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UNIVERSITIES, THE US HIGH TECH ADVANTAGE, AND THE PROCESS OF GLOBALIZATION*

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ABSTRACT

Research universities throughout the world are part of a larger effort by nation-states to bolster science and technological innovation and compete economically. The US remains highly competitive as a source of high tech (HT) innovation because of a number of market positions, many the result of long-term investments in institutions such as research universities and in R&D funding, and more broadly influenced by a political culture that has tended to support entrepreneurs and risk-taking. In essence, the US was the first mover in pursuing the nexus of science and economic policy. The following essay places universities within this larger political and policy environment by discussing market factors that have influenced knowledge accumulation and HT innovation in the US, their current salience in the face of globalization, and the growing market position of competitors, such as the EU. The paper also provides observations on major US state-based HT initiatives intended to create or sustain Knowledge Based Economic Areas (KBEAs).[1] Thirteen variables are used to assess the overall comparative ability for creating KBEAs, including the vitality of regional and national research universities, patterns of R&D investment, access to venture capital, intellectual property laws, educational attainment levels of the workforce, access and retention of the global labor force, and political interest and forms of government support for promoting science and technology.

Among the paper's conclusions: There is a large disconnect in US policy related to promoting KBEAs and national competitiveness. Few policymakers, or even the higher education community are aware of stagnant and, in some states, real declines in higher education access *and* graduation rates relative to economic competitors, that the US is no longer a net importer of high tech goods, or that the US is no longer the number one destination for international students.[2] Combined with global changes in the market for S&T talent, and the significant and increasingly successful effort of competitors to increase the educational attainment of their population, the US's HT advantage is eroding – although there remain a number of strengths, chiefly related to an entrepreneurial culture, more conducive tax advantages for business, a cadre of elite research universities, and the highest concentration of venture capital in the world.[3] But even here, these advantages may wane over the next decade as the world becomes more economically, and educationally, competitive. The US generally lacks a broadly conceived strategy for retaining America's high tech advantage.

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New growth theory has become a ubiquitous part of the lexicon of international business and university leaders, and, perhaps most importantly, ministries and political leaders of almost all political persuasions. The shared axiom essentially states that postmodern economies, and increasingly developing economies, are growing in their dependence on “knowledge accumulation.” Promoting knowledge accumulation locally, via knowledge-based businesses and entrepreneurial universities working together, and supported by government, leads to technical innovation, new products, robust local economies, and ultimately greater national productivity and global competitiveness.

In part, the growing political acceptance of the new growth theory relates to a number of highly touted regional success stories, what I call for the purposes of this paper Knowledge Based Economic Areas (KBEAs). The United States, in particular, continues to be viewed as the most robust in creating KBEAs, providing in some form an influential model that is visited and revisited by business and government leaders, and some academics, who wish to replicate its wonders. But with significant efforts by regional and national governments to pursue the edicts of new growth theory, and to create KBEAs on their own political and cultural terms, one might ask what are the current advantages, and disadvantages, of the American model. Does the US retain a substantial global advantage, in part by being one of the first movers in creating vibrant KBEAs? With growing global competition in creating strong high-technology clusters in regional areas, what policy innovations are being pursued in the US?

The following essay attempts to place universities within the larger political and policy environment by discussing market factors that have influenced knowledge accumulation and HT innovation in the US, an assessment of their current salience in the face of globalization, and the growing market position of competitors, such as the EU. As a follow-up on a previous HEMP article on that topic, the article also provides observations on major US state-based HT initiatives to create KBEAs and discusses the prospect of a major new federal initiative to increase national R&D funding.[4]

1. The Status of the US HT Advantage[5]

One widely understood challenge centers on how to create the conditions and circumstances for knowledge-based economic areas (KBEAs) that are not simply regionally or nationally competitive, but globally competitive. Universities, and the educational attainment of a population generally, play a critical role – perhaps as important as any other major policy and investment variable. Indeed, the first major US KBEAs focused on non-defense HT sectors, including the San Francisco Bay Area (including Silicon Valley), Boston, the Austin area in Texas, and a number of others, that benefited from the presence of major and high-quality research universities. But there is, obviously, much more complexity underlying the factors required to both generate and sustain KBEAs, as well as the HT sector in general.

The US remains highly competitive as a source of HT innovation because of a number of market positions, many the result of long-term investments in institutions (such as research universities) and R&D funding, and more broadly influenced by a political culture that has tended to support entrepreneurs and risk-taking. In essence, the US was the first to understand and pursue the nexus of science and economic policy. The following narrative outlines a number of the market factors that have historically influenced knowledge accumulation and HT innovation in the US, along with a brief assessment of their current salience in the face of globalization.

a) Political Interest and Support for HT — the mantra of the postmodern economy

Among the general public, and most importantly among major political leaders in the US, the tenets of new growth theory, as noted previously, are growing in influence. With declines in older manufacturing and consumer goods industries, high technology and service industries are widely viewed as the sources of near- and long-term economic competitiveness.

This worldview is, of course, shared by many other developed economies, such as the EU. The difference is that the US has had a longer history of essentially believing (rightly or wrongly) that HT innovation and economic activity will, in some form, be the crux of its future economy, and this belief influences R&D investment rates. There is, of course, abundant empirical evidence of the central importance of HT innovation, including highly productive regional economic areas such as Silicon Valley and the San Francisco Bay Area for IT, San Diego in communications, and Boston for biotechnology. But there has also emerged a political rhetoric influenced by these success stories, including the desire to replicate in some form their seemingly universal formulas for success, and by an optimistic enthusiasm and sense of political competition that often drives policymaking.

The major change in the US, and similar trends in other parts of the world, is the movement of policymaking and public investment intended to promote HT innovation and encourage university-business collaboration, to the regional (or state) and local level, with state governments increasingly becoming active. However, there are peculiarities to the dynamics of policymaking in the US. For one, the source of public R&D funding has been the federal (national) government historically. State- and local-based initiatives to build university-business collaborations two decades ago, for example, were in large part pursued to capture federal funds. This motivation remains, but increasingly states are simply investing their own money in basic research efforts in areas such as stem cells – an area that, for political reasons, the current Bush administration has refused to fund via federal coffers.

Political interest, enthusiasm, and the sense of political competition (to borrow the practices of competitor states or local regions, or to beat them to new policy initiatives), are in some form prerequisites to building KBEAs. Arguably, although with many nuances, the US has a high political interest in and desire to promote KBEAs and HT innovation, the same as anywhere in the world. At the same time, the US has its own peculiar ironies in how citizens view science and technology. For example, less than half the American population accepts the theory of evolution. Whether and how the theory of evolution is taught in public schools remains one of the most contentious issues in science education. A recent US survey has not shown much change over time in the public's level of knowledge about science.

At the same time, the most recent Eurobarometer does show an increase, with marginal change occurring in almost all countries surveyed, although there is considerable variation in science-knowledge across countries in Europe. Belgium, Germany, Ireland, Luxembourg, and the Netherlands recorded double-digit increases between 1992 and 2005 in the percentage of correct responses to science literacy questions. These political and cultural factors hinder development of a more scientifically educated population and workforce, and ultimately the number of native-trained scientists and engineers.

b) University and Private Sector Interactive Vibrancy – high-quality, elite HE institutions and growing partnerships

In the course of creating the world's first mass higher education system, the US built a large array of public and private universities that have found merit and success in interacting with and supporting private enterprise and local economies. The public universities that emerged in the mid- to late-1800s, in particular, had as part of their charters the responsibility of providing research and training in agricultural fields and emerging areas of industrial engineering that catered to local and regional needs. From the institutions' founding, the governing boards of these public institutions reflected these important components of their charge, with the majority of their members usually representing business and farming interests.

The result was a culture that promoted applied uses of scientific and engineering research that, by the early 1900s, became a major cultural component in most major American research universities, public and private, and particularly in engineering fields. In addition, federal funds, the initiatives of state and local governments, and the efforts of sectarian communities and private benefactors helped to create a vast array of public and private institutions that, essentially, supported the emergence of a cadre of high-quality research universities. One indicator of the concentration of high-quality research universities is the high ranking of US institutions in a variety of studies, including the highly publicized study based at Shanghai's Jiao Tong University.

Figure 1.
Regional Distribution of Top World Universities
Jiao Tong University - Shanghai Rankings 2006

	AMERICAS	EUROPE	ASIA/PACIFIC	AFRICA
Top 10	8	2	0	0
Top 50	39	9	2	0
Top 100	57	35	8	0
Top 500	198	205	93	4

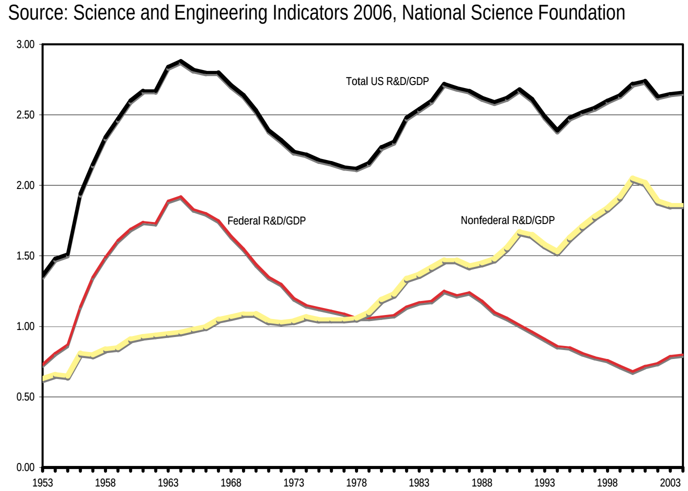
The idea of mass higher education to service, at least in part, the broad and ever-expanding needs of local and regional economies in the US stood in sharp contrast to most other nations (such as most of Europe), and gave the US a significant market advantage. The tradition of public-private partnerships and other cultural and legal factors (such as intellectual property laws) continue to significantly shape HT innovation in the US. Foremost, there is a relatively strong building of alliances and flow of funding. Since 1993, R&D expenses paid to other domestic R&D performers outside their companies have increased as a proportion of company-funded R&D performed within firms. In 2003, companies in the United States reported $10.2 billion in R&D expenses paid to other domestic R&D performers outside their companies, compared with $183.3 billion in company-funded R&D performed within firms. The contracted-out R&D represented 5.6% of all industry R&D in 2003, compared with only 3.7% in 1993.

Participation by federal laboratories in cooperative research and development agreements (CRADAs) increased in FY 2003 but was still below the mid-1990s peak. Federal laboratories participated in a total of 2,936 CRADAs with industrial companies and other organizations in FY 2003, up 4.3% from a year earlier but still below the 3,500 peak in FY 1996. At the same time, US companies continue to partner with other American and international companies worldwide to develop and exploit new technologies. New industrial technology alliances worldwide reached an all-time peak in 2003 with 695 alliances, according to the Cooperative Agreements and Technology Indicators database. Alliances involving only US-owned companies have represented the largest share of alliances in most years since 1980, followed by alliances between US and European companies.

c) Relatively High R&D Investment Rates – investment in basic research

Absolute levels of R&D expenditures are important indicators of a nation's innovative capacity and are harbingers of future growth and productivity. Indeed, investments in the R&D enterprise strengthen the technological base on which economic prosperity increasingly depends worldwide. The relative strength of a particular country's current and future economy and the specific scientific and technological areas in which a country excels are further revealed through comparison with other major R&D-performing countries.

