

# The new geography of global innovation

Goldman  
Sachs

Global Markets  
Institute

## The new geography of global innovation

While the United States and Japan remain leaders in innovation, increased competition from growth markets, notably China, suggests a changing landscape. Research and development spending in Asia surpassed EU levels in 2005, and is likely to overtake US levels in the next five years, thanks primarily to striking growth in R&D investment in China.

Measures of R&D intensity, or R&D investment as a share of GDP, allow for cross-country comparisons of commitment to R&D. R&D intensity has remained flat across G7 markets during the last decade at 2.1%. In China it has impressively doubled as a share of GDP since 1999, reaching 1.5%, which remains low by international standards.

R&D investment is driven largely by the corporate sector, which finances more than two-thirds of total R&D spending in many countries. Companies in a range of industries, from pharmaceuticals to technology hardware, have exposure to new hubs of global innovation.

## Pipeline concerns and the role of human capital

The new geography of global innovation is critically dependent upon higher education in science and engineering (S&E) fields. Student interest in S&E is low in G7 countries, suggesting that these markets are likely to have difficulty replacing an aging cohort of native-born scientists and engineers. Reliance on foreign-born skilled labor is set to rise further as the world's S&E skill base shifts toward Asia, notably China, where S&E fields represent 40% of all new university degrees awarded (more than two and a half times US levels).

## New geography demands a policy response

Innovation-led productivity growth in the G7 will increasingly require public policies which attract and retain skilled foreign students and workers. In the short term, a more flexible and talent-friendly immigration regime can help developed economies and companies to benefit from the globalization of S&E skills. Longer-term investments in R&D and science education can further enable G7 countries to remain competitive by rebuilding student interest in S&E fields and by expanding the domestic supply of skilled S&E labor.

### Douglas Gilman

(212) 902-3132 douglas.gilman@gs.com  
Goldman Sachs & Co.

The Global Markets Institute is the public policy research unit of Goldman Sachs Global Investment Research. Its mission is to provide research and high-level advisory services to policymakers, regulators and investors around the world. The Institute leverages the expertise of Research and other Goldman Sachs professionals, as well as highly-regarded thought leaders outside the firm, to offer written analyses and host discussion forums.

## Table of Contents

---

<b>Introduction</b>	<b>3</b>
The new geography of global innovation	3
Pipeline concerns and the role of human capital	4
New geography demands a policy response	4
<b>The new geography of global innovation</b>	<b>4</b>
Shifting patterns of R&D investment	4
The corporate sector drives the increase in spending	5
Employment by US multinationals is shifting toward growth markets.	8
Shifting patterns of innovative activity	9
<b>Pipeline concerns and the role of human capital</b>	<b>11</b>
More students are studying outside the G7 ...	11
... and more of them are studying science and engineering	11
Educational pipeline feeds a rapidly aging skilled labor force	14
<b>New geography demands a policy response</b>	<b>15</b>
Immigration policy	15
Innovation policy	16
Education policy	17
Conclusion	19
<b>Bibliography</b>	<b>21</b>

The author would like to thank Abby Joseph Cohen, Sandra Lawson, Sarah Friar and Julio Quinteros for helpful comments.

## Introduction

---

**Much of the focus on the rise of the BRICs (Brazil, Russia, India, and China) has centered on their role as engines of global manufacturing. Low unit labor costs, large populations and favorable demographics mean that this trend has additional room to run in many emerging countries, including the N-11 countries. Beyond manufacturing, however, the growth markets story is increasingly about innovation. This paper discusses the globalization of innovative activity and implications for economic competitiveness and public policy in developed countries.**

**The United States and Japan remain leaders in global innovation, but a range of measures suggests that new hubs of global innovation are emerging, notably China. This shift is supported by a number of drivers, including: (1) strong R&D investment growth in Asia, which is increasingly financed by the private sector; and (2) the globalization of higher education, particularly in science and engineering.**

**The emergence of new centers of science education and global R&D enables firms in a range of sectors to rethink where they operate and invest. Policy initiatives, particularly concerning immigration and skills, can support the future competitiveness of G7 countries. Efforts to deepen innovation within these countries may also help address rising challenges to sustainable growth, including healthcare cost inflation, energy security and climate change.**

### The new geography of global innovation

**Changing global R&D flows suggest continued shifts in scientific output**

A range of measures suggests a changing and more global innovation landscape. While the United States and Japan remain leaders in science and technology innovation, they face increased competition from leading growth markets, notably China. R&D spending in Asia exceeds EU levels and is likely to overtake US levels in the next five years. This principally reflects strong growth in China, now the world's third leading R&D investor (at \$100 billion), behind the United States (at \$325 billion) and Japan (at \$123 billion). The government's target of spending 2.5% of GDP on R&D by 2020 would translate into a tripling of China's R&D investment over the next decade, to \$300 billion.

While ambitious government goals for R&D intensity suggest continued growth in R&D spending in China and a relative reweighting of the global total, broader changes in R&D investment are largely driven by the corporate sector in many markets. Industry finances the majority of R&D investment spending both in the United States and Japan as well as across many growth markets. Industry finances more than 65% of total R&D spending in the United States, 70% of total R&D spending in China, and approximately 75% of total R&D spending in Korea and Japan. Companies driving this shift are those in pharmaceuticals, computer and electronic products, and transportation equipment, as well as those in some professional, scientific, and technical services fields.

**New centers of global science suggest opportunities for R&D investment and employment across a range of sectors**

Along with a shift in R&D investment we find that emerging markets are home to a rising share of global patenting activity, improved high-tech trade balances and strong labor productivity growth, which further affects incentives for R&D investment and employment. The global dispersion of innovative activity enables companies across a range of sectors to rethink where they operate and invest, making several markets, including China and India, increasingly attractive to corporate R&D investment and employment.

**The globalization of S&E education is reshaping the world's S&E skill base**

**Pipeline concerns and the role of human capital**

The new geography of global innovation is critically dependent upon higher education in S&E fields. Local students in G7 countries show little interest in science and engineering education today. These fields represent less than 25% of all new university degrees awarded in G7 countries, and just 15% of all new degrees awarded in the United States. Against the backdrop of an aging supply of local scientists and engineers, this suggests that G7 countries will increasingly need to turn elsewhere for skilled labor. Reliance on foreign-born skilled labor is set to rise further as the world's S&E skill base shifts toward Asia, notably China, where S&E fields represent 40% of all new university degrees awarded (more than two and a half times US levels). As noted below, however, there are questions regarding the comparability of degree standards across countries.

**Policy action on immigration, innovation, and education remains "top of mind" in G7 countries**

**New geography demands a policy response**

Public policies that attract and retain skilled foreign nationals are essential to innovation-led productivity growth in G7 countries. In the short term, a more flexible and talent-friendly immigration regime can help developed economies (and companies) to benefit from the globalization of S&E skills and the heightened mobility of highly-skilled workers. Longer-term investments in innovation, including R&D, and science and math education, can support G7 competitiveness by rebuilding student interest in S&E fields and by expanding the domestic supply of skilled S&E labor. Well-positioned companies in the technology and healthcare sectors, including **technology hardware, healthcare services** and **medical technology**, could be notable beneficiaries of effective policy action, as could those in **educational services**.

## The new geography of global innovation

---

**A range of measures suggests a changing and more global innovation landscape. While the United States and Japan remain leaders in science and technology innovation, they face increased competition from leading growth markets, notably China.**

**Shifting patterns of R&D investment**

**R&D spending in Asia exceeds EU levels and is likely to overtake US levels in the next five years. Rapid growth in China, now the world's third leading R&D investor at \$100 billion per year, is a major factor.**

**The United States remains the world's leading R&D investor**

The shifting geography of R&D is most evident in terms of investment. In absolute terms, global R&D spending has nearly doubled over the past decade, reaching \$1 trillion. G7 markets account for more than \$615 billion of this investment (with \$325 billion coming from the United States and \$123 billion coming from Japan), but their shares have declined since the late-1990s, offset by large share gains in China and, to a lesser extent, other growth markets in Asia.

The current pace of R&D investment growth in Asian markets, most notably China and Korea, is considerably higher than the pace of growth in G7 markets, suggesting continued convergence. R&D spending in China has grown by more than 20% per year, on average, during the last decade, and by 8% per year in Korea. Average R&D investment in G7 markets, by comparison, has grown by 3.2% annually during the same period.

