one from engineering and one from medicine, developed a new instrument that detects the genomic response of human blood cells to new drugs. With support from the Coulter Foundation, they started a company called HemoShear to produce the instrument in Charlottesville. Just two weeks ago, HemoShear was awarded a $4.3 million Small Business Innovation Research grant from the NIH to develop a database that will allow their researchers to profile the effects of 50 drugs on the human blood vessel system. The database they develop will help predict the safety and efficacy of new drugs. HemoShear

is one example of the virtuous cycle of investment, discovery and creation that improves the human condition.

Groundbreaking discoveries would not be possible without the unhurried, patient work of basic research. Just to clarify terms, *basic research* is research conducted purely to respond to scientific curiosity and to deepen our knowledge, often with no direct commercial benefits. *Applied research* uses accumulated knowledge from basic research to develop new solutions to problems and to create new products and technologies. Universities now conduct most of the basic research in this country. According to the National Science Foundation's *Science and Engineering Indicators, 2010*, universities conducted 55 percent of the basic research in the United States in 2008, while business and industry conducted less than 20 percent.[6]

There was a time in our history when corporations and major industrial labs, such as Bell Labs, conducted basic research. But gradually over the years corporations have pulled back from basic research and focused on development. They have withdrawn because of the business mindset that fixates on immediate results and quarterly profits. Research and development (R&D) at most companies is now mostly "D" and very little "R."

This has left the "R" to universities. Fortunately, universities are well suited to focus on basic research because we have a culture that fosters the long view thinking necessary for this kind of work. Universities encourage curiosity and creativity over the long term, as opposed to the short-term perspective that prevails in most companies. Because they are able to remain focused on the long view, university researchers have the freedom, and perhaps most importantly, the patience, to conduct the kind of disruptive, innovative research that becomes the foundation of technological advancements.

The past 30 years have been especially productive, thanks to passage of the Bayh-Dole Act in 1980. This legislation allowed universities to own the intellectual property, or IP, arising from federally sponsored research, with royalties shared between the university and inventors. In the years since 1980, the number of startups and products based on university IP has shot up dramatically, because universities and researchers are now incentivized to commercialize their inventions.

Prior to 1981, fewer than 250 patents were issued to U.S. universities annually.[7] Now, let's fast-forward three decades. According to the Association of University Technology Managers' most recent survey of U.S. start-up creation and licensing activity, 596 new companies were formed as a result of university research in fiscal year (FY) 2009, and 658 new commercial products stemming from university research were introduced in the same period.[8] The survey showed that 3,423 university-based start-ups were operating successfully as of the end of FY 2009. Another recent study estimated that university-based inventions contributed as much as $457.1 billion to U.S. gross industrial output and created more than 279,000 new high-tech jobs from 1996 through 2007.[9]

Beyond the value that new inventions bring to the economy, greater educational attainment among the population has a generative effect on the economy, too. A Brookings Institution policy brief cited a data analysis from 146 countries, collected between 1950 and 2010, that showed that each year of additional average schooling translates into at least a 2 percent increase in economic output.[10] In Virginia, one of the key goals of Governor Bob McDonnell's Top Jobs higher education legislation is to increase the number of degrees earned by Virginians by 100,000 over the next 15 years. Why? Because more education equals greater economic output and better quality of life for all citizens.

All the complicated data that I have cited could be translated into a very simple recipe for economic growth—gather diverse human talent in a university setting, add proper financial investment, allow time for discovery through basic research, add incentives for commercialization, and stir vigorously.

We have seen the positive economic results of this formula for over a half-century. All of us have benefitted from the new discoveries and innovations that have emerged from university research. But the great success story of higher education as the driver of the American economy is now threatened by several factors. And this is happening at the worst possible time, because other nations are gearing up their systems of higher education just as these threats here at home are taking hold.