Figure 2.
R&D as a Percentage of Gross Domestic Product: 1953–2004
Source: Science and Engineering Indicators 2006, National Science Foundation



Since 1953, US R&D expenditures as a percentage of GDP have ranged from a minimum of 1.4% in 1953 to a maximum of 2.9% in 1964. Most of the growth over time in the R&D/GDP ratio can be attributed to steady increases in nonfederal R&D spending. Non-federally financed R&D, the majority of which is company-financed, increased from 0.6% of GDP in 1953 to an estimated 1.9% of GDP in 2004 (down from a high of 2.1% of GDP in 2000). The increase in non-federally financed R&D as a percentage of GDP is indicative of the growing role of S&T in the US economy.

Yet much of the R&D expenditures in the US are concentrated geographically in about ten states, and these states vary significantly in terms of the types of research performed within their borders. In 2003, the top 10 states in terms of R&D accounted for almost two-thirds of US R&D. California alone accounted for more than one-fifth of the $278 billion of R&D that could be attributed to one of the 50 states or the District of Columbia. Over half of all R&D performed in the United States by computer and electronic products manufacturers, for example, is located in California, Massachusetts, and Texas, while the R&D by chemicals manufacturing companies is particularly prominent in two states, accounting for 61% of New Jersey's and 49% of Pennsylvania's business R&D. Together these two states account for almost one-third of the nation's R&D in this sector.

The United States remains one of the biggest investors in R&D with the highest relative investment in basic research, most of which is conducted in its network of research universities. For example, in 2000, global R&D expenditures totaled at least $729 billion, half of which was accounted for by the two largest countries in terms of R&D performance, the United States and Japan. Worldwide, there remains a heavy concentration of R&D in seven major economies. The US, Canada, France, Germany, Italy, Japan, and the United Kingdom performed over 83% of OECD R&D in 2002. At the same time, more money was spent on R&D activities in the United States in 2002 than in the rest of the G-7 countries combined.[6]

R&D intensity indicators, such as R&D/gross domestic product (GDP) ratios, continue to demonstrate the advantages enjoyed by developed, wealthy economies in the global HT economy. Yet there are signs that competing nations are beginning to push R&D investment rates in both the public and private sector that match or exceed the rates in the US. Overall, in 2004 the US spent 2.7% of its total GDP and ranked fifth among OECD countries in terms of reported R&D/GDP ratios. Israel (not an OECD member country), devoting 4.9% of its GDP to R&D, led all countries, followed by Sweden (4.3%), Finland (3.5%), Japan (3.1%), and Iceland (3.1%).

But there are two major market advantages for long-term economic growth for the US relative to other economies. First is the high proportion of R&D investment by the private sector. R&D performed by the business sector is estimated to have reached $219.2 billion in 2004. The business sector's share of US R&D peaked in 2000 at 75%, but following the stock market decline and subsequent economic slowdown of 2001 and 2002, the business activities of many R&D-performing firms were curtailed. The business sector is projected to have performed approximately 70% of US R&D in 2007.

Figure 3.
US R&D by Character of Work: 2004
Source: Science and Engineering Indicators 2006, National Science Foundation

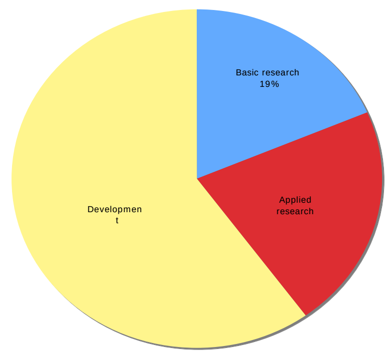
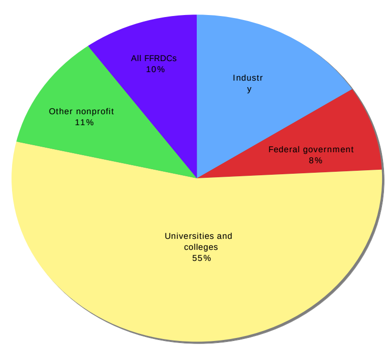


Figure 4.
US Basic Research by Performer: 2004
Source: Science and Engineering Indicators 2006, National Science Foundation



The second market advantage is the relatively high investment rates in basic research and the way that funding is dispersed. The United States expends approximately 19 percent of its total R&D portfolio on basic research; a little more than one-half of this research is funded by the federal government and performed in the academic sector. The largest share of this basic research effort is conducted in support of life sciences. Yet other nations have begun to re-allocate their total R&D portfolios to compete with the US. For example, the Russian Federation now spends 16 percent of all its R&D expenditures on basic research; in South Korea, which is currently the sixth-largest R&D-performing member of OECD, the figure is 14 percent; in Japan, 12 percent.[7] Indicating the growing emphasis on promoting scientific research and HT innovation in the EU, basic research now accounts for more than 20 percent of total R&D performance reported in Italy, France, and Australia.

In the postmodern world, however, national rates of R&D expenditures, and the role of public and private sector funding, fail to capture significant global shifts in research activity. With the growth of HT clusters and research expertise worldwide, US-based multinational corporations (MNCs) continue to expand their investment in R&D activity overseas. In 2002, R&D expenditures by affiliates of foreign companies in the United States reached $27.5

billion, up 2.3% from 2001 after adjusting for inflation. By comparison, over the same period, total US industrial R&D performance declined by 5.6%, after adjusting for inflation. Cross-country R&D investments through MNCs continue to be strong between US and European companies. At the same time, certain developing or newly industrialized economies are emerging as significant hosts of US-owned R&D, including China, Israel, and Singapore. In 1994, major developed economies or regions accounted for 90% of overseas R&D expenditures by US MNCs. This share decreased to 80% by 2001. The change reflects modest expenditures growth in European locations, compared with larger increases in Asia (outside Japan) and Israel.[8]

d) Venture Capital — US still most robust

Venture capital is a primary source of funding for HT businesses. The US remains the single largest source of venture capital, representing a major market advantage unmatched by any other major developed nation. The lack of an equity investment culture, information problems, and market volatility are factors that hinder the development of early-stage financing in many OECD countries.

In the United States, a continuum of capital providers, e.g. business angels and public and private venture funds, helps diversify risk and ensures a steady flow of quality deals. These networks — together with the use of staged financing instruments linked to performance, provision of technical and managerial support, and easy exits on secondary stock markets — have contributed to the survival and growth of portfolio firms. The number of venture capitalists with financial and technical expertise is limited in many countries and has not generally matched the rapid growth in risk capital supply across the OECD. Some countries, including Canada and Sweden as well as Israel, fill this experience gap by attracting venture investors from abroad.[9]

In many countries, structural, regulatory, and fiscal barriers act to constrain the development of a dynamic venture capital market and business environment. A 2007 study on venture capital notes that, around the world, almost 20 percent of all venture deals take place across national boundaries, an increase of 250 percent over the preceding five-year period. The authors observe that this trend has been accelerated by the practice of "venture licensing," the replication of proven business models in new markets.[10] Though the US, Europe, and Israel remain key in the industry, practices like this are expected to lead to even more focus on emerging markets in the coming years.

Not everyone agrees, however, that national borders are disappearing as a factor in venture investment. US firms are merely dabbling in overseas markets. Although many US portfolios include foreign companies, most of the time these firms make up less than 5 percent of total firm investment. Instead, US venture firms appear to be taking a different approach to capitalizing on emerging markets. About 88 percent of respondents to one recent survey indicated that their portfolio includes companies with a significant portion of their operations overseas, mostly in India and China. This figure is almost twice the number reported last year. One conclusion is that venture capital firms remain cautious about expanding their global portfolios and that, although the pace of global investment will continue to grow in the next few years, it will do so slowly.[11]

Yet despite the small amount of portfolio space dedicated to investments in China and India, the sum of all of these smaller investments from around the world has made China a major presence in the industry. The report [which?] also provides a number of new models for global investment, including "international joint funds, strategic limited partners, local funds with a global brand, local teams under one global fund, or a hybrid of these models" that may ease some of the reservations of US firms about investing globally. These types of partnerships, which are already changing the face of global venture investment, may create an industry in which international investment is common, but a local presence is necessary.

e) Intellectual Property (IP) - US as the first mover

In part because it has been one of the most prolific generators of intellectual property, the US has created a relatively elaborate and generally protective set of laws that, in turn, has significantly influenced economic development. Two major developments help to decipher the proliferation of IP and its influence on the American market.

First, in 1980 the federal government revised patent and licensing law. The Bayh-Dole Act of 1980 opened the doors for universities and their faculty and researchers to own patents and issue licenses developed through federally funded research. Previously, by allowing universities and research staff to jointly own discoveries supported by federal research grants, Bayh-Dole is credited with providing an important market force for creating the entrepreneurial university and for bolstering activity in a key economic sector, a model later replicated by other national governments, beginning with the UK during the Thatcher administration. Bayh-Dole generated a revised worldview for both the university and business sectors by encouraging tech-transfer, arguably an exaggerated sense of potential profits for researchers, universities, and business partners alike. This national initiative, along with the funding of new federally funded university-business centers in engineering, had another effect: State governments, and to a lesser extent municipal governments, looked for new ways to harness their universities to support and grow their tech-based businesses and to compete for growing federal funding.

Figure 5.
US Patents Granted by Country of Origin: 1990-2003
Patents in Thousands
Source: Science and Engineering Indicators 2006, National Science Foundation

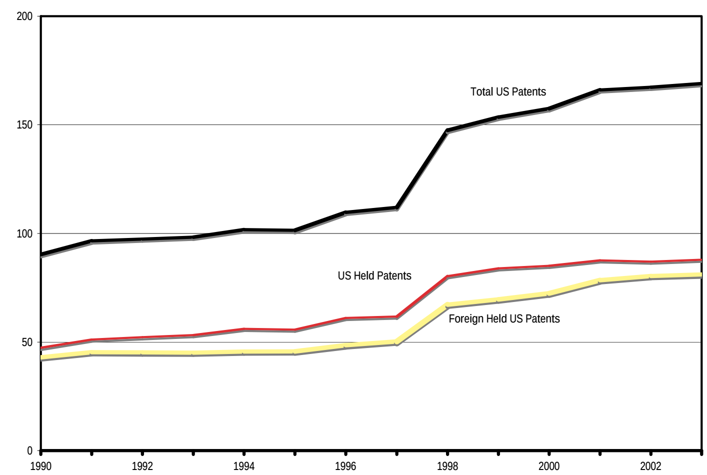
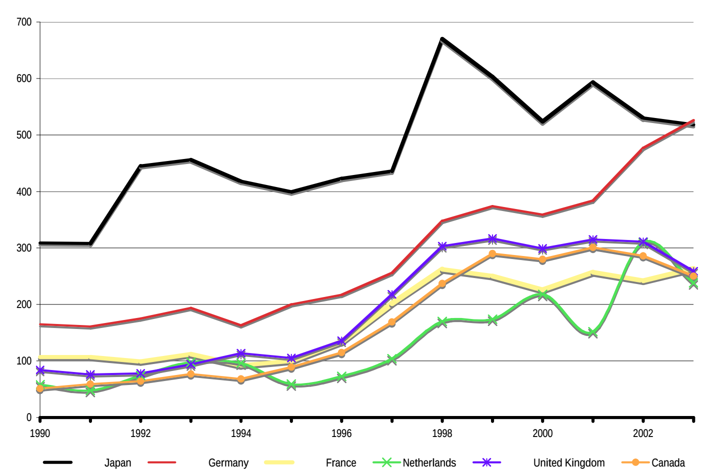


Figure 6.
US Biotech Patents by Foreign Inventor: 1990-2003
Number of Patents
Source: Science and Engineering Indicators 2006, National Science Foundation



Another major shift in IP laws was shaped by the legal system, and specifically by what was liberally determined to be a patentable discovery or idea. Remarkable discoveries in the life sciences, fed in part by long-term investments in basic research, created unique requests for patents and licenses. In 1980, the same year the Bayh-Dole Act was passed, the US Supreme Court upheld a lower court decision providing an extremely broad definition of "patentable material," including the patenting of organisms, molecules, and research techniques related to new biotechnology fields.[12]

Arguably, the growing focus on patents and licensing by universities, and by industry, has had a deleterious effect on the sharing of information and discoveries that previously bolstered scientific inquiry. But this new focus has also encouraged greater investment by capital markets and resulted in research collaborations in the US to a degree not yet replicated in similar developed economies. Within the US domestic economy, a record number of patents (more than 169,000) were issued in the United States in 2003, although the rate of growth in US patenting has slowed since 2000.[13] Nonetheless, US patents have enjoyed a period of nearly uninterrupted growth since the late 1980s.