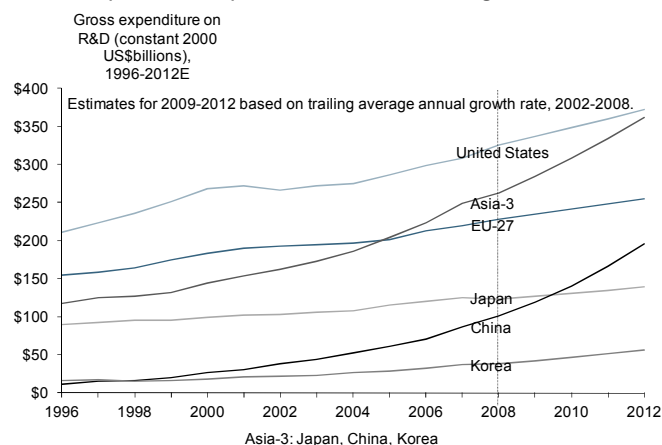
Measuring R&D investment as a share of GDP allows for cross-country comparisons of commitment to R&D. R&D intensity has remained flat across G7 markets during the last decade at 2.1%. In China it has doubled as a share of GDP since 1999, reaching 1.5%, which remains low by international standards. R&D intensity in Japan and Korea is meaningfully higher at approximately 3.5%.

**R&D investment remains a key policy priority in China; spending is likely to reach \$300 billion by 2020**

Ambitious policy goals in China suggest that future investment in research and innovation will remain strong. The government’s spending target of spending 2.5% of GDP on R&D by 2020 would translate into a tripling over the next decade, to \$300 billion. This investment is likely to be accompanied by a sharply rising number of researchers, many of whom are ultimately responsible for deploying incremental R&D investment. Elsewhere, R&D intensities in Korea and Japan already significantly exceed US levels. See Exhibits 1-2.

**Exhibit 1: Steady rise in global R&D investment**

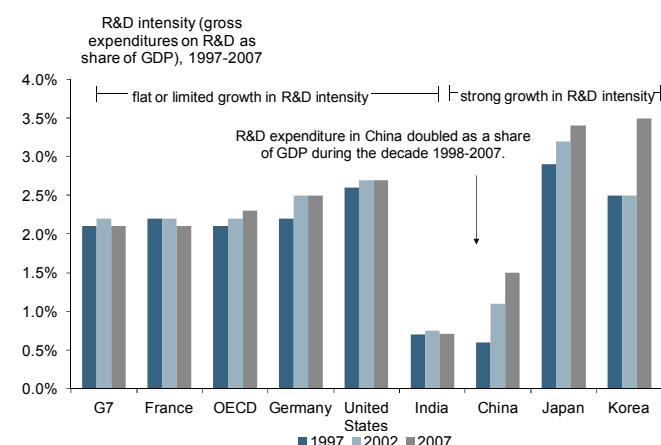
Asia outpends Europe, continues to converge to US levels



Source: Global Markets Institute, OECD.

**Exhibit 2: Greatest R&D intensity gains are in Asia**

China’s investment has doubled as a share of GDP since ‘99

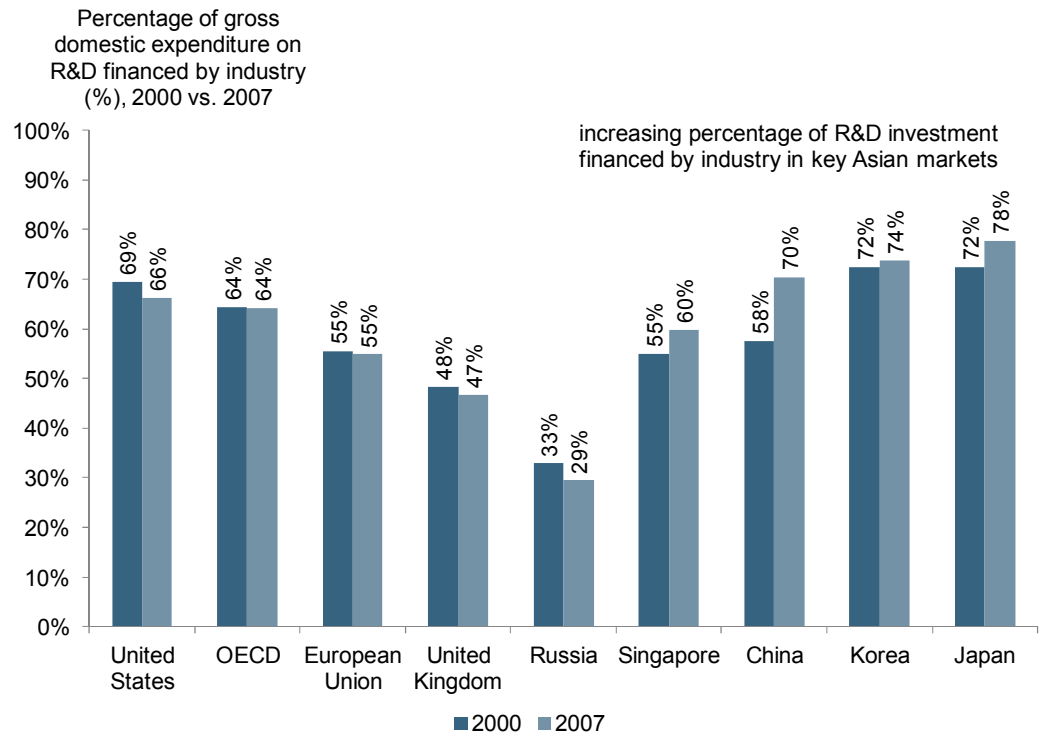


Source: OECD.

**The corporate sector drives the increase in spending**

The corporate sector finances the majority of R&D investment spending, both in the United States and Japan as well as across many growth markets. Industry finances 70% of total R&D spending in China, up sharply from 58% in 2000. Industry finances more than 65% of total R&D spending in the United States and approximately 75% of total R&D spending in Korea and Japan (see Exhibit 3). India is a notable exception, with government sources financing more than 80% of total R&D expenditure. Globally, fifteen of the top 25 public companies by reported R&D investment, collectively responsible for nearly \$84 billion in R&D investment, are headquartered outside of the United States, primarily in Japan and Europe. These companies fall primarily in the pharmaceutical, technology hardware, and automotive industries.

**Exhibit 3: Increasing percentage of R&D investment financed by the private sector**  
 Approximately 75% of R&D spending in China, Korea and Japan now driven by industry



Source: OECD.

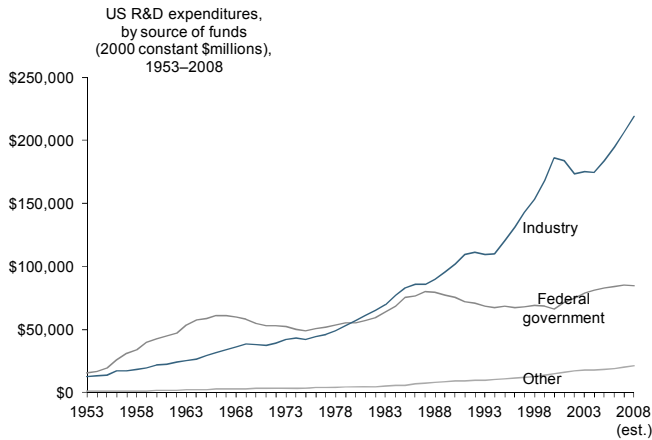
**The new geography of global innovation is also evident in private sector R&D investment by US-based multinationals.**

As growth abroad outpaces growth within the United States, a rising share of this industry R&D is deployed abroad (see Exhibits 4-6).

**R&D investment by US multinationals continues to rise, with foreign affiliates playing an increasingly important role**

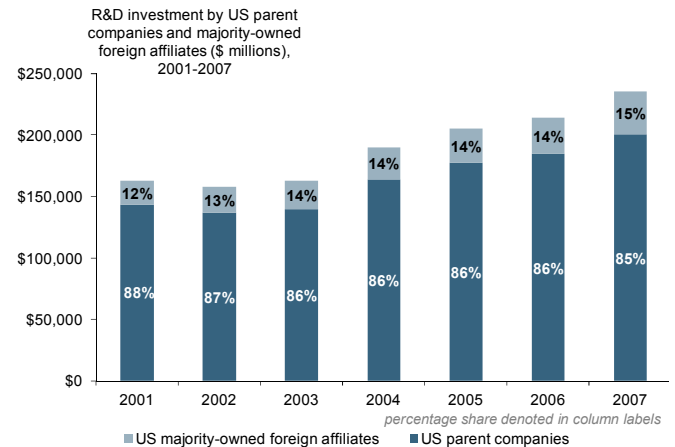
- Total R&D investment by US-based multinationals nearly doubled over the decade to 2007, reaching \$235 billion. While US parent companies are responsible for 85% of this R&D investment, investment attributable to the majority-owned foreign affiliates (MOFAs) of US firms has grown notably. This shift is increasingly important given that the corporate sector now accounts for more than 65% – and rising – of total US R&D investment.
- Much of the R&D investment by foreign affiliates has been in research-intensive industries such as pharmaceuticals and technology hardware, as firms in these fields link up with local universities and establish dedicated research centers in emerging markets. For example, Pfizer, the world’s second-leading corporate R&D investor (at \$7.4 billion), has both its own R&D Center in Shanghai and research partnerships with leading Chinese universities.