The Threats to Success

In recent years, federal investment in university research has leveled off and even declined. The federal government provided $31.2 billion, or 60 percent, of funding for academic R&D expenditures in FY 2008. In inflation-adjusted dollars, this represents only a 0.2 percent increase from FY 2007 and follows decreases of 1.6 percent in FY 2007 and 0.2 percent in FY 2006. According to the federal agencies that provide the funding, total federal obligations for academic R&D peaked in 2004 at $22.1 billion (in constant 2000

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dollars) and declined by almost 7 percent to an estimated $20.7 billion by FY 2009.[11]

At the same time that federal support for university research has been waning, state support for public colleges and universities has been cut dramatically. According to a report from the Center on Budget and Policy Priorities, at least 20 states proposed major cuts in higher education funding this year.[12] This included proposed cuts of as much as a billion dollars in California.

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This year's cuts are just the latest bad news in a two-decade trend. State support on a per student basis hit a 25-year low last year, according to State Higher Education Executive Officers, a nationwide association.[13] In a *Chronicle of Higher Education* survey conducted last month, chief financial officers from 500 colleges ranked declining state support as "far and away the most worrisome factor facing their institutions."[14]

Because of the drop in federal support and sharp reductions in state support, some college leaders say that stark financial realities will force colleges and universities to scale back their missions. They will have to cut research and academic programs and other core facets of what we do. We cannot allow this to happen; the stakes now are simply too high.

While support for higher education is on the decline here in the U.S., support in other nations, such as China and India, is on the rise. These nations are investing in the research capacities of their universities because they know that this investment is the key to competitive success in the 21st century. In the U.S., we risk losing our edge because we are pulling back at precisely the time that other nations are investing heavily in scientific research and in higher education generally.

Another threat to higher education's role in economic growth is the belief that university research is incompatible with a great undergraduate education. In fact, critics say that research detracts from teaching and learning. This belief is grounded in a static and fundamentally underachieving approach to students' abilities. I would argue the opposite point: that participation in research enriches and improves teaching and learning.

The argument that research and teaching are complementary is supported by a paper published in *Science* magazine in August that was co-authored by four faculty members in U.Va.'s Curry School of Education and several colleagues at other universities.[15] They studied research proposals created by two groups of graduate students: one group whose members had *only* research responsibilities, and a second group whose members had *both* research and teaching responsibilities. The study showed that graduate students who conducted research *and* taught were much better at generating testable hypotheses and designing valid experiments. In other words, teaching experience contributes substantially to the development of research skills.

Just as government investment in research creates a virtuous cycle of innovation, connecting research to teaching creates another virtuous cycle in which research and teaching reciprocally improve each other. At U.Va. and other Virginia research universities there is a culture that fosters this cycle. Faculty members integrate scholarship and research in their courses, drawing no sharp distinction between teaching and research. This past summer, for example, 24 U.Va. students received Harrison Undergraduate Research Awards to support independent projects. Their work focused on a wide array of topics. One student studied the use of anti-depressants to treat post-traumatic stress disorder. Another student researched unlawful pre-trial detention in the Ugandan criminal justice system. One student researched how sensory information about taste is processed in the brain. Another student studied the effectiveness of a water filtration system in a rural community in Guatemala. Such projects give our undergraduate students access to the labs, tools, and, most importantly, the *minds* of our faculty members. Research does not detract from students' undergraduate education. On the contrary, it enlivens the learning experience. It familiarizes students with the culture of research and the life of a scientist. This is a net gain for the students *and* for the universities.

We have seen that various pressures are threatening higher education's capacity to drive the economy. The pressures are lackluster federal support, a progressive collapse of state support, and skepticism about the compatibility of research with undergraduate education. If these are some of the problems we face, what are the solutions?

What Needs to Happen Now

I believe we need a renewed national acknowledgement of the essential role that colleges and universities play in driving the economy, followed by appropriate investments to support that role. Federal investment in academic research and development is the surest means of ensuring our national security now and in future generations. We know that the recent debt ceiling compromise could lead to serious cuts in federal R&D funding in 2013. This would be a grave mistake. Our economy will remain mired in the mud unless we re-invest in the research that drives innovation.