The US also retains a strong market position in the number of international patents held and marketed to other nations. In 2003, US receipts totaled $48.3 billion and its trade in intellectual property produced a surplus of $28.2 billion, up about 5% from the $25.0 billion surplus recorded a year earlier. About 75% of transactions involved the exchange of intellectual property between US firms and their foreign affiliates. Exchanges of intellectual property among affiliates grew at about the same pace as those among unaffiliated firms. These trends suggest both a growing internationalization of US business and a growing reliance on intellectual property developed overseas.

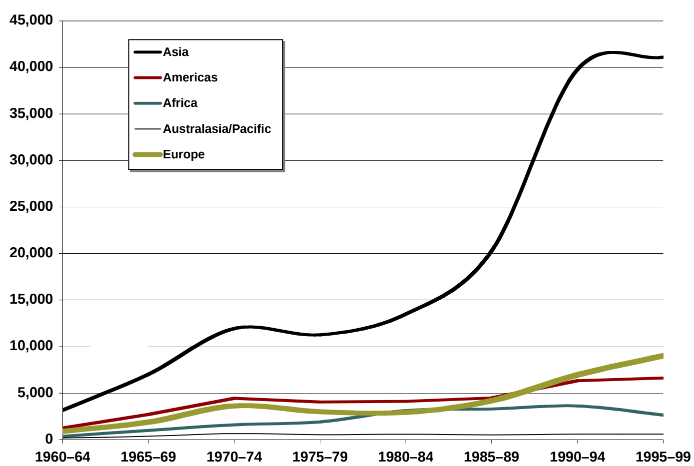
Yet another indicator of changing markets is the growing number of US patents held by foreign sources. In 2003, US residents accounted for about 55% of all successfully granted patents, while foreign inventors accounted for about 45% of the total. A decade ago, businesses based in Japan, Germany, the UK, France, Canada, and a few other developed economies were the largest source of US patent applications. This has changed. Since 1997, Taiwan and South Korea replaced France and Canada in the top five foreign sources of inventors seeking US patents. In 2003, Taiwan accounted for 9% of foreign sources of US patent applications and South Korea for close to 7%. Canada and the United Kingdom accounted for 5% and France for 4%. If recent patents granted to residents of Taiwan and South Korea are indicative of the technologies awaiting review, many of these applications will prove to be for new computer and electronic inventions. Also impressive is the growth in patent applications by inventors from Israel, Finland, India, and China.

Foreign firms now account for about 36% of all US biotechnology patents, with a significant share coming from companies and investors based in Japan and European. Japan and Germany are not only the leading foreign generators of US patents overall, they are also the leading foreign sources for US patents granted that are related to biotechnologies. Recently, however, Germany's share of US biotechnology patents granted has been rising while Japan's share has been falling. In 2003, Germany was still the leading foreign source, accounting for 6.5% of US biotechnology patents granted, up from around 4% in the late 1990s, while Japan's share was 6.4%, about half the share held by Japanese inventors in the early 1990s. These patenting trends indicate that while the US remains a leading source of patents, and offers a liberal business environment, there are concrete signs of significant technology innovation in Asia and in a transitioning Europe.

f) Tax Policy — US most advanced and long term

One major US advantage in shaping investment patterns and promoting risk-taking relates to tax policy at the federal, state, and, increasingly, local level as well. The US has long engaged in using tax structures not simply to generate revenue, but to shape economic behavior – a characteristic relatively new to most other economies, including the EU, that have focused on relatively simple tax structures. For example, bankruptcy laws in the US have been the most liberal of any major developed economy, reflecting a political culture that essentially promotes entrepreneurship, recognizes the high rate of failure among all types of businesses, and spreads the risk so that a business failure does not mean permanent ruin. The complexity of the tax system has also long included “tax credits,” encouraging businesses to invest in technology and increasingly in R&D. At the same time, the US tax code is so complex, and easily amendable, that it is also subject to major political influence, largely by corporate interests, including the growing HT sector. State and local taxation systems, historically, varied significantly and were rather simplistic, including a sales tax in some states, or an income tax model like the federal system, or both.

Figure 7.
Geographic Origin of Foreign Graduate Students Enrolled in US Universities 1960 – 2000
Source: Science and Engineering Indicators 2006, National Science Foundation

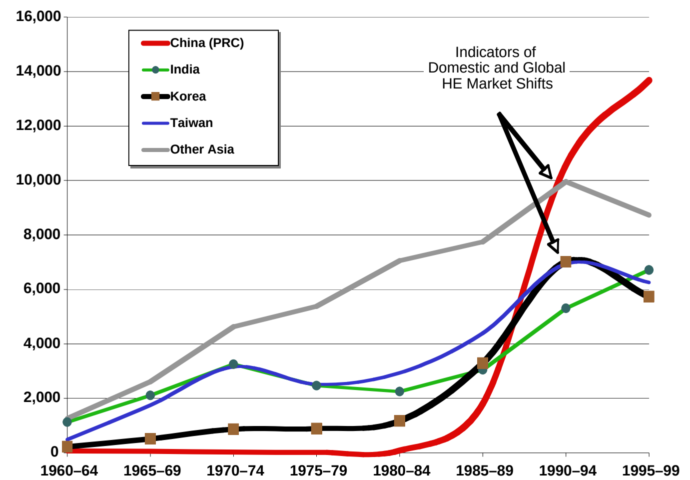


But over the past three decades, states and local government have become much more engaged in shaping tax policy to attract desirable businesses, including HT, and to generate investment in both university and business-based research. From 1990 to 2001, for instance, research and experimentation (R&E) tax credit claims by companies in the United States grew twice as fast as industry-funded R&D, after adjusting for inflation, but growth in credit claims varied throughout the decade. R&E tax credit claims reached an estimated $6.4 billion in 2001. From 1990 to 1996, companies claimed between $1.5 billion and $2.5 billion in R&E credits annually; since then, annual R&E credits have exceeded $4 billion. However, in 2001 R&E tax credit claims still accounted for less than 4% of industry-funded R&D expenditures.

g) Talent Pool and Mobility — attractiveness and openness to skilled labor and foreign students
The US has reaped tremendous advantages by its early commitment to mass higher education. Over most of the last century, more Americans went to college and graduated, with many entering graduate programs, than citizens of any other nation in the world. Adding to the nation's supply of talent has been a relatively open-market approach to attracting academics and researchers. In the 1930s, the US provided a haven for preeminent scientists escaping Nazi Germany and World War II. The emergence of a large network of high-quality, sometimes prestigious universities that would hire foreign nationals as professors and researchers contrasted sharply with many if not most nations where university faculty held or hold civil service positions, and in which national governments limited the hiring of non-native talent.

Particularly after World War II, and beginning in earnest during the 1960s, the presence of foreign students in US universities also grew dramatically, supported sometimes by the students' national governments, and increasingly by offers of student financial aid in graduate programs such as engineering where, today, foreign nationals are often more than 50 percent of the total students in a given program.

Figure 8.
National Origin of Foreign Graduate Students from Asia Enrolled in US Universities 1960 – 2000
Source: Science and Engineering Indicators 2006, National Science Foundation



In previous decades, students who came to the US for both undergraduate and graduate programs largely stayed in the US and entered the job market. Their presence has dramatically influenced HT innovation and the growth of that sector in the US economy. For example, one study indicates that nearly one-third of all the successful start-ups in Silicon Valley were started by foreign nationals, most of whom gained their training in American universities. As shown in the Figures 7 and 8, foreign nationals from Asia became the largest single source of talent coming to the US for education, largely in graduate programs in science and engineering. Bolstered by Chinese national government initiatives, students from China became the largest single source of foreign students in the US beginning in the early 1990s. The overall growth in all foreign nationals entering US graduate degree programs in that period also reflected a significant shortfall in the training of "native" US students in STEM fields, and the push by HT economic sectors to get the talent they needed via US universities, and by successfully advocating more liberal visa policies for highly educated immigrants.

This pattern of attracting and then retaining talent is beginning to erode for two general reasons. First, the US, along with other developed economies with mature higher education systems, are finding that a growing number of foreign nationals educated in science and engineering fields, and professionals that have long contributed to S&T innovation and businesses, are beginning to return to their native economies as they mature, buttressed by national policies to attract top scientific talent. Second, the overall market for higher education, one of the primary means of attracting talent, is both growing and shifting with maturity of university systems in the EU and elsewhere.

Since 2000 and 2005, the number of international students in national higher education systems (defined as those students with citizenship or residency in another country) has grown from around 1.8 million to 2.7 million. Over that short period, most EU nations have either retained or expanded their market share of international students, as shown in Figure 9; countries such as Australia and New Zealand have also grown in their market share. Meanwhile, and in the midst of a significant expansion in the number of students seeking higher education outside of their home countries, the share of international students attending US universities and colleges has declined from just over 26 to 21.6 percent.

Figure 9.
International Student Enrollment in National Systems of Higher Education: Sample Group 2000 and 2005*
Source: OECD Education at a Glance 2007 tables C3.1 C3.8

	% International Enrolled		# of Students		% Foreign Student of Total National Enroll 2005	
	2000	2005	2000	2005	All Enroll	Doctoral and Res
EU Sample						
UK	12.3%	11.7%	222,798	318,396	17.3%	41.4%
Germany	10.3%	9.5%	186,968	259,787	11.5%	-
France	7.5%	8.7%	136,953	236,344	10.8%	34.4%
Italy	1.4%	1.7%	24,917	44,979	2.2%	4.3%
Spain	2.2%	1.7%	40,740	45,524	2.5%	18.9%
Belgium	2.2%	1.7%	40,558	45,252	19.9%	30.8%
Sweden	1.4%	1.4%	25,463	39,254	9.2%	20.3%
Switzerland	1.4%	1.4%	26,008	36,801	18.4%	43.2%
Austria	1.7%	1.3%	30,373	34,620	14.1%	20.2%
Netherlands	0.1%	1.2%	1,455	32,712	5.6%	-
Sub-Total EU Sample Total	40.5%	37.6%	736,234	1,093,670	10.6%	26.7%
Oceania/Asia Sample						
Australia	5.8%	6.5%	105,852	176,917	20.6%	28.3%
New Zealand	0.5%	2.5%	9,094	69,240	28.9%	38.3%
Japan	3.7%	4.7%	66,567	127,849	3.1%	17.1%
Sub-Total EU Sample Total	10.0%	13.7%	181,512	374,007	17.5%	27.9%
Other Major Providers						
Canada	2.2%	2.8%	40,558	50,198	-	-
Russia Federation	2.3%	3.3%	41,104	60,201	1.4%	-
South Africa	0.1%	1.9%	1,546	33,647	-	-
US	26.1%	21.6%	475,242	589,906	3.4%	24.1%
Total International Students Enrolled in OECD Nations	85.0%	84.2%	1,545,945	2,295,289	7.6%	17.5%
EU 19					6.3%	17.5%
Total Number of International Students Enrolled Globally			1,818,759	2,725,996		

* Largely defined as students with citizenship outside of the national higher education system they are enrolled in.