**Exhibit 4: The private sector finances a growing majority of total US R&D investment ...**



Source: National Science Foundation.

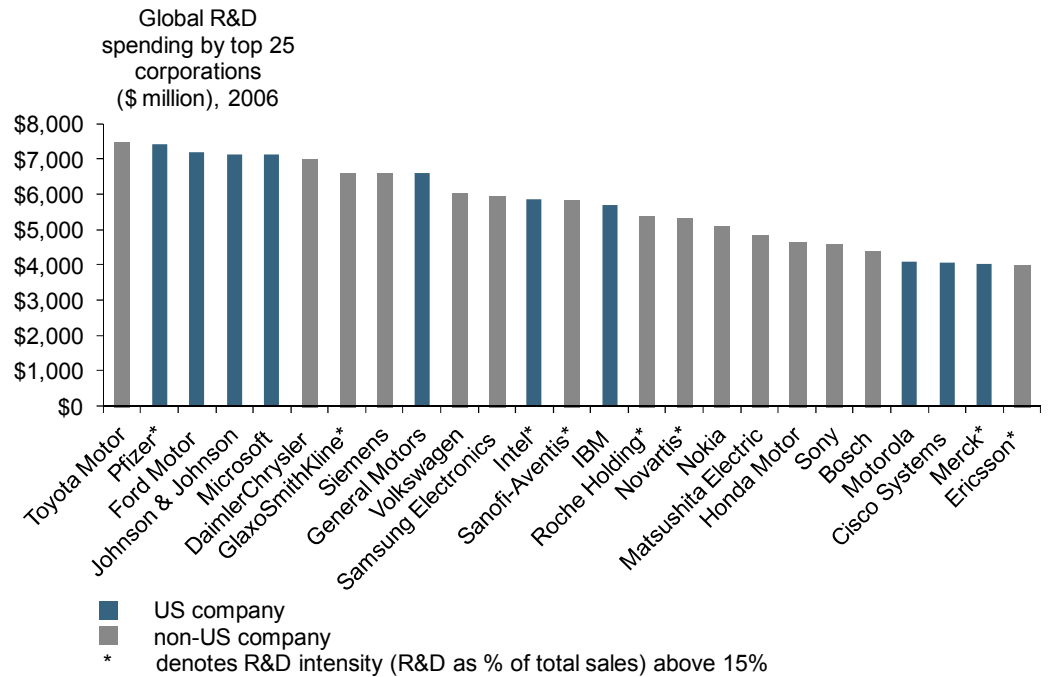
**Exhibit 5: ... and foreign affiliates have gained share**



Source: National Science Foundation, Global Markets Institute.

**Exhibit 6: Non-US companies represent 15 of the top 25 public companies by reported global R&D investment as of 2006**

R&D intensity, or R&D as a percentage of sales, highest among pharmaceutical firms



Source: Standard & Poor's, Global Markets Institute.

### Employment by US multinationals is shifting toward growth markets.

- Total employment by US multinationals exceeded 32 million in 2007. The share of total employment attributable to majority-owned foreign affiliates has grown from 25% in 2000 to more than 31% in 2007.
- Total employment by foreign affiliates is highest among companies in the manufacturing industry (including chemicals, computer and electronic products, and transportation equipment) and those in the professional, scientific and technical services industry (such as computer systems design). For example, nearly 40% of Microsoft's full-time employees are outside the United States. The company has operations that employ 1,500 full-time research and developers in China, along with another 1,500 in India.

### Recent R&D investment and employment commitments in growth markets

Several examples demonstrate the rising importance of growth markets, in particular China, to R&D investment and employment by US multinationals. These investments are increasingly driven by the growing supply of skilled S&E labor and favorable policy incentives.

- **Pfizer** has both its own R&D Center in Shanghai and partnerships with leading Chinese universities. These initiatives fund the education of Chinese students and support fundamental research and capacity building in China's healthcare system.
- **Ford Motor Company** recently announced plans to expand its Brazilian operations. The focus of this investment is the development of a new global vehicle, EcoSport, which will be entirely developed in the company's engineering center in Camaçari, Brazil, for the domestic market as well as for export.
- **Microsoft** has operations that employ 1,500 full-time research and developers in China. The company's development center in India has more than 1,500 employees and has contributed to the filing of 270 patents in the last five years.
- **Boeing** has dramatically expanded its R&D presence in India. The company opened the Boeing Research and Technology center in Bangalore in 2009, building on existing research partnerships with the Indian Institute of Science and the Indian Institutes of Technology. India's role as a key research and manufacturing partner was also evident when TAL Manufacturing Solutions, part of India's Tata Group, supplied technology for Boeing's 787 Dreamliner.
- **Intel** established the Intel China Research Center in 1998, with a focus on advanced technology R&D. Since then, Intel Capital has announced new equity investments in clean technology and healthcare software in China. The company operates in more than 16 cities in China and is also expanding its R&D efforts in India in core areas such as power efficiency and health platforms.
- **Cisco Systems** recently committed more than \$1 billion in India over three years, including \$750 million for R&D. The company now employs more than 1,400 people in its Global R&D Center in Bangalore.
- **IBM** launched the China Analytics Solutions Center in 2009, supporting the company's investments in China and the region. This follows an earlier partnership with China's Ministry of Education to strengthen the local science curriculum.
- **Applied Materials** opened the world's largest solar research center in Xian, China in 2009.



## Shifting patterns of innovative activity

**As global R&D investment tilts toward growth markets, we find these same economies are home to a rising share of global scientific output as well as increased patenting activity and improved high-tech trade balances.**

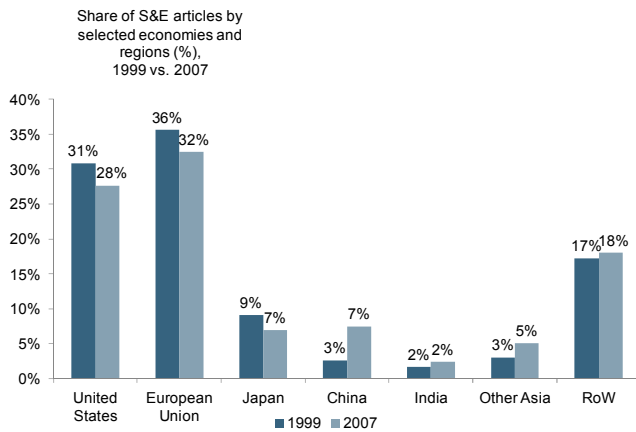
**Primary indicators of R&D output underscore the return on R&D investment in growth markets, as scientific output and patenting activity rise**

The global distribution of research and scientific activity is shifting as output volume rises sharply in Asia. This principally reflects developments in China, where the publication of leading scientific articles has risen six-fold since the mid-1990s, from 9,000 to nearly 57,000 articles per year. US and European research publications remain highly regarded and are the leading sources of S&E research articles (see Exhibit 7).

Beyond basic research, patent data confirm that development activity is starting to shift toward Asia as well. The share of US patents attributable to inventors residing in the United States or Europe, currently 62%, is down from 70% in 1999, largely offset by share gains in Asia (see Exhibit 8). Foreign inventors received a first-time majority of all US patents granted in 2008. In fact, six non-US firms now rank among the top ten private-sector recipients of US patents: all are based in Asia, five in Japan and one in Korea. The pipeline of patent applications points to continued future growth of the non-US share.