Once again, the past holds lessons for the future. Fifty-four years ago, the Soviet Union launched the Sputnik satellite and triggered the Space Race. For years we had assumed that our nation was more technologically advanced than the Soviet Union. Sputnik proved we were wrong. In the U.S. Congress, Clare Boothe Luce from Connecticut called Sputnik's beeping noise "an intercontinental outer-space raspberry to a decade of American pretensions that the American way of life was a gilt-edged guarantee of our national superiority."[16]

Sputnik was a national wake-up call, and with the passage of the National Defense Education Act in 1958, we began a period of vigorous investment in education at all levels, especially in math and science. Funding for both the National Science Foundation and the National Institutes of Health grew dramatically over the next decade. Funding for NSF increased from $34 million in 1958 to $500 million in 1968, while NIH's funding grew from $210 million to $1.08 billion.[17]

Our global competitors are investing in higher education now, and we need to do the same, just to keep pace. Public-private partnerships should be an essential part of this renewed focus. The heads of federal research-funding agencies know that universities are the linchpins of economic growth, and they know that connecting universities to private partners will accelerate growth.

On July 28, the same day that CNN published a story portraying the American economy as a bus stuck in the mud, the National Science Foundation announced a plan to spend $1.25 million this year on a program to connect 100 of its university grantees with members of the private sector to help convert academic research into marketable products.[18] The initiative, called Innovation Corps, or I-Corps, will identify scientific and engineering discoveries that have practical applications from among the NSF's recently financed projects and provide researchers with networking opportunities outside the laboratory. This is a good idea; we need more ideas like this one.

We have two examples of effective public-private partnerships in Virginia. We are now part of an innovative partnership that brings the state together with U.Va., Virginia Tech, Virginia State University, the Virginia Community College System, and Rolls Royce to collaborate on a variety of fronts in engineering and business. The partnership is resulting in the creation of two major research centers that will support the needs of industry: the Commonwealth Center for Advanced Manufacturing, or CCAM, which will be adjacent to a new Rolls Royce factory in Prince George County, and the Commonwealth Center for Aerospace Propulsion Systems at Virginia Tech, which will bring together best-in-class researchers to collaborate on research activities critical to jet engine design. This public-private partnership leverages the assets of higher education to pave the way for innovation and new technologies that will generate new jobs in Virginia.

Another example is the annual U.Va. Venture Summit, which brings venture capitalists representing at least $15 billion in active capital funds here each year. At the summit, potential investors hear pitches from start-up companies and entrepreneur teams, and they provide live feedback. This year's summit drew venture investors from Singapore, San Francisco, Boston, New York, and other places around the globe.

A West Coast example of public-private partnership is the CONNECT program, based in the University of California-San Diego. This program connects inventors and entrepreneurs in the San Diego region with the resources they need to commercialize products. The program has been a great success for a quarter of a century. CONNECT has assisted in the formation and development of more than 2,000 companies since 1985.

Economic Engines, and More

We know that universities are engines of innovation and economic growth, but this characterization may oversimplify and undervalue their contributions. Yes, universities transfer research to industry; yes, they generate new inventions; yes, they spin off technologies that lead to the formation of startup companies. But they do more than that.

Richard Florida, author of the book *The Rise of the Creative Class,* writes that universities supply to our nation the "three T's": technology, talent, and tolerance.[19] In addition to being engines of innovation, universities attract talent in the form of teachers, researchers and students, while luring entrepreneurial people who are attracted by universities' resources. At the same time, universities foster a tolerant culture that is open to new ideas and diverse perspectives. Students and faculty from a wide range of racial and socioeconomic backgrounds and from various national origins come together in a meritocracy that encourages tolerance for new ideas and experimentation.