Much is made in the media and elsewhere about the US being the number one single destination for foreign students to study in a tertiary institution. But this is not a fair comparison as the size of the US, at around 350 million people, is larger than four of the largest EU nations combined – Germany at approximately 83 million, the UK and France at 61 million each, Italy at 59 million, and Spain at 41 million, for a total of 305 million. Figure 9 provides data on international student enrollment among a sample group of ten EU nations, all with the highest percentage of international students in the EU and with a combined population approximately similar in size. While the overall world market share has dropped slightly between 2000 and 2005, this is in the midst of a boom in the overall number of students. Over that period, the US grew by some 115,000 international students; the sample group grew by some 310,000 students. The sample group also significantly grew in the percentage of overall national enrollment that international students represent. In the US, only about 3.4 percent of all enrolled students are international. In the EU sample group the percentage is 10.6 percent, with the largest numbers of students attending universities in the UK, Germany, and France.

An important caveat is that much of the growth in international students within the EU relates to the Bologna and Lisbon Declarations, and the creation of an evolving European Higher Education Area. The result of these policy reforms and the general concept of EU citizenship have resulted in much greater mobility within the EU for tertiary-bound students. About half of all international students in EU nations are EU members. Most are not enrolled in degree programs, but in one-year exchange programs. Yet a clear pattern is emerging in which the international attractiveness of major EU higher education centers, along with the entrepreneurial effort to enroll international students in Australia, New Zealand, and even Japan, marks, in some form, the shifting of the market. Most EU and many OECD countries have conscious national policies to draw talented international students to their home universities. There is no strategic approach at the national or even state level of government in the US, which remains largely decentralized in its approach to the structure and goals of higher education.

The US does retain a strong international draw at the graduate level, and particularly in engineering, the sciences, and business management. Most Chinese students wishing to study abroad still come to the US. Nearly 30 percent of all international Chinese students enroll in a US university or college. And some 24 percent of all international doctoral-level students in the US are foreign nationals. But as an indicator of shifts in the global talent pool, there is now an even a higher percentage in the EU sample group (nearly 28 percent); in Australia the percentage is 28 percent. There is then the question of the relative quality of the international student pool, and the quality and reputation of the graduate programs they enroll in – all rather difficult factors to evaluate. The US remains a world leader in the prestige and, arguably, the quality of its advanced graduate programs. Yet there is growing evidence that students throughout the world no longer see the US as the primary place to study; that in some form this correlates with perceived quality and prestige in the EU and elsewhere; and, further, that the trajectory of growth in international students may mean a continued decline in the US market share of international students.

Attracting talent from abroad is an important component of the US's HT advantage. Educating a more robust native population should be an equally, if not more, important goal. A significant factor that will influence the US's market position, and the general socioeconomic health of the nation, is the significant relative decline in higher education attainment rates of Americans when compared to other developed economies.

Although the United States still retains a lead in the number of people with higher education experience and degrees, at the younger ages a different story emerges. On average, the postsecondary participation rate for those aged 18 to 24 in the United States is approximately 33 percent according to a 2005 study, down from around 38 percent in 2000. In the US, more students today are part-time than in the past, and more are in two-year colleges; the wealthiest students are in the four-year institutions, and students from lower and even middle income families are now more likely to attend a two-year college, less likely to earn a bachelor's degree, and take much longer to attain a degree than in the past.[14]

In contrast, within a comparative group of fellow OECD countries, many nations are approaching 50 percent of this younger age group participating in postsecondary education, and most are enrolled in programs that lead to a bachelor's degree. According to 2004 data, the US has slipped from first to 14th in the higher education participation rate. Without a major effort by states and the federal government, and by higher education institutions, it is likely that this ranking will go down further over the next decade. The US will undoubtedly remain a leader in HT and will continue to draw talented graduate students and scientists to its unmatched network of research universities. Already the initial negative influence of the Patriot Act has ebbed and foreign applications to US graduate schools have begun to increase once again, although perhaps the numbers will grow at a slower pace than in previous decades.[15]

However, because of concerted policy efforts and investment in education, particularly in science and technology programs at universities, and because of the corresponding growth of S&T sectors, new competitors for faculty, graduate students, and more generally talent will continue to grow in number and quality. America's once-dominant competitive advantage will diminish. Universities in the EU, for example, have grown significantly in their ability to attract graduate students (outside of Oxbridge), and many are becoming more liberal in their willingness to hire foreign nationals as faculty. The Bologna Agreement and other policy initiatives seek great mobility of talent and jobs, influenced at least in part by the American model. Moreover, the emergence of English as the dominant language in academia and business once had been, and now remains, a market advantage for the US, the UK, and other

English-speaking countries. But the use of English in non-English-speaking nations, and the growing number of graduate programs (particularly professional programs) offered in English throughout the world is also diminishing the market advantage of US universities.

An emerging body of research largely produced by the scientific community and economists worries about the ability of the US to continue its market advantage in both attracting and retaining talent from abroad. A congressionally requested report by a preeminent committee of scientists and S&T leaders, chaired by the former CEO of Lockheed Martin Marietta, Norman Augustine, recently argued that "a comprehensive and coordinated federal effort is urgently needed to bolster US competitiveness and pre-eminence in these areas."[16] The political traction of such analysis, however, has proven marginal, thus far.

Labor economist Robert Freeman has observed that a diminished comparative advantage for the US in high-tech will "create a long period of adjustment for US workers, of which the off-shoring of IT jobs to India, growth of high-tech production in China, and multinational R&D facilities in developing countries, are harbingers." The US will need to adjust, he notes, reflecting the observations of many others, by developing "new labor market and R&D policies that build on existing strengths" and that recognize scientific and technological advances in other countries.[17]

Comprehending the significance of these market shifts will be key for the US's future economic competitiveness. As of this writing, America remains a nation mired in a protracted and expensive occupation in Iraq and Afghanistan, facing a growing trade imbalance and a weakening economy. These realities, along with neoconservative Republican control of the White House, which has been bent on reducing the role of government, have resulted in marginal investment in major and outstanding domestic needs over a protracted period. As discussed later in this essay, there is a major initiative to increase federal R&D spending in the physical sciences, but it is unclear if it will survive in its present form in light of the current economic downturn and the politics that surrounds the pending November 2008 presidential election.

2. A Comparative Assessment of the US's Competitive Advantage

The US remains a productive environment for S&T and will remain so in the short run not only because of the excellence of its research universities and the growth of new business sectors like biotechnology. There is also the availability of venture capital, relatively high rates of R&D investment, and tax incentives and legal precedents that, thus far, are not yet matched in other economies.

Figure 10.
National and Regional Factors for Knowledge Based Economic Areas
10 Point Scale; 1 = Low; 10 = High
Improving = +; Declining = -

	US	Bay Area	EU
1. Vitality of research universities	8	10	7+
2. R&D investment — public	8+	9+	7+
3. R&D investment — private	8	9	4+
4. Access to venture capital	10	10	6+
5. Intellectual property laws/protection	9	9	8+
6. Concentration of knowledge-intense companies	8	10	8
7. High-quality workforce	6 -	9	7+
8. Workforce mobility	9	10	6+
9. Access to global labor/immigrant factor	9-	10-	7+
10. Supporting risk taking — culturally, legally	10	10	6+
11. Open business environment	8	9	7
12. Quality of life: housing, transportation	8 -	7-	8
13. Political support/government inducement	8	8	8

With the exception of the dot-com bust, university research and HT economic growth remain robust in the US. For example, the science and engineering workforce in the United States has grown rapidly, both over the last half-century and the last decade. From 1950 to 2000, employment in S&E occupations grew from fewer than 200,000 to more than 4 million workers, an average annual growth rate of 6.4%. Between the 1990 and 2000 censuses, S&E occupations continued to grow at an average annual rate of 3.6%, more than triple the rate of growth of other occupations. Between 1980 and 2000, the total number of S&E degrees earned grew at an average annual rate of 1.5%, which was faster than labor force growth but less than the 4.2% growth of S&E occupations. S&E bachelor's degrees grew at a 1.4% average annual rate, and S&E doctorates at 1.9%.

On average, American companies spend three times as much as those in Europe on R&D, and they have access to some ten times as much debt financing. This is one reason why many S&T firms in Europe and other parts of the world set up offices in the US — not to gain access to scientific expertise, but to capital markets. Because of the high cost for an initial public offering on the stock market, many international firms are merging with existing, and often fledgling, US firms.

The question is how long these American advantages will remain. The global environment is changing rapidly, with individual countries growing significantly in their R&D abilities, in part via government policies and in part because of expanding investment by the private sector. The European Research Area and the emerging 7th Framework are intended to significantly boost R&D investment *and* to help shape tax policies and the availability of capital.[18]

Figure 11.
US Trade Balance in Advanced HT Products: 2000-04 $b
Source: Science and Engineering Indicators 2006, National Science Foundation

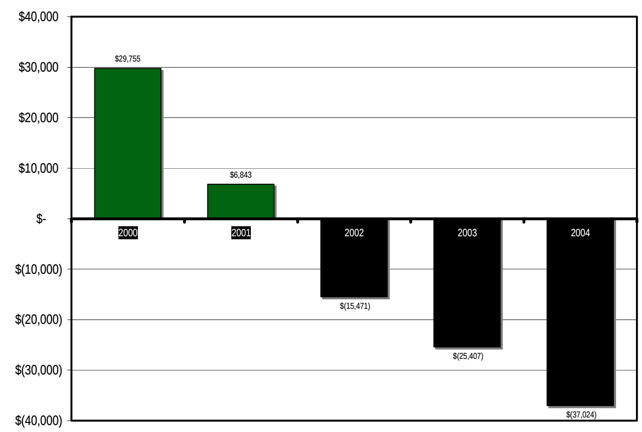
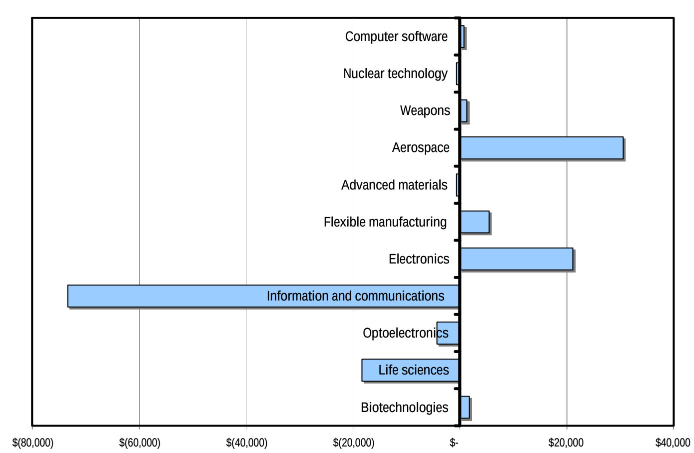


Figure 10 offers an unscientific assessment by the author of the major factors that promote and sustain national and regional HT economies. Most of these advantage factors have, in some form, been discussed previously. Added to our list are factors such as the overall quality of the science and tech workforce, mobility within a region or nation for these workers, the concept of a relatively open business environment (e.g., collaborations between universities and businesses, and between different business enterprises, and the sharing of workforce and knowledge which is widely perceived as one ingredient in the success of Silicon Valley), and the overall quality of life offered to that workforce, including housing, local schools, and transportation. Increasingly in cities and in regions with successful HT sectors, housing costs are rising, with the real or potential threat of diminishing the attractiveness of the region for employees. Also, in the US, urban area schools are generally declining in quality and there is poor public transportation and the increased division of rich and poor, all of which add strain to the quality of life.