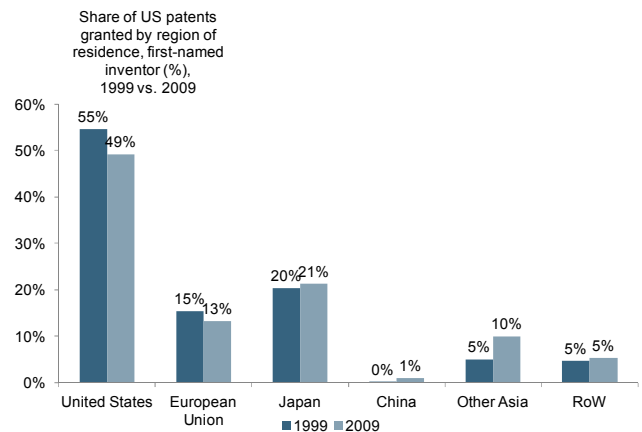
The expansion of research and development activity feeds into strong technology manufacturing capabilities in many emerging markets. R&D investment in these markets raises the absorptive capacity for new technology and is ultimately reflected in the trade balances for a broad range of technology goods. In fact, China surpassed the United States as the world's leading exporter of IT goods in 2004. Much of this represents the manufacturing of technology goods developed abroad for re-exportation, including to the United States. See Exhibits 9-11.

**Exhibit 7: Global research output shifts toward Asia...**



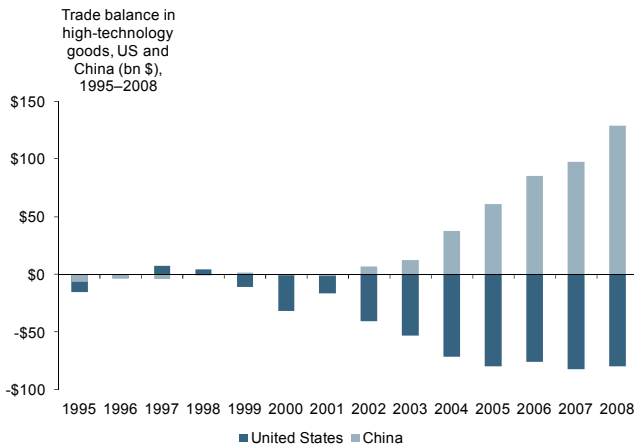
Source: National Science Foundation, Global Markets Institute.

**Exhibit 8: ... as inventors outside the US and Europe receive a rising majority of US patents**



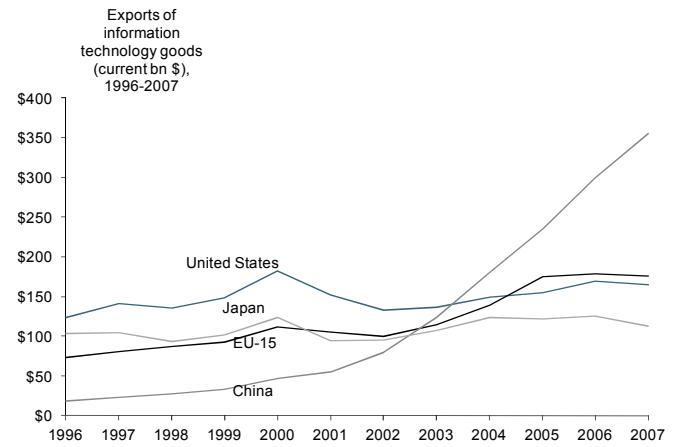
Source: US Patent and Trademark Office (USPTO), Global Markets Institute.

**Exhibit 9: High-tech trade balances continue to widen ...**  
China's trade balance in high-tech goods now \$129 bn



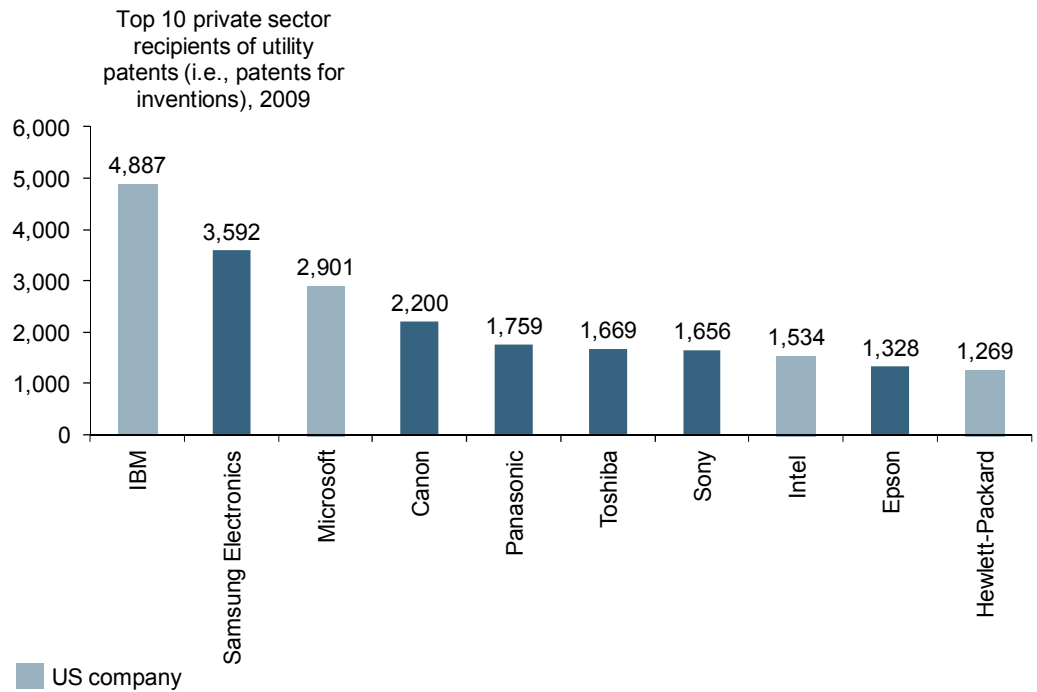
Source: National Science Foundation.

**Exhibit 10: ... as China surpasses the United States to become the world's leading exporter of IT goods**



Source: OECD.

**Exhibit 11: Non-US companies receive many US patents**  
Six Asian firms rank among the top ten private sector recipients of US patents



Source: USPTO.

## Pipeline concerns and the role of human capital

**The new geography of global innovation is critically dependent upon higher education, particularly in S&E fields, which is the pipeline to future skilled labor in related sectors. Student interest in science and engineering is flat and low across the G7, just as the expansion of university education in major emerging markets supports the development of S&E skills abroad.**

**Enrollment is up sharply, as emphasis shifts to improving the quality of higher education in many countries**

### More students are studying outside the G7 ...

One of the most important consequences – and drivers – of globalization over the past two decades has been the expansion of higher education outside the major developed countries. This growth in skilled labor underpins the shift in innovative activity and presages more rapid future growth of innovative activity in developing markets.

University enrollment has more than doubled worldwide since 1990, and now exceeds 150 million, as enrollment rates rise from a low base in several populous countries. The United States was home to 20% of the world's university-enrolled student population in 1990, but has less than 13% of that same population today, roughly equal to the EU share. Over the same period, China's share has more than doubled, reaching 15%, making it the largest source of new university graduates in the world.

This shift is largely the result of policy focus in growth markets, which has helped expand access to, and improve the quality of, higher education. The share of university-age students in China enrolled in some form of post-secondary education, 22%, has nearly tripled since 2000, though it remains well below the US enrollment rate, 82%. Since the mid-1990s, China's Ministry of Education has focused on elite universities, consolidating a range of other educational institutions in order to improve quality. Policymakers have also taken steps to limit admissions growth in doctoral programs, focusing on efforts to improve the quality, evaluation and accreditation in higher education.

The enrollment rate in post-secondary education in Brazil has nearly doubled since 2000, reaching 30%. Progress has been slower in India, where enrollment rates rose from 10% to 14%. Given India's large student-age population, this still translates into an increase in enrollment of 5.5 million students.

As university enrollment rates rise from a relatively low base in many countries, the global distribution of skilled labor will continue to change. In the future, even a small change in educational participation is likely to reshape the global distribution of skilled labor, given the absolute size of the student-age population in China and India (roughly five times that of the United States) and other populous countries.

### ... and more of them are studying science and engineering

**The rapid expansion of educational capacity and degree production outside of G7 countries is particularly evident in science and engineering fields.** This expansion is largely driven by strong student interest in China and Korea, where interest in S&E fields is now more than double US levels.