The three "Ts" allow universities to create what Florida calls "creative hubs" that foster regional development. We see these creative hubs in the greater Boston area; in the Silicon Valley; in North Carolina's Research Triangle; in Charlottesville, Northern Virginia, and other locales in this state; and in other areas across the nation where universities invigorate and stimulate the

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economies of the regions that surround them. Nonetheless, Virginia can do more. Data from the National Science Foundation show that relative to the national average for all states, Virginia's spending on academic research is low. In 2007 academic R&D expenditures in Virginia were $971 million and amounted to $2.53 per $1,000 of state gross domestic product (GDP).[20] Nationally, the figure was $3.55—an amount 40 percent more than in the commonwealth. Virginia's performance was also subpar in relation to the neighboring states of Maryland and North Carolina. In Maryland $2.5 billion ($9.61 per $1,000 of state GDP) was devoted to academic R&D, and in North Carolina $1.9 billion ($4.83 per $1,000) was spent. Despite its many strengths, clearly Virginia has some distance to go to equal its neighbors and even the national average in research spending.

Perhaps more than ever, we need our universities to function well and to receive adequate support because universities are uniquely well suited to tackle the big, complex problems we are facing as a society such as climate change, disease control, economic turmoil, and other multi-faceted problems. University researchers and scholars are able to work across disciplines and to draw connections between their areas of expertise to arrive at solutions for these complex problems. Universities are built around a spirit of collaboration that today's problems demand.

One multi-disciplinary project at U.Va. is bringing faculty from engineering, architecture, chemistry and business together to address major energy issues. Known as ESPRIT (for Energy Systems Prototyping, Research, Innovation and Translation) this team is applying systems approaches to develop energy conservation solutions, including low-loss energy transmission and energy efficient buildings and communities. ESPRIT is just one example of similar programs here and at other universities that draw together faculty from various disciplines to tackle real world problems. This is where today's and tomorrow's discoveries and innovations will emerge, not just in isolated fields of study, but also in the intellectual territory between disciplines.

Time to Get Going

In discussing higher education as the engine of our economy, I've focused mainly on the past half-century. But the increasing role of universities in our nation's economic growth is a result of much older, fundamental forces that have shaped our nation since its beginnings.

Over the past two centuries, we have seen the shift from an agricultural economy to an industrial economy in the 19th century, and then, in more recent years, the shift from an industrial economy to a knowledge economy. At an earlier time, natural resources and factory—style manufacturing were the drivers of economic growth. Now, knowledge, creativity and innovation are the driving forces of economic growth.

Our nation's colleges and universities, together, form a collective engine of knowledge growth and innovation. With adequate support, this great engine can propel us into a bright future of economic prosperity. *Without* adequate support for higher education, we might just stay stuck in the mud. The stakes are high, and the consequences of inaction could be devastating. It's time to get going.

ABOUT THE AUTHOR

Teresa A. Sullivan was elected eighth President of the University of Virginia, effective August 1, 2010. Previously she was the provost and executive vice president for academic affairs at the University of Michigan where she was also a professor of sociology in the College of Literature, Science, and the Arts. Prior to coming to the University of Michigan, Ms. Sullivan was executive vice chancellor for academic affairs for the University of Texas System, a position she held from 2002 until May 2006. Ms. Sullivan first joined the University of Texas at Austin in 1975 as an instructor and then assistant professor in the Department of Sociology. From 1977 to 1981, she was a faculty member at the University of Chicago. Ms. Sullivan returned to Texas in 1981 as a faculty member in sociology. Ms. Sullivan's research focuses on labor force demography. She is the author or co-author of 6 books and more than 50 scholarly articles. A graduate of James Madison College at Michigan State University, Ms. Sullivan received her doctoral degree in sociology from the University of Chicago.

Endnotes

Editor's note: When available, web links for sources are shown. At the time of publication all of the links worked. However, some links may be unstable and may not work with certain browsers or they may have been modified or withdrawn. If you cannot open a link with your default browser, then try another. For example, if you cannot open the link with Microsoft Internet Explorer, try Firefox, Chrome, or Safari.

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