Figure 12.
US Trade Balance in HT Categories: 2004 $b
Source: Science and Engineering Indicators 2006, National Science Foundation



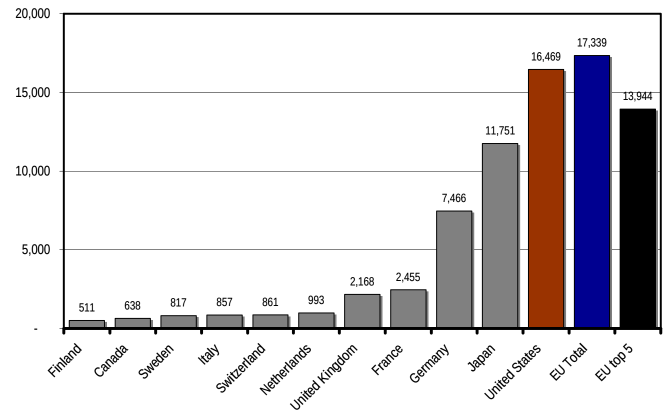
The objective of Figure 10 is to offer an assessment of the general status of these various advantages in supporting KBEAs in the US, in the San Francisco Bay Area (including Silicon Valley and biotech corridors in San Francisco and around Berkeley), and in the EU (particularly among the EU top 5) on a ten-point scale — ten being the most favorable. In addition, the author's sense of the trajectory of each advantage factor is indicated by a plus (going up) or minus (going down).

Americans are generally not looking across the Atlantic or Pacific, or across their borders, for ideas on HT policymaking. Lawmakers and other policymakers are concerned about being competitive in the global marketplace, but the US remains largely isolationist in its leanings despite the fact that the HT sector is increasingly an international endeavor. The focus of government and much of the business sector is on protecting or expanding foreign markets, intellectual property rights, and tax incentives; buttressing venture capital markets; and reducing restrictions on immigrant/visitor visas.

US political culture retains a sense that it is a nation that remains the most productive and innovative home for science and technology, and that, for instance, the cure for cancer or the breakthroughs promised by stem cell research will be homegrown. Thus far, this seems to ignore the significant knowledge centers in Europe and emerging S&T centers in countries like China, India, and other parts of the world.

An important indicator of the research gains and HT productivity of Europe and other parts of the world is a relatively little-known fact, at least among Americans. The US no longer has a trade surplus in HT advanced products (thus not counting mass consumer items such as electronics). A major bright spot in the overall trade imbalance has been its relatively strong export of HT goods and services. Maintaining and, indeed, enhancing this market position was one of the major reasons for the concerted policy efforts beginning in the early 1980s with the passage of Bayh-Dole and other federal initiatives that formed a formal transition of science policy as a major component of national economic policy.

Figure 13.
US and EU International HT Patents: 2003
Source: Science and Engineering Indicators 2006, National Science Foundation



Patents applied for at the European Patent Office (EPO), the Japanese Patent Office (JPO) and granted to the the US Patent & Trademark Office (USPTO), estimations for priority year 2001. The priority date corresponds to the first international request for protecting an invention

For some two decades, the US enjoyed a substantial surplus in HT products. However, as shown in Figures 11 and 12, between 2001 and 2002 the US moved from a $6 billion surplus to a $15 billion deficit in these goods and services. In 2004, the deficit was more than $25 billion. Within the various categories of HT products, aerospace and electronics retained surpluses; the largest single deficit was in information and communications. It is important to note, however, that these shifts reflect the process of globalization and the international nature of many HT businesses. American-controlled HT firms, for example, have products being created and manufactured throughout the world, as do other major international conglomerates. The blurring of national boundaries in terms of business activity, including finance, makes the story line of surpluses and deficits increasingly complicated.

Yet another indicator of the shift in America's HT advantage is the growth of international patent activity (see Figure 13). The widely perceived US hegemony does not accurately reflect recent data. The accompanying chart demonstrates that among OECD countries the US retains a major market position.[19] The growing EU has an actual larger total number of patents, with a significant portion generated by individuals and HT businesses in Europe's top five economies. The trajectory indicates that Europe, and many other parts of the world, are making sizable and relatively fast gains as global players in HT markets. Even in the area of R&D investment, as noted earlier, the market is shifting.

As a percentage of GNP, federal funding for basic research in the US in the physical sciences and engineering has been declining for the past 30 years, to less than 0.05% in 2003. Asia's developing economies are placing increasing percentages of the GNP into science and technology, and they are [on?] the edge of a payoff, with their share of global high-tech exports rising from 7% in 1980 to 25% in 2001. According to National Science Foundation figures, the US percentage fell from 31% to 18%.[20]

3. Cluster Theory – The Geographic Dispersion of US HT

While the US remains a major source of HT innovation and job growth, among the various states there are significant differences in the geographic dispersion of mature KBEAs, particularly in the generation of new HT businesses and centers of venture capital. A recent study indicates that larger firms with over 1,000 employees are the most likely to collaborate with universities and other public research institutes (non-profits).

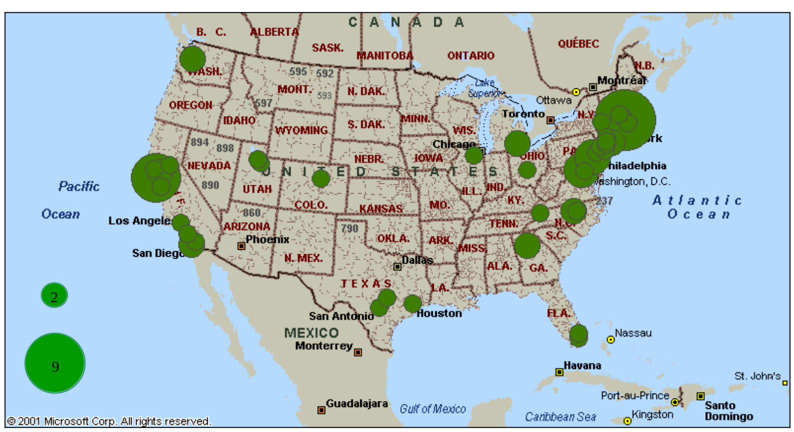
Further, most if not all of these firms are already engaged in R&D activity, sometimes via contracting research activity, and have therefore successfully built a capacity to absorb and use public-generated research.[21] Another study indicates, not surprisingly, that university-based start-ups are largely concentrated in states with the largest economies and with the largest levels of venture capital.[22] Figure 14 shows that the total amount of US venture capital investment in 1996 was $11.3 billion, and rose to $26.0 billion in 2006. Most states retained their market share of that venture capital investment portfolio, with California the only state that significantly increased its share from just over 40 to 48 percent.

Figure 14.
Top 10 U.S. States Receiving Venture Capital Investment: 1996 and 2006
Source: Science and Engineering Indicators 2008

	1996	*2006*
All States ($billions)	*$11.3*	*$26.0*
States % Share	*100.0*	*100.0*
California	*40.4*	*48.0*
Massachusetts	*9.6*	*10.9*
Texas	*4.7*	*5.3*
New York	*3.6*	*4.9*
Washington	*3.6*	*3.9*
New Jersey	*3.6*	*3.1*
Pennsylvania	*2.7*	*2.9*
Maryland	*1.2*	*2.6*
Colorado	*2.7*	*2.5*
North Carolina	*1.6*	*1.8*
All Others	*26.3*	*14*

A recent study by Martin Kinney and Donald Patton illustrates the geographic concentration of firms that grow from start-ups into public companies listed on the New York Stock Exchange (Initial Public Offering of Stock, or IPOs) and also the concentration of new HT activity in sectors such as semiconductors and biotechnology. IPOs indicate the maturity of the industry. Data is from the period 1996 through 2000.[23] As the accompanying two charts indicate (Figures 15 and 16), in the biotechnology sector, there is a heavy concentration of new firms in specific regions: the states of Massachusetts (the Boston area), New York and the East Coast corridor down to Maryland, along with California's San Francisco Bay Area and San Diego. These regions accounted for approximately half of the 65 HT businesses going public. New IPOs emerged also in North Carolina, Georgia (Atlanta), Michigan (Ann Arbor), Texas (Austin and Houston), and the state of Washington (Seattle).

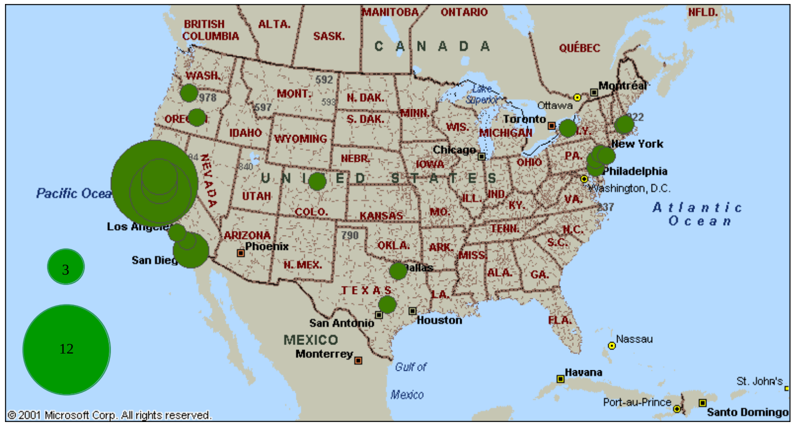
Figure 15.
Cluster Theory - The US Example
Location of Biotechnology IPOS (65 firms going public 1996 - 2000)
Source: Martin Kenney and Donald Patton, 2005



Semiconductor IPOs in that period of four years were even more concentrated, with the vast majority in the Bay Area and San Diego, followed by Boston and the New York-to-Maryland corridor. A similar pattern of concentration is found in the telecommunication sector. In all three HT sectors – biotech, semiconductors, and telecommunications – there is a general reoccurrence of HT business activity. In each of these geographic areas, there is a link between existing and high-quality research universities and the existence of an urban environment that has built, over time, a robust and talented workforce and research environment.

There is also evidence that this workforce, including a significant number of HT business professionals, scientists, and engineers, often with immigrant backgrounds, are mobile, moving from one KBEA to another. Further, there is a distinct pattern in which the vast majority of venture capital investments are focused in these areas, specializing in making bets within an HT research and business environment that appears to offer the best potential payoff. Even then, one recent study estimates that some 70 percent of venture capital investments in US HT businesses fail.

Figure 16.
Cluster Theory - The US Example
Location of Semiconductor IPOS (44 firms going public 1996 - 2000)
Source: Martin Kenney and Donald Patton, 2005



At the same time, data collected by the US Bureau of Labor on the number of employees in HT businesses in both the public and private sectors indicates a much more dispersed geographic distribution. In this case, employment numbers include all those in businesses and industries classified by the US government as HT, including financial services and industries such as automobile manufacturing and aerospace – a wide swath of activity in the economy.

Figure 17.
Dispersed Pattern of HT Employment: 2000
50 State Comparison: HT as a Percentage of All State Employment
Source: US Office of Technology Policy, State Science and Technology Indicators, 2004.