**S&E degrees represent 40% of all new degrees in China, reshaping the global S&E skill base**

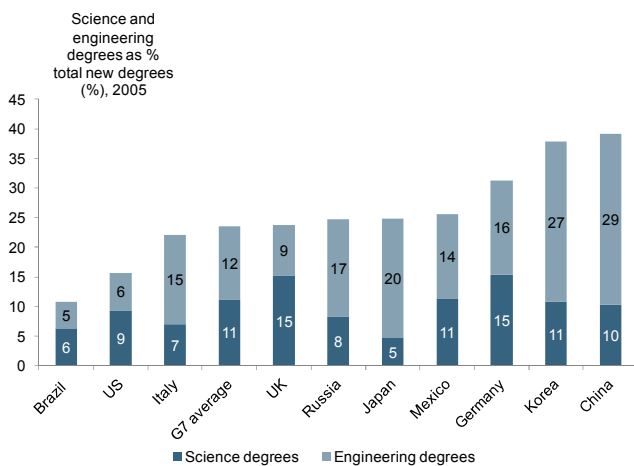
S&E degrees represent nearly 40% of all new university degrees awarded in China and Korea, compared to 24% across the G7 and just 15% in the United States. The yawning gap is most evident in engineering, which represents nearly 30% of all new university degrees awarded in China, compared to 12% across the G7 and just 6% in the United States.

While the United States continues to have the highest percentage of the adult population with an advanced S&E education, gaps are narrowing, led by strong S&E doctorate

production in Asia and Europe. In absolute terms, China's S&E doctorate production has grown by an average of 18% per year since 1998, thanks in part to a lower base level. China's S&E doctorate production is likely to have surpassed US levels since the latest data were released in 2006. China already awards four times as many engineering doctorates as the average G7 country.

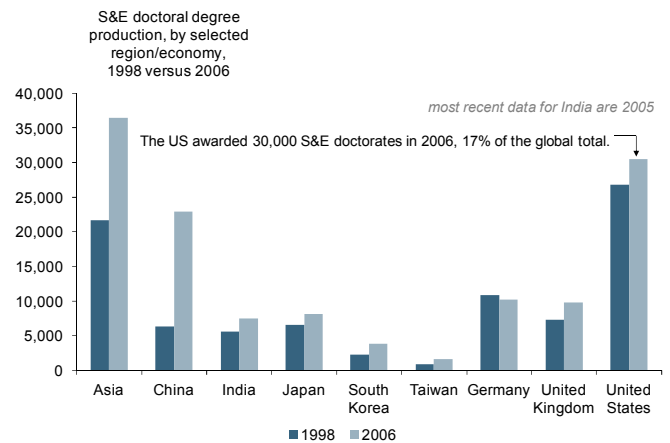
Investment in S&E education is also evident in a number of markets not recently known for commitment to higher education in these fields. In Saudi Arabia, for example, King Abdullah University of Science and Technology opened in September 2009 with a \$10 billion endowment, placing it ahead of all but the top five US universities by endowment size. See Exhibits 12-13.

**Exhibit 12: S&E interest in Asia now 2.6X US levels ...**  
40% of all new degrees in China are in S&E fields, compared to 15% in the United States



Source: OECD, Global Markets Institute.

**Exhibit 13: ... driving convergence in S&E degree output**  
China may have surpassed the US in S&E doctorate output



Source: OECD, national ministries of education.

**The globalization of science and engineering education is also evident *within* the United States, where foreign-born students earn a rising majority of graduate degrees in these fields.**

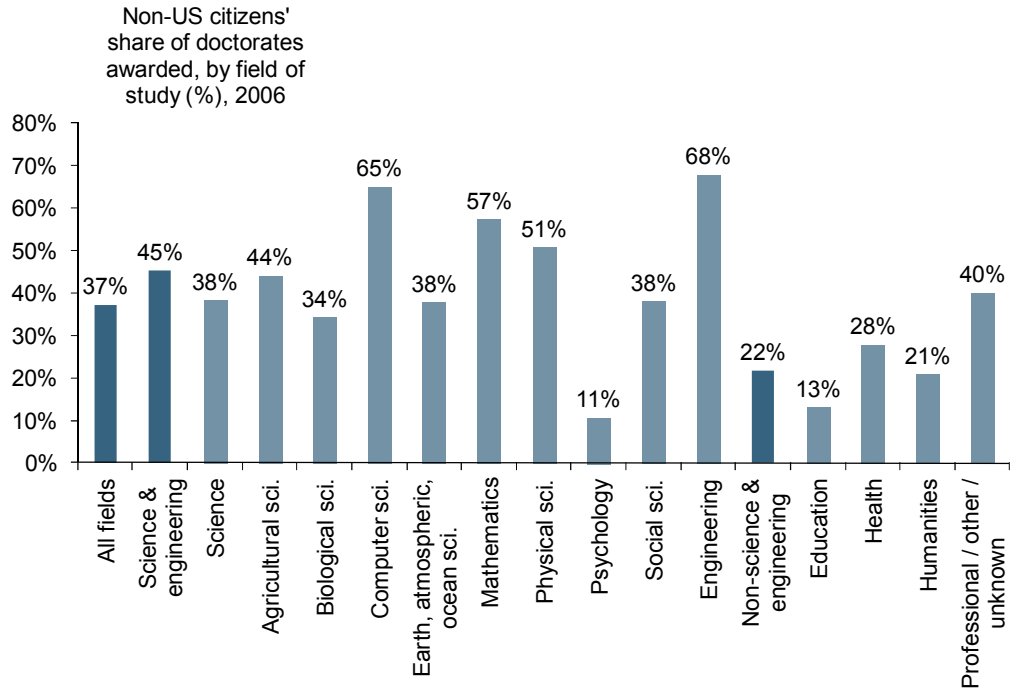
**Foreign-born students receive nearly 70% of US doctorates in engineering**

Foreign-born students receive nearly 40% of all US doctorates awarded today; the figure is nearly 70% in fields such as engineering and computer sciences. See Exhibits 14-15. If current trends were sustained, foreign-born students would receive the majority of all US doctorates by 2020.

Most of the recent expansion in US higher education, as measured by the increase in degrees awarded, has come from S&E education. Half of this incremental growth is in turn attributable to non-US students, led by an explosive increase in the foreign student population from China and, to a lesser extent, from India.

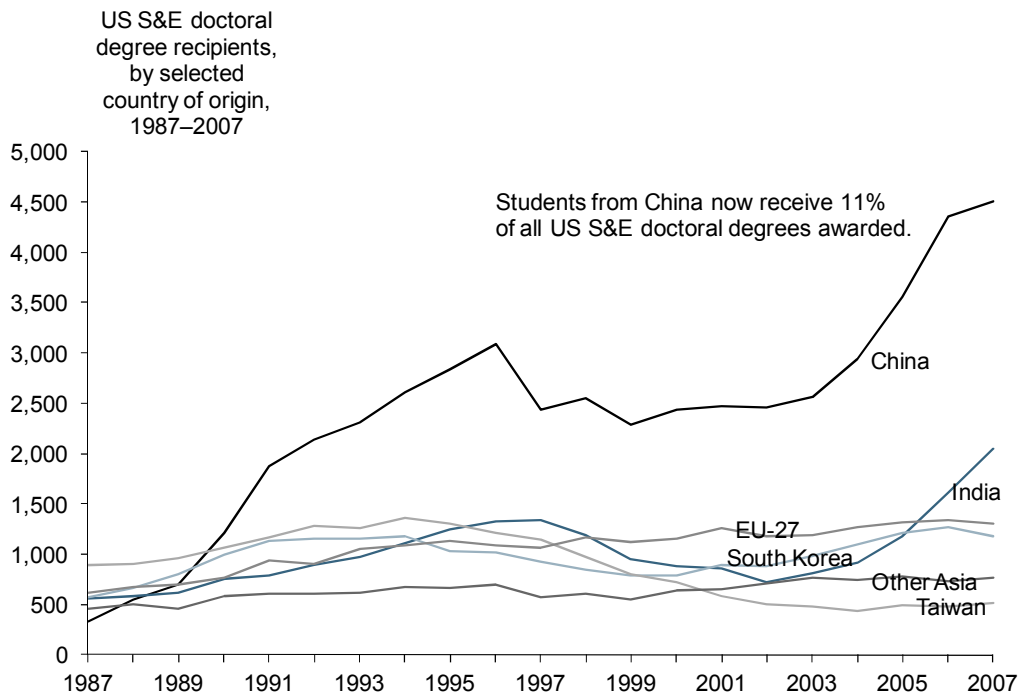
Low levels of student interest in S&E fields across G7 countries suggest that native-born students in these countries are not being "crowded-out." They further suggest that G7 markets are likely to have difficulty replacing an aging cohort of native-born S&E labor without greater reliance on inward migration of skilled labor.

**Exhibit 14: Foreign-born students now dominate US doctorate education in critical fields, especially engineering, math and the physical sciences**



Source: National Science Foundation.

**Exhibit 15: ... led by China's growing presence**  
US S&E doctorates awarded to Chinese students up sharply



Source: National Science Foundation.

## Educational pipeline feeds a rapidly aging skilled labor force

Today's students are tomorrow's scientists, engineers and skilled workers. Global shifts in the S&E skill base are driving increased reliance on foreign-born skilled labor in the United States and other G7 markets. Reliance is set to rise further as an increasing number of native-born scientists and engineers approach traditional retirement age.

Foreign-born workers are increasingly important to the skilled labor force in G7 markets:

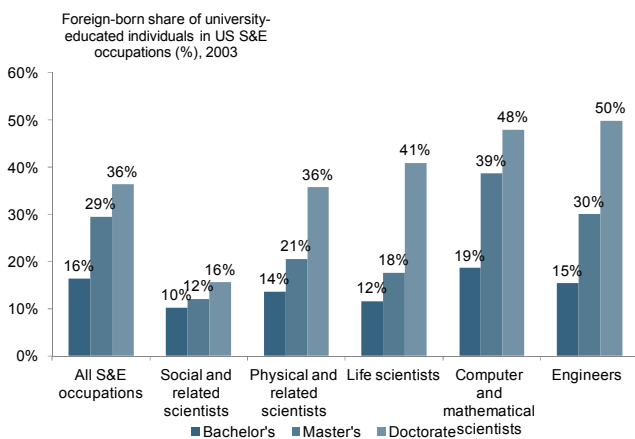
- 23% of the 4.8 million university-educated workers in US S&E occupations are foreign-born, as are 36% of those with a doctorate. This is meaningfully higher than the foreign-born share of the total US labor force (17%) and of the total US population (14%).
- Reliance on foreign-born scientists and engineers is set to rise as an increasing number of native-born scientists and engineers approach traditional retirement age. 30% of S&E doctorate holders in the US labor force are age 55 or older today, up from 21% in the early 1990s. As discussed above, the domestic pipeline is shrinking even as the current labor force ages.

**Continued aging of the native-born workforce points to pipeline concerns in G7 markets ...**

**... suggesting that reliance on foreign-born labor will rise in highly-skilled occupations**

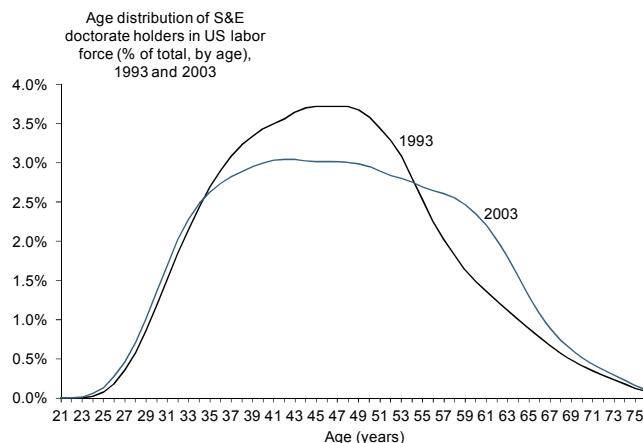
This story is replicated across G7 markets, all of which face the challenge of aging populations. The share of the G7 population aged 55 or older, currently 30%, will rise to 35% by 2030, according to UN estimates. In Japan, it will exceed 45%. See Exhibits 16-17.

**Exhibit 16: Increased reliance on foreign-born labor ...**  
Majority of highly-educated US engineers are foreign-born



Source: National Science Foundation.

**Exhibit 17: ... set to rise as native-born workers age**  
Aging of the US S&E workforce hints at pipeline concerns



Source: National Science Foundation, Global Markets Institute.

## New geography demands a policy response

---

**Public policies that attract and retain skilled foreign nationals are essential to innovation-led productivity growth in G7 countries. In the short term, a more flexible and talent-friendly immigration regime can help developed economies to benefit from the globalization of S&E skills and the heightened mobility of highly-skilled workers. Over the long term, competitiveness will be strengthened by investments in innovation, including support for R&D, and preparatory science and math education.**

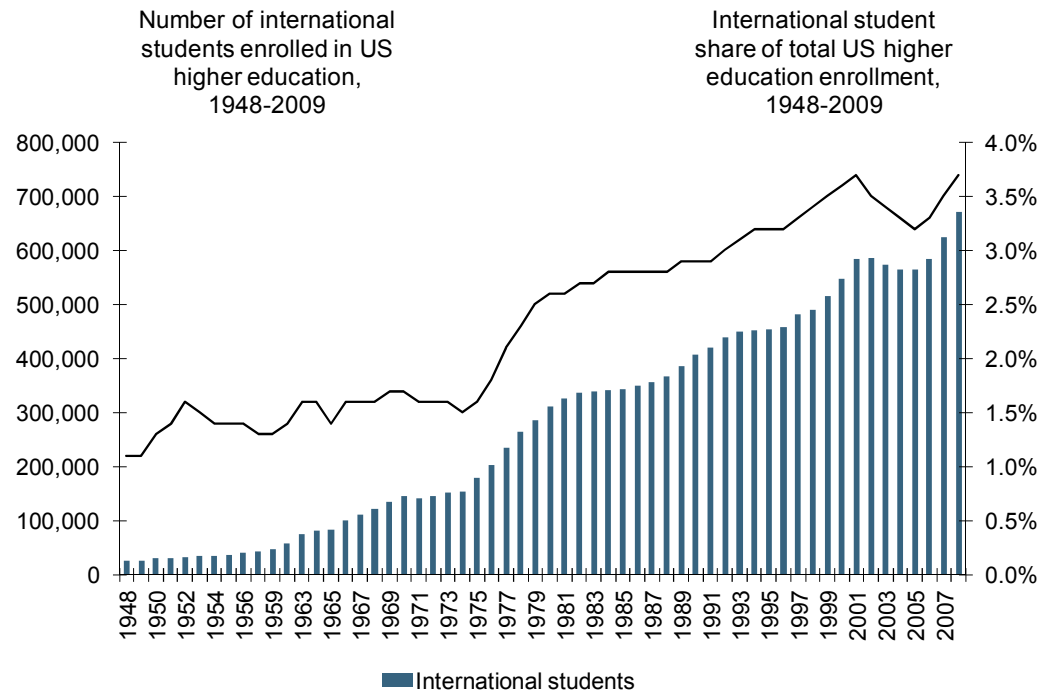
### Immigration policy

Investments in education and innovation, while they represent important generational commitments, take time to pay off. **In the short term, a more flexible and talent-friendly immigration regime can help developed economies to attract and retain skilled foreign nationals, and benefit from the globalization of S&E skills.**

The number of international students studying in OECD countries is rising in absolute terms and as a share of total enrollment. Its continued rise is not inevitable, however. More stringent student visa procedures in the wake of September 11, 2001, for example, led to a three-year decline in the number of international students enrolled in US higher education – the first decline in thirty years (see Exhibit 18). The “stay rates” of these students also declined, though they generally remain quite high. For example, up to 90% of US S&E doctorate recipients from China plan to stay in the United States after graduation, according to the National Science Foundation. Policies in a number of countries are now focused on encouraging the return of skilled nationals working abroad, suggesting that stay rates, while driven by a number of considerations, could decline in the future.

For those international students who seek to work in the United States after graduation, their ability to do so is often governed by the availability of H-1B temporary work visas. This is particularly relevant to computer-related occupations, which accounted for half of all H-1B visas granted in 2008. In practice, the fixed cap on H-1B visas bears little resemblance to changing industry needs over the economic cycle, and political discussions about the program are often unrelated to prevailing industry needs.

Revisiting skilled immigration policy is only one part of a broader approach to comprehensive immigration reform. The US Senate’s recent introduction of the StartUp Visa Act of 2010 outlines a new visa class for immigrant inventors, EB6, and suggests that immigration reform is likely to remain a focus of attention in the coming months.

**Exhibit 18: 3-year decline in the international student population following tighter visa procedures post-9/11**


Source: Institute for International Education, Global Markets Institute.