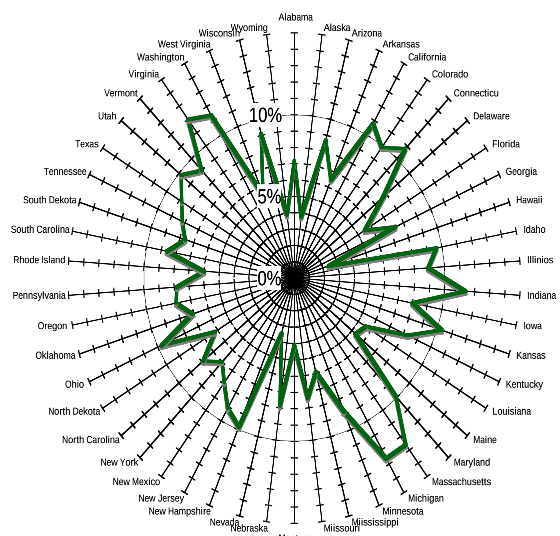


Figure 17 shows the total employment in HT businesses by state and as a percentage of all workers -- unfortunately, not by major regions within a state. The employment numbers indicate that while states such as Massachusetts, California, Texas, Michigan, and Maryland (where there is a high concentration of federal and private research laboratories) have many HT businesses, many other states have relatively high employment in HT industries as well. The chart also indicates the concentration of university R&D as a percentage of the gross state product (GSP). Again, this data provides a more nuanced illustration of the role of university-based R&D in relationship to a state's entire economy. Some big HT states, such as California, which has the highest number of HT employees of any state and secures the most federally and privately funded R&D investments, have economies that are extremely diverse; or, in other words, HT is important, and the role of research universities is a major factor in these states' economies, but neither is a dominant player now or for the foreseeable future in most states.[24]

One possible implication of the dispersed HT employment in the US is that as this sector continues to mature, the traditionally dominant KBEAs may continue to create innovation and businesses, but actual employment may end up in other geographic areas — effectively helping to create competitors. Further, innovative HT businesses, as they grow, seek other locales, whether in the US or increasingly in other nations, in which to locate part or all of their operations. One obvious example is the tremendous dispersal of the software industry. Efforts by governments to build and support KBEAs may reap significant local economic and social benefits, but they might not keep the investment locally as jobs are dispersed to other regions. These benefits are national and international.

In total, in 2000 some 8.8 percent of the workers in the US were employed in the HT sector. In comparison, the EU-15 average for that year was 7.6 percent, with Germany having the highest percentage at around 11.2 — according to data collected by CORDIS. The problem is that this data is already old, although it is the latest data I could secure. The probability is that there is significant growth of nascent KBEAs in the US, EU, and elsewhere, building on the formula of university and private sector coordination and, increasingly, government-based initiatives.

4. Funding Initiatives in the US

The politics of HT, and the devotion to new growth theory, yield a growing sense of competition and a remarkable new era of policymaking, driven, in part, by a sense of urgency and by the natural laws of interest group politics. In the US, this has created a remarkable level of effort by states and regional governments to make targeted investments that are relatively new, and to enter policy arenas once largely reserved for the federal government — the traditional source of publicly supported R&D. Some investments are attempts to leverage federal funding, or to create new funding streams; for example, to create public-funded venture capital in states that lack private investors, or in the case of stem cell–related research, to fill a void left by the Bush administration’s edict effectively severely limiting federal funding for research thought improper by neoconservatives.[25] Even with recent advances for alternatives to embryonic stem cells, the unprecedented limits set by President Bush have, essentially, led to a entirely new pattern of basic science funding, largely by already high-tech and more liberal states such as California and New York.

Over the last decade or so, lack of leadership at the federal level in science and technology funding, where funding levels to date have been relatively stagnant except for the National Institutes of Health, has resulted in state political leaders being active policymakers in areas thought vital to the socioeconomic health of their respective state. This has occurred not only in S&T, but also in health care, immigration, and in issues related to global warming and energy. In an earlier study, I provided an initial analysis of the frenzy of state and local initiatives. As a follow-up to that study, Appendix 1 provides a sample of recent state-based initiatives to promote and support KBEAs. Each of these initiatives have been presented and debated, in some instances passed or defeated, by state and local governments in the US over an eight-month period – January through August 2007.

There is a prospect, however, of a significant consensus of the need for a new infusion of federal funding largely intended to bolster basic research and support the nation’s HT efforts – if not in the coming federal budget, then in the next with a new president and depending, in some form, on the health of the national economy. Earlier in 2007, both houses of Congress passed legislation that incorporated many of the recommendations provided by the influential National Academies report, *Rising Above the Gathering Storm.*[26] But there was a need to reconcile the two different bills for final legislation to be signed or vetoed by the president. After months of negotiations, the House and Senate recently approved the most significant bill in years to bolster US research.

The America Creating Opportunities to Meaningfully Promote Excellence in Technology, Education, and Science (COMPETES) Act authorizes over $43 billion in new federal spending over the next three years that will support US math and science education and federal research agencies. In fact, the legislation would double the budget authorizations of the National Science Foundation (NSF), the Department of Energy's (DOE) Office of Science, and the National Institute of Standards and Technology (NIST) laboratory activities.

President Bush signed the COMPETES Act in August 2007, despite the administration's strong reservation about some aspects of the legislation. The act establishes several new federal programs to encourage innovation and commercialization. The new NIST Technology Innovation Program will replace the existing Advanced Technology

Program by providing competitive grants to small- and medium-sized businesses commercializing a critical new technology. Single companies may receive up to $3 million over three years, while joint ventures may be eligible for $9 million over five years. The bill also creates a new program within DOE to develop technologies that help overcome the country's long-term energy challenges. At the same time, the bill omits several of the measures that had originally drawn the ire of the administration, including a requirement that all federal science agencies set aside 8 percent of their R&D budget for novel, pan-disciplinary research.[27]

5. The Interplay of Politics and Policy

It is important to note the process of federal budgeting that may significantly influence the true fate of COMPETE. With the war in Iraq, competing priorities of Democrats and Republicans over the federal deficit, an global economic slowdown, and emerging plans for a major reform in health care, the final budgeting for COMPETE may be significantly different. An earlier initiative by the Bush administration with similar goals has largely languished, in part because of the significantly different budget priorities of his administration with a newly elected majority in the House and US Senate, and the fact that the US is making only marginal attempts to deal with outstanding domestic policy issues.

In addition, a new presidential administration that will be in place by 2009 may also alter the federal commitment. Prior to the writing of this article, no presidential hopeful has, thus far, made any significant announcement on national science and technology, or on the role of science in long-term economic development. Significant new federal funding may indeed appear – some increase seems inevitable as HT industry and the science community will attempt to influence the platform of each party and HT businesses continue to expand their lobbying power.

As discussed in this paper, even with the successful implementation of COMPETE, states and local governments will likely continue to be the most prolific generators of new HT initiatives, based on rational assessments of best practices, new ideas, and increasingly the sense of competition and devotion to new growth theory. In the course of a growing era of state initiatives, the respective role of federal and state governments, and therefore the attention of the S&T community, will continue to be substantially altered — again, a relatively new phenomenon. Further, the role of lawmakers and the HT sector in driving new publicly funded initiatives and tax initiatives, and the role of the academic community, are growing in complexity as only partially discussed in this paper. The politics of HT policymaking (why and how policy is generated and how funds are invested) in the US, in the EU, and elsewhere, is an area of research that needs a fuller exploration. The perceived wonders of a high tech–driven society, and the political culture it has bred, are driving forces that are creating new policies and funding – perhaps justified, but not always?

Finally, and as discussed in this paper, there is a large disconnect in US policy related to promoting KBEAs and national competitiveness. Few policymakers, or even the higher education community, are aware of stagnant and, in some states, real declines in higher education access *and* graduation rates relative to economic competitors.[28] With global changes in the market for S&T talent, and the significant and increasingly successful effort of competitors to increase the educational attainment of their populations, the US's HT advantage, and more generally its historical competitive advantages, are eroding — although there remain a number of advantages, chiefly related to an entrepreneurial culture and the highest concentration of venture capital in the world.[29] The role of science and technology in society continues to grow; many countries have assessed their weaknesses, and have strategic approaches largely focused on educational attainment, building their higher education systems, and increased R&D output; most, and in particular the EU, are constantly assessing their relative competitiveness to that of the US and other developed economies. US policymakers are thus far less strategic, assume that the nation's high tech advantage is intact, and are generally not conscious of the breadth of change within the global economy.

How might the US think more strategically? Beyond making targeted investments in areas such as energy or biotechnology, long-term economic growth may well be linked to broad measures of social and economic health, including general education attainment levels, mitigations to large scale disparities in wealth, more robust paths for socioeconomic mobility, the provision of a basic social welfare safety net, and adequate public services (e.g., transportation and public education). These measures may be similar in importance to more traditional notions of what creates competitive economies, such as having a healthy network of research universities, encouraging entrepreneurship, providing tax incentives to promote risk-taking, the availability of venture capital, and creating policies conducive to attracting talent from throughout the world. In the US, state and regional governments can and are making investments to promote KBEAs. But it may well require a larger vision, a sense of leadership, and strategic investments by the federal government and a progressive president keep the US's high-tech advantage.

APPENDIX 1.

A Sample of the Frenzy of State Initiatives: 2007[30]

The following provides a sample of recent state-based initiatives to promote and support KBEAs. Each of these initiatives has been presented and debated, in some instances passed or defeated, by state and local governments in the US over an eight-month period — January through August 2007. The sample was chosen in part to provide an environmental scan of the varied initiatives, most related to funding university. These state initiatives also emerged largely before major indicators of an economic downturn occurred, which is now requiring most states to cut their planned 2008-09 budgets and, undoubtedly, to scale back S&T funding and plans.

Texas – Cancer Initiative
Governor Rick Perry, a Republican, signed in June 2007 a major new biomedical initiative to create a cancer institute with proposed funding over a ten-year period under a bond act that will generate $3 billion for voter approval. The measure will be presented to voters in November. The measure will essentially create an NIH-type agency for cancer research and was first advocated by a friend of former Governor Ann Richards, who died from esophageal cancer, and was influenced by California's high-profile passage of a $3 billion dollar bond act for stem cell–related research in 2004 — an initiative that was unprecedented in its scale, and in the concept that states might directly fund basic research in targeted areas once reserved largely to the federal government.

New York — Rural Cluster Development Initiative
New York Governor Eliot Spitzer signed legislation establishing a new program to stimulate employment and income growth by promoting cluster-based strategies in rural regions of the state. Sponsored by state Senator George H. Winner Jr., chairman of New York's Legislative Commission on Rural Resources, Senate Bill 3234 outlines the Cluster Based Industry and Agribusiness Development Grant Program, which will provide seed grants of up to $25,000 on a competitive basis to community-based economic development corporations. The Empire State Development (ESD) Corporation, the state's lead economic development agency, will disperse funds as part of its comprehensive rural revitalization program. Clusters are expected to be organized around the existing strengths in certain regions, as well as the emerging technologies and research under development at the universities and colleges dotting the landscape of rural New York.[31]

California — Additional Funds for Existing University-Industry Research Centers
Governor Arnold Schwarzenegger unveiled the $95 million Research and Innovation Initiative in January to provide funding to several university-based projects focused on clean energy, biotechnology and nanotechnology research, and commercialization. The state budget for the year 2007-08 included $70 million in lease revenue bond funding for the Energy Biosciences Institute and the Helios Project at the University of California (UC). UC Berkeley will receive $40 million for the Energy Biosciences Institute to focus on the development of alternative fuel, and $30 million is allocated for the Helios Project, an initiative by the Lawrence Berkeley National Laboratory to create sustainable, carbon neutral sources of energy. Lawmakers also approved $6 million for UC labor research programs. Not included in the budget is $15 million in operating funds for the California Institutes for Science and Innovation. UC officials hope to re-engage policymakers on the subject in the future, according to a press release from the UC Office of the President. [32]

Illinois — Venture Fund Initiative Fails
Governor Rod Blagojevich proposed the creation of the Illinois Community Assets Fund during his combined State of the State and Budget Address in March to increase access to capital and financing for economically distressed communities and populations. However, following a volatile legislative session in Illinois between the governor and lawmakers, a budget agreement was reached, but it does not include funding for several of the governor's priorities, including a $100 million state-run venture capital fund. Blagojevich signed the FY08 budget last week, vetoing approximately $500 million. Lawmakers also left out the governor's recommendation of $20 million in grants to the Illinois Regenerative Medicine Institute for stem cell research.