## Innovation policy

**In the medium term, government policy can also support innovation by investing in basic research and digital infrastructure.**

### Declining federal support for R&D likely to strain basic research

The financial crisis and subsequent fiscal concerns have led to a reduction in public investment in research and development in several developed countries. In dollar terms, this pullback has generally been offset by rising corporate R&D investment. Yet because public and private R&D funding tend to support different stages of the innovation lifecycle, the pullback in public investment may strain basic research, particularly in the physical sciences and engineering. Renewing public investment in R&D can help stimulate complementary co-investment in applied research by the private sector, particularly in fields such as energy and health, where the public benefits of such investment are high. Moreover, increased coordination of public and private research efforts can further improve national innovation capacity – often at low cost – as can appropriate tax incentives.

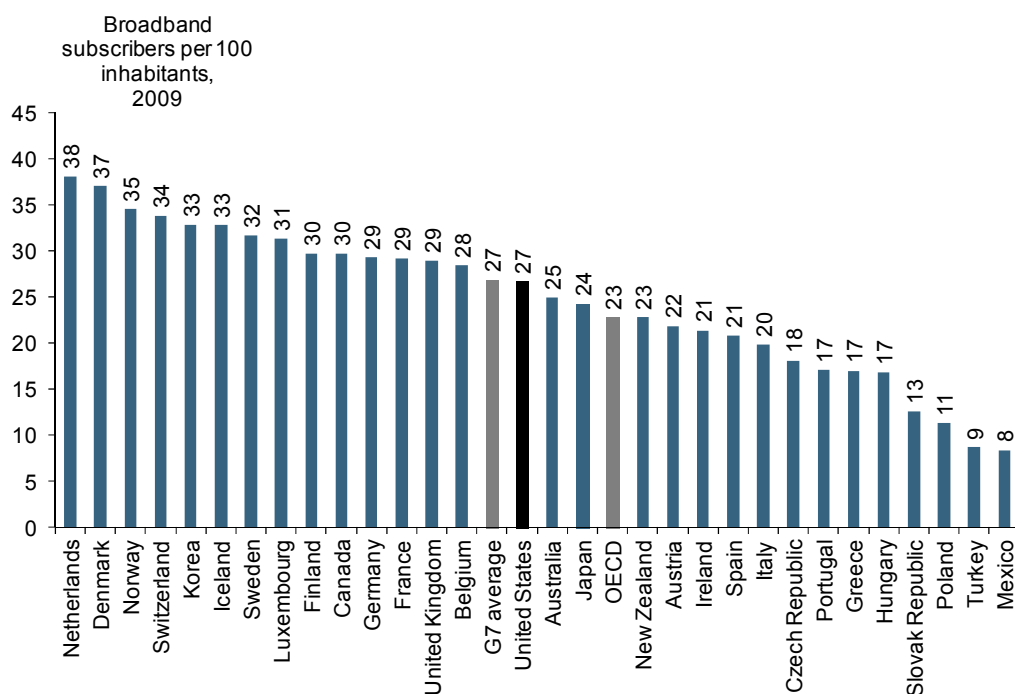
There is broad agreement that effective use of robust R&D tax credits can effectively stimulate private research spending. A temporary form of research credit has existed in the United States in some form since 1981, but has frequently been allowed to expire. The recent proposal to expand and make permanent the research tax credit in the United States, currently under review, may be an important part of policy reform in this area.



**US policy focus is now on the research tax credit and broadband penetration, with implications for a range of sectors**

Government policy is also central to the design and expansion of innovation infrastructure, including high-speed wireless broadband. The United States remains the largest broadband market in the OECD, with 75 million subscribers, but it ranks 15<sup>th</sup> among OECD countries in terms of broadband penetration (see Exhibit 19). Recognizing the importance of digital infrastructure, the US FCC recently proposed more extensive government investment in broadband penetration. If enacted, the plan is likely to create opportunities for companies in a number of sectors, including: **wireless broadband service providers** and **wireless infrastructure providers, electronic medical records** and **e-care providers, online educational services**, and **integrated utility companies** leveraging smart grid technology. Importantly, enhanced broadband access is often viewed as an essential part of broadening the delivery of S&E education.

**Exhibit 19: The US remains the OECD's largest broadband market, but penetration is low**



Source: OECD, Global Markets Institute.

### Education policy

**The most effective way to support the long-term competitiveness of the labor market is to invest in skills. High-quality schools and robust vocational training are essential to the creation and retention of jobs in high value-added sectors. They can also help address the domestic skills gap in highly specialized fields, particularly as a growing cohort of skilled (and relatively young) workers comes online in growth markets.**

**Long-term investments in science, technology, engineering and math (STEM) education are critical to G7 competitiveness**

The quality and flexibility of the highly-skilled labor market, and the system of higher education on which it depends, are essential to economic recovery. Below-average and declining performance on leading international indicators of educational quality raise concerns about the US outlook. The average math literacy score among 15-year-olds is in the bottom quartile of OECD countries for which comparable data are available (see Exhibit 20). US science literacy is better on a relative basis though it remains well below average (see Exhibit 21). In both math and science, US students score below those in all but one G7 country: Italy. These results reinforce the need for investment in preparatory science,

**The United States led the world in its share of young adults with a college degree as recently as the 1980s; it now ranks 12th**

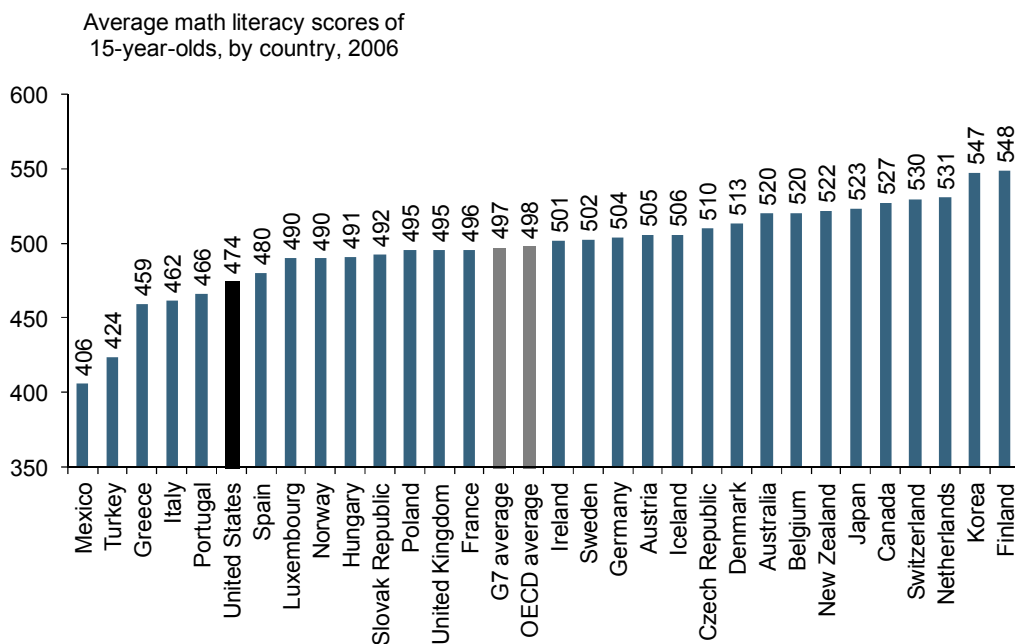
technology, engineering and math (STEM) education as well as tax credits for continued education and training.

US employment and income growth over the next decade will depend critically on educational attainment in these fields. Total US employment is projected to grow by 15.3 million in the decade to 2018, led by growth in professional and related occupations, according to the US Bureau of Labor Statistics. Employment growth is expected to be relatively strongest in healthcare and computer-related occupations, and roughly half of the 30 fastest growing occupations will require at least a bachelor’s level education. Young adults in the United States (ages 25-34) are now less likely than their counterparts in many other countries to have attained such an education.