The FY08 budget does includes funding for existing programs within the Department of Community and Economic Opportunity (DCEO), including $5.5 million for the Community Technology Center Grant Program, $5 million for the Entrepreneurship Center Program, and $2 million for the Manufacturing Extension Program. Among the governor's line item vetoes were $1 million for the Innovation Challenge Grant program, $1 million for the Entrepreneur in Residence Program, and $750,000 for a grant to the University of Illinois for Illinois VENTURES.

Arkansas — Secures National Science Fund Grant

The National Science Foundation (NSF) will grant the Arkansas Science and Technology Authority (ASTA) $9 million through the Experimental Program to Stimulate Competitive Research (EPSCoR) to enhance the state's research capabilities. The new funds will be used to support a broad range of activities, from attracting world-class scholars to fostering entrepreneurship in select technology areas. The program, dubbed the Arkansas Advancing and Supporting Science, Engineering and Technology (ASSET) Initiative, will provide additional research funding to three of the state's university campuses: the University of Arkansas in Fayetteville, the University of Arkansas at Little Rock, and Arkansas State University in Jonesboro. These schools will receive financial support for the establishment of two new research centers and to promote interdisciplinary and multi-institutional research in promising fields.

The first center will investigate the nexus of agricultural, energy, environmental, and health sciences in the use of plant materials for energy generation. The Plant Powered Production (P3) Center will be a statewide virtual facility that will bring together researchers from each of these disciplines and will facilitate cooperative research between the state's institutions of higher education. A second center, the Wireless Nano- Bio- Info-Tech Sensor System and Center, will provide a collaborative infrastructure for nanosensor research at the University of Arkansas. Researchers at the center will contribute to the development of wireless arrays of low-cost, specialized nanosensors that can be used in power generation, food preservation, and biodevices.

ASTA's ASSET Initiative also will invest in a range of programs beyond university R&D to support high-tech growth in these emerging fields. The state's strategy includes a Human Resource Development and Community Outreach plan that will support entrepreneurs through training and education to commercialize the technologies developed at these new centers. In addition, ASSET will sponsor seminar series, discipline-specific regional and national meetings, and electronic access to scientific journals for researchers. The initiative also plans to develop K-12 and undergraduate educational programs and new opportunities for underrepresented groups in scientific research.[33]

Oregon — Innovation Plan

Oregon lawmakers have agreed to fund nearly all of Governor Ted Kulongoski's innovation proposals, including investments in seven new industry initiatives and the creation of two new signature research centers. The innovation plan passed by lawmakers falls $10 million short of the original $38 million proposal introduced by the Oregon Innovation Council and included in Kulongoski's 2007-09 budget released in December 2006. Kulongoski signed four bills encompassing the initiative, with one bill including $9 million over the biennium for Oregon's first signature research center, the Oregon Nanoscience and Microtechnologies Institute (ONAMI) — $1 million less than the governor's recommendation — and $2.5 million for a new signature research center, the Bio-Economy and Sustainable Technologies (BEST) Center. Research conducted by the BEST Center will focus on clean energy, bio-based products and green building.[34] Additionally, SB 5508 includes $2.9 million to support manufacturing competitiveness, such as advanced training and R&D to ensure a competitive workforce, and $4.2 million for the Wave Energy initiative to help build a sustainable industry on the Oregon coast by using ocean waves to generate electricity. The Food Processing Innovation and Productivity Center will receive $3.4 million for R&D and training.

Funding for the state's second new signature research center is designated within HB 5035. The legislation includes $5.25 million for the Oregon Translational Research and Drug Development Institute to develop and commercialize new drugs to fight infectious diseases. The institute also will provide access to drug development resources that many companies cannot afford to build themselves, according to the governor's press office. SB 579 expands the authority of the Oregon Growth Account (OGA) Board and Oregon State Treasurer's office, giving them the authority to invest money from the OGA account into funds designated to make seed investments in new and existing emerging companies. The budget does not include funding for the proposed $5 million Cluster Accelerator Fund, a partnership with the Oregon Economic Development Department to strengthen the state's innovation pipeline in selected technology areas.

North Carolina — TBED Initiatives

After running on a monthlong stopgap budget, North Carolina lawmakers reached a $20.7 billion budget agreement for budget year 2007-08 that included funding for major research initiatives, public and higher education, and TBED-related items.

Under the budget agreement signed Tuesday by Gov. Mike Easley, University of North Carolina (UNC)-Chapel Hill is slated to receive $25 million this year, $40 million next year, and a recurring $50 million in future years to expand cancer research. Funding for the initiative comes from a 10 percent increase on tobacco products other than cigarettes, $21.2 million in general fund revenue over the biennium, and $8 million from the Tobacco Trust Fund each year.

In keeping with a legislative mandated study enacted last year, the budget appropriates $5 million to establish the North Carolina Biofuels Center. The action plan, *Fueling North Carolina's Future: North Carolina's Strategic Plan for Biofuels Leadership*, outlines nine strategies for the coming decade to strengthen the state's future in biofuel development and use.

The budget also provides $1 million to establish the North Carolina Green Business Fund as a special revenue fund within the Department of Commerce. The fund will invest in projects focusing on three priority areas: encouraging the development of the biofuels industry; fostering the development of the green building industry; as well as attracting and leveraging private-sector investments in clean technology and renewable energy products.

The North Carolina Biotechnology Center appropriation for budget year 2007-08 was $15.6 million, with $3 million earmarked to create regional innovation centers that focus on research and technology transfer in biotechnology-related fields. Budget funding for other initiatives includes $14 million for the One North Carolina Fund; $4.8 million for the One North Carolina Small Business Fund to provide grants under North Carolina's SBIR/STTR program; $4 million to the e-NC Authority to increase availability of internet connectivity in rural areas of the state; and $1.5 million for the Support Defense and Security Technology Accelerator, a business incubator focused on homeland security and defense industries.

Education initiatives in both K-12 and higher education fared well in the budget. The budget provides $4.4 million to fund the Focused Education Reform Pilot program, which will offer teacher recruitment and retainment bonuses, teacher mentoring, and science and math instructional assistance. A new School Technology Pilot program will receive $3 million, which — along with a grant from the Golden LEAF Foundation and private sector funds — will be used to establish eight pilot high schools that incorporate technology in the classroom by providing computers for all teachers and students. UNC System initiatives funded within the budget include:

- $6 million for matching funds for UNC system campus endowed professorships;
- $5 million in additional operating funds for the bioengineering program at North Carolina State University (NCSU) College of Engineering;
- $3 million to create a research competitiveness fund to support strategic investments in emerging areas such as nanoscience, marine science, and biomanufacturing, emphasizing interdisciplinary research;
- $2 million for tuition waivers aimed at recruiting and retaining top-tier graduate students in science and technology;
- $1.5 million to expand initiatives at NSCU for R&D of bioenergy technologies;
- $1.5 million for math and science teacher recruitment efforts for NCSU and UNC-Chapel Hill;
- $1.4 million for a joint graduate school of nanoscience and nanoengineering at the Millennium Campus of UNC-Greensboro and North Carolina A&T State University;
- $1 million in additional operating funds for the Biomanufacturing Research Institute and Technology Enterprise initiative at North Carolina Central University; and

- $500,000 for NCSU Entrepreneurship and Regional Cluster–based Economic Development Funds to expand activities, foster new microenterprises, capture the production of new high-technology based products, and pursue focused recruitment and retention efforts in high-priority job clusters.[35]

Maryland — Venture Capital

The Maryland Technology Development Corporation has awarded more than $500,000 to seven start-up technology companies. The program, TEDCO's Maryland Technology Transfer Fund (MTTF), is designed to help businesses transfer technology from Maryland universities and federal laboratories into the marketplace. The grants range between $70,000 and $75,000. TEDCO reports that MTTF has provided funding to 71 companies. With a total investment of $4,078,793, these companies have gone on to receive downstream funding from angel and venture investors, federal awards, and other resources exceeding $152.4 million.

Pennsylvania — Energy and Science Education

As part of the budget deal agreed upon earlier this week between Governor Ed Rendell and Pennsylvania lawmakers, two of the governor's major TBED priorities — the Jonas Salk Legacy Fund and an alternative energy fund — will be voted on later this year. Under the budget agreement, lawmakers committed to a roll call vote in November to decide on the Jonas Salk Legacy Fund, which proposes borrowing $500 million from the state's tobacco settlement proceeds to invest in scientific research. The initiative will be matched on a dollar-for-dollar basis, yielding $1 billion in new bioscience investments, according to the governor's press office.

Rendell will call a special legislative session beginning Sept. 17 to consider alternative energy and conservation legislation. Lawmakers agreed to consider a $60 million annual commitment with the option of a bond authorization of up to $750 million. The governor's Energy Independence Strategy calls for the creation of a fund to help bring energy products and technologies to the market.

The 2007-08 budget for the state's Department of Education included increased funding for Pennsylvania public high schools to prepare students for careers in high-skill areas. The budget includes $90 million — a $70 million increase over last year — for the Classrooms for the Future initiative, which provides laptops to high school students in more than 350 public schools. Other investments in education include:

- $13.5 million (35 percent increase) for the Science: It's Elementary program to assist students in becoming active in the field of science;
- $11 million (38 percent increase) for Project 720 to help 30 additional high schools increase the rigor of their academic programs to prepare students for college and high-skill careers;
- $10 million for dual enrollment funding to help high school students earn college credit; and
- $2 million to launch new technical college programs to provide an opportunity for high school graduates to earn workforce credentials and associate degrees in high-demand career fields.

The enacted budget includes $51.7 million for the Ben Franklin Technology Development Authority Fund within the Department of Community and Economic Development (DCED). DCED will receive $45 million for the Opportunity Grant Program to create and retain agricultural, manufacturing, and R&D jobs, $22.5 million for customized job training, and $2 million for Keystone Innovation Zones. Rendell signed the FY 2007-08 budget into law on Tuesday.[36]

Oklahoma — Bioenergy Center, University Chairs in Science

Oklahoma is one step closer to positioning itself as a leader in sustainable energy production with the creation of a $40 million Bioenergy Center. The legislature passed SB 510 at the close of the 2007 session last month, establishing the Oklahoma Bioenergy Center announced by Governor Brad Henry during his State of the State Address earlier this year. The Bioenergy Center is a joint collaboration among the University of Oklahoma, Oklahoma State University, and the Noble Foundation. The institution will coordinate the state's resources and research programs in the fields of biofuels and bioenergy development and production, utilizing a $10 million annual appropriation over the next four years. Research efforts will focus on sustainable economic production of cellulosic ethanol and developing critical steps in production of biodiesel and ethanol from non-cellulosic sources.

The center's 2008 fiscal year appropriation will be channeled through the state's lead TBED agency, the Oklahoma Center for the Advancement of Science and Technology (OCAST). The total OCAST budget for FY08 is $28.9 million, including surplus monies added throughout the year. OCAST will receive $6 million in surplus funds specifically for the Bioenergy Center. An additional $4 million from the OCAST budget also is directed to the center. From the OCAST budget, $500,000 is directed to a Biofutures Institute in Tulsa and $350,000 is set aside for research equipment.

Additionally, HB 1105, a spillover bill distributing excess revenues after the state's maximum reserve balance is met, calls for $500,000 for OCAST to use to provide seed capital funding, a sharp decline from last year's funding level of $5 million. The agency's traditional programs will be funded at current levels.

Legislators also approved a $50 million increase of the authorization for endowed chairs at Oklahoma colleges and universities and $16.5 million for capital projects at the University of Oklahoma, Oklahoma State University, and regional universities, including the state's Cancer Center. Department of Commerce appropriations for FY08 include $250,000 for the Oklahoma Alliance for Manufacturing Excellence and $300,000 for the creation of a Small Rural Manufacturers Program at Oklahoma State University.

Lawmakers did not allocate funding for two of the governor's major economic development initiatives. Henry's proposed budget included $50 million to the Economic Development Generating Excellence endowment fund and $15 million to the Opportunity Fund from surplus general revenue funds. Both initiatives were funded last year. The budget awaits Henry's anticipated signature.

Minnesota — Energy Initiative, Funding for TBED
Funding for energy and TBED initiatives were highlighted in the year 2007-09 biennial budget at the close of the legislative session in Minnesota late last month. Winning nearly unanimous approval from the legislature was Governor Tim Pawlenty's Next Generation Initiative announced during his State of the State Address.

The $170 million Agriculture and Veterans Omnibus Bill, which provides funding for the initiative, creates the Next Generation Energy Board to research and recommend how the state can most efficiently achieve energy independence. The bill also focuses on Minnesota's 25x25 goal, similar to the national 25x25 initiative. Minnesota energy companies are required under the bill to provide 25 percent of electricity from renewable sources by 2025. The goal also aims for agriculture, forestry, and working lands to produce 25 percent of the total energy consumed in Minnesota and expand the Fuel Replacement Goal to 25 percent by 2025. Other major components include:

- $4.25 million for a renewable energy research pool that includes $1.25 million to continue Clean Energy Resource Teams and $2 million for plug-in hybrid electric vehicles and other automotive technology demonstrations, such as E85 conversion kit testing;
- $3 million for the E85 Everywhere initiative to double the number of E85 pumps in the state;
- $1.4 million in Next Generation Energy Grants for biofuels and biomass research, including the creation of a biomass fuel supply depot in LeSueur or Scott County and a feasibility study of renewable forest resources by the Bois Forte Band of Chippewa;
- $1 million in 25x25 grants for on-farm biogas recovery facilities or methane digesters and another $1 million to continue the state's rebate program;
- An aggressive energy saving goal for Minnesotans to reduce use of fossil-fuel by 15 percent by 2015; and
- A goal of 1,000 certified Energy Star commercial buildings in the state by 2010.

To ensure Minnesota achieves maximum economic benefits from enhanced renewable energy activities, the bill calls for the commissioners of the Minnesota Department of Employment and Economic Development (DEED), Agriculture, Commerce, and the Public Utilities Commission to develop a strategy that focuses on this goal.

The 2007-09 Budget appropriates $49.2 million for the Business and Community Development Division within DEED over the biennium. Included in this amount is a one-time appropriation of $1.75 million to the BioBusiness Alliance of

Minnesota for bioscience business development programs to promote and position the state as a global leader in bioscience business activities. Additional programs receiving funding include:

- $750,000 for a one-time appropriation to Minnesota Technology Inc. to support its small business growth acceleration program;
- $250,000 in FY08 for the University Enterprise Laboratories to support early-stage and emerging bioscience companies;
- $200,000 over the biennium to help small businesses access federal funds through the Small Business Innovation Research and Small Business Technology Transfer programs; and
- $125,000 in FY08 to develop and operate a bioscience business marketing program to market Minnesota bioscience business and business opportunities to other states and countries.

Massachusetts and Ohio — Broadband Initiatives
While many parts of the country are looking for innovative means to increase the number of citizens and businesses connected to high-speed Internet in both urban and rural areas, two governors recently announced initiatives targeting the further extension of broadband services throughout their states.

Massachusetts Governor Deval Patrick declared the commonwealth would invest $25 million into a new "broadband incentive fund" to be managed by a division of the Massachusetts Technology Collaborative (MTC), named the Broadband Institute. Under the plan, private companies will compete for funds to install equipment such as network fiber and wireless towers in rural areas that currently do not have broadband. According to the MTC, 32 towns in Massachusetts lack broadband access and 63 municipalities only have broadband in a limited area. The program's goal is to make broadband available to all communities by 2010.

Ohio's recent moves have targeted the expansion of broadband delivery to multiple stakeholders, including state and local government. Governor Ted Strickland signed an executive order that extends and strengthens the state's broadband network to all of Ohio's counties and creates an organization to oversee future high-speed Internet development. The order directs some of the available bandwidth from the 1,850-mile, 10-gigabit Ohio Supercomputer Center Network (OSCnet) to a new entity named the Next Generation Network. This entity will be dedicated to the consolidation of service delivery and improved connectivity for state and local government, county and city network rings, public safety, the courts system, underserved populations, and additional public/private initiatives. OSCnet will concentrate exclusively on computing and connectivity resources for Ohio colleges and universities, small- and medium-sized companies, K-12 schools, hospitals, public broadcasting stations, and local, state, and federal research centers. Together, the two networks will be administered as the Broadband Ohio Network.

The newly formed Ohio Broadband Council will be responsible for efforts to extend the Broadband Ohio Network to all of the state's 88 counties. Additionally, the council is expected to coordinate future broadband programs funded by the state, to pursue federal investments in broadband, to address the digital divide in the state's rural and urban areas, and to promote both public and private broadband initiatives.[37]

NOTES

1 This article builds on a previous analysis of US state-based HT initiatives in an earlier publication by the author. See John Aubrey Douglass, "The Entrepreneurial State and Research Universities in the United States: Policy and New State-Based Initiatives," *Higher Education Management and Policy* (OECD) 10 (1) , 2007.

2 See John Aubrey Douglass, "The Higher Education Race," International Higher Education, Fall 2007.

3 For a discussion of the convergence of national efforts to increasing higher education attainment rates, see: John Aubrey Douglass, "A Global Scenario for Higher Education Systems" GUNI-UNESCO Dec 2007 http://www.guni-rmies.net/news/detail.php?id=1141

4 This article builds on a previous analysis of US state-based HT initiatives in an earlier publication by the author. See John Aubrey Douglass, "The Entrepreneurial State and Research Universities in the United States: Policy and New State-Based Initiatives," *Higher Education Management and Policy* (OECD) 10 (1), 2007.

[5] Significant portions of this section of the brief rely on data and analysis provided in the most recent edition of *Science and Engineering Indicators* (2006) published by the National Science Foundation. For more information, see: http://www.nsf.gov/statistics/seind06/c4/c4h.htm#c4hl7

[6] See Science and Engineering Indicators 2006, National Science Foundation: http://www.nsf.gov/statistics/seind06/c4/c4h.htm#c4hl7

[7] Compared with patterns in the United States, however, a considerably greater share is funded for engineering research activities in each of these three countries.

[8] Science and Engineering Indicators 2006.

[9] Science Technology Industry – Venture Capital: Trends and Policy Recommendations, OECD 2004.

[10] Ernst & Young's Acceleration: Global Venture Insights Report 2007: http://www.ey.com/global/content.nsf/International/SGM_-_Venture_Capital_Insight_Report_2007

[11] Deloitte, Global Trends in Venture Capital 2007 Survey: http://www.nvca.org/pdf/US_Rpt_Global_VC_Survey_7-25-07.pdf

[12] David C. Mowery, Richard R. Nelson, Bhaven N. Sampat, and Arvids A. Zeidonis, *Ivory Tower and University-Industry Technological Transfer Before and After the Bayh-Dole Act* (Stanford University Press, 2004).

[13] National Science Foundation, *Science and Engineering Indicators 2006,* see figures 6-22 appendix table 6-12.

[14] For an analysis of the decline in the US advantage in higher education access and degree production, see John Aubrey Douglass, *The Conditions for Admission: Access, Equity, and the Social Contract of Public Universities* (Stanford University Press, 2007).

[15] Council of Graduate Schools, "Findings from the 2006 CGS International Graduate Admissions Survey

[16] Committee on Science, Engineering, and Public Policy, *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future* (New York: National Academies Press, 2006).

[17] Freeman, "Does Globalization of the Scientific/Engineering Workforce Threaten US Economic Leadership?"

[18] A recent EU report states that Europe's lagging R&D intensity results from structural characteristics, including tax incentives and an improved environment for entrepreneurship among small firms, not underinvestment in R&D by individual and usually large European firms. See Petro Moncada-Paternò-Castello et al., "Does Europe Perform Too Little Corporate R&D? Comparing EU and non-EU Corporate R&D Performance," European Commission Joint Research Centre, Institute for Prospective Technological Studies (IPTS), Seville, 2006.

[19] Patents applied for at the European Patent Office (EPO), the Japanese Patent Office (JPO) and granted to the US Patent and Trademark Office (USPTO), estimations for priority year 2001. The priority date corresponds to the first international request for protecting an invention

[20] National Sciences Foundation, *Science and Engineering Indicators 2006* (Washington DC: National Science Foundation, 2006).

[21] Robert Fontana, Aldo Geuna, and Mirrell Matt, "Factors Affecting University-Industry R&D Collaboration: The Importance of Screening and Signaling," Research Centre in Economics and Management, Strasbourg, 2005.

[22] Celestine Chukumba and Richard Jensen, "University Invention, Entrepreneurship, and Start-Ups," National Bureau of Economic Research, Tech-Based Economic Development Research Center, 2005.

[23] Martin Kenney and Donald Patton. "Entrepreneurial Geographies: Support Networks in Three High-Tech Industries*." Economic Geography* 81 (2): 201-228.

[24] For a further discussion on the differences among the states in HT activity, see John Aubrey Douglass, "*The Entrepreneurial State and Research Universities in the United States: Policy and New State-Based Initiatives*," *Higher Education Management and Policy* (OECD), 10 (1), 2007.

[25] *Ibid.*

[26] Committee on Prospering in the Global Economy of the 21st Century, *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future (*National Academies Press 2007).

[27] The American Institute of Physics plans to run a series of articles in its FYI science policy news bulletin examining the details of the new legislation and its likely implications for US scientific research. The latest issue of FYI is available at http://www.aip.org/fyi/.

[28] See John Aubrey Douglass, "The Higher Education Race," International Higher Education, Fall 2007.

[29] For a discussion of the convergence of national efforts to increasing higher education attainment rates, see John Aubrey Douglass, "A Global Scenario for Higher Education Systems" GUNI-UNESCO Dec 2007 http://www.guni-rmies.net/news/detail.php?id=1141

[30] This section of the brief includes analysis and reports offered by the State Science and Technology Institute and their *SSTI Weekly Digest*.

[31] The text of S.B. 3234 can be accessed at: http://assembly.state.ny.us/leg/?bn=S03234

[32] The FY 2007-08 Enacted Budget is available at: http://www.ebudget.ca.gov/

[33] See: http://www.asta.arkansas.gov/newsroom/index.php?do:newsDetail=1&news_id=58

[34] Senate Bills 5508, 579 and 582 and House Bill 5035. SB 5508

[35] HB 1473 is available from the North Carolina General Assembly at: http://www.ncga.state.nc.us/
[36] HB 1286 is available at http://www.budget.state.pa.us/budget/cwp/view.asp?a=3&q=167632
[37] The council's website is http://www.ohiobroadbandcouncil.org/