The United States already spends notably more than other OECD countries on education, with much of the investment made at the state and local level. Cumulative education spending per student in the United States is more than 35% higher than the level of spending in Japan, for example, despite the demonstrably lower science and math outcomes noted above. While soaring fiscal deficits are likely to limit the ability of capacity-constrained state and local governments to further increase funding, in many ways the more important issues are the efficiency of spending and the quality of the standards. An expansion of early-age STEM education can benefit from public-private partnerships and new sources of discretionary education funding, including private foundations.<sup>1</sup>

**Exhibit 20: US math literacy is well below G7 and OECD averages**

US math literacy in the bottom quartile of OECD countries

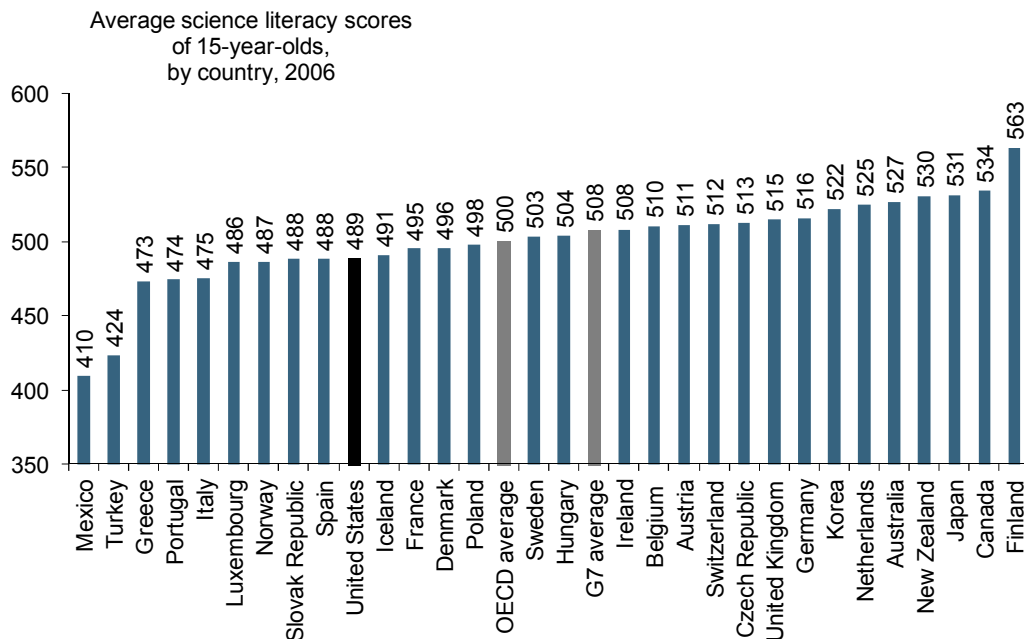


OECD PISA scoring ranges from 0 to 1,000 and is scaled to have an average of 500.

Source: OECD, Global Markets Institute.

<sup>1</sup> For example, earlier in 2010, twelve national foundations committed \$500 million in 2010 funds to leverage the US Department of Education’s \$650 million Investing in Innovation Fund. These funds will help to implement new national standards in math and other subjects.

**Exhibit 21: ... US science literacy is marginally better, though still below-average**  
US science literacy in the bottom third of OECD countries



OECD PISA scoring ranges from 0 to 1,000 and is scaled to have an average of 500.

Source: OECD, Global Markets Institute.

## Conclusion

### A range of measures suggests a changing and more global innovation landscape.

While the United States and Japan remain leaders in science and technology innovation, they face increased competition from leading growth markets, notably China. R&D spending in China has grown by more than 20% per year, on average, during the last decade, and by 8% per year in Korea.

There has been a notable increase in R&D intensity in China, which has doubled since 1999 and continues to converge on the G7 average of 2.1% of GDP. The majority of this growth has been driven by the corporate sector.

**The new geography of global innovation is critically dependent upon higher education in science and engineering fields – the pipeline to skilled labor.** Current low levels of native student interest in S&E fields suggest that G7 markets are likely to have difficulty replacing an aging cohort of native-born scientists and engineers. Reliance on foreign-born skilled labor is set to rise further as the world's S&E skill base shifts toward Asia, including China and Korea, where S&E fields represent 40% of all new university degrees awarded (more than two and a half times US levels). The yawning gap is most evident in engineering, the leading field of study for CEOs of S&P 500 companies, where student interest in most countries is now higher than it is in the United States.

**Public policies which attract and retain skilled foreign nationals are essential to innovation-led productivity growth in G7 countries.** In the short term, a more flexible and talent-friendly immigration regime can help developed economies to benefit from the globalization of S&E skills. Longer-term investments in R&D and preparatory science and math education can further enable G7 countries to remain competitive by rebuilding student interest in S&E fields and by expanding the domestic supply of skilled S&E labor.

**These policies are also critical to managing challenges to sustainable development, including healthcare cost inflation, energy security and climate change, and to meeting ambitious goals being set in these areas.** This is particularly true in Asia, where above-trend population growth and rapid urbanization will continue to fuel rising demand for health services, transportation, energy and resources, heightening policy focus on innovative solutions to a range of development challenges.

Even such well-funded areas as national defense require investment in innovation capacity and skilled labor. For example, the National Research Council recently concluded its review of nuclear forensics in the United States by stating, "At present, personnel skilled in nuclear forensics at the national laboratories are too few and are spread too thinly. Furthermore, a substantial fraction of the experienced personnel are retired, now eligible for retirement, or nearing retirement age. The university pipeline produces too few people in needed specialties and universities will not produce them without stable funding for relevant R&D". This one example is likely being repeated in many other technical fields.

## Bibliography

---

- American Energy Innovation Council. (June 2010). *A Business Plan for America's Energy Future*.
- Borjas, G. J. (2004). *Do Foreign Students Crowd Out Native Students from Graduate Programs?* National Bureau of Economic Research.
- Bureau of Labor Statistics, US Department of Labor. (2009). *Foreign-born Workers: Labor Force Characteristics in 2008*. US Department of Labor.
- Committee on Nuclear Forensics. (2010). *Nuclear Forensics: A Capability at Risk*. Washington, DC: National Research Council.
- Council of Economic Advisers, Executive Office of the President. (2007). *Immigration's Economic Impact*.
- Division of Science Resource Statistics, National Science Foundation. (2007). *Asia's Rising Science and Technology Strength*. National Science Foundation.
- Fiegenger, M. K. (2008). *Survey of Earned Doctorates: Doctorate Recipients from US Universities, Summary Report 2007-2008*. Division of Science Resources Statistics, National Science Foundation.
- Finn, M. G. (2007). *Stay Rates of Foreign Doctorate Recipients from US Universities, 2005*. Oak Ridge Institute for Science and Education.
- Foley, D. J. (2006). *Characteristics of Doctoral Scientists and Engineers in the United States: Detailed Statistical Tables, 2006*. National Science Foundation.
- Kannankutty, N., & Burrelli, J. (2007). *InfoBrief: Why Did They come to the United States? A Profile of Immigrant Scientists and Engineers*. National Science Foundation.
- Kolesnikova, N. A. (January/February 2010). Community Colleges and Economic Mobility. *Federal Reserve Bank of St. Louis Review*, 92(1), 27-53.
- McGinnis, P., & Nora Johnson, S. (2006). *Working in America: Transitioning in a Global Economy*. The Global Markets Institute, Goldman Sachs.
- Ministry of Science and Technology for the People's Republic of China. (2006). *National Guidelines for Medium- and Long-term Plans for Science and Technology Development of China, 2006-2020*.
- National Research Council. (2010). *The Dragon and the Elephant: Understanding the Development of Innovation Capacity in China and India*. Washington, DC: The National Academies.
- National Science Board. (2010). *Science and Engineering Indicators 2010*. Arlington, VA: National Science Foundation.
- OECD. (2009). *Education at a Glance 2009: OECD Indicators*. Paris, France: OECD.
- OECD. (2009). *International Migration Outlook*. Paris, France: OECD.
- OECD. (2009). *Measuring China's Innovation System: National Specificities and International Comparisons*. Paris, France: OECD.
- OECD. (2008). *OECD Science, Technology and Industry Outlook 2008*. Paris, France: OECD.
- OECD. (2010). *The High Cost of Low Educational Performance: The Long-Run Economic Impact of Improving PISA Outcomes*. Paris, France: OECD.
- The Task Force on the Future of American Innovation. (2005). *The Knowledge Economy: Is the United States Losing its Competitive Edge?*
- US Department Education. (2009). *American Recovery and Reinvestment Act Report: Summary of Programs and State-by-State Data*. Washington, DC: US Department Education.
- US Federal Communications Commission. (2010). *Connecting America: The National Broadband Plan*.

## Disclosures

---

This report has been prepared by the Global Markets Institute, the public policy research unit of the Global Investment Research Division of The Goldman Sachs Group, Inc. ("Goldman Sachs"). As public policy research, this report, while in preparation, may have been discussed with or reviewed by persons outside of the Global Investment Research Division, both within and outside Goldman Sachs, and all or a portion of this report may have been written by policy experts not employed by Goldman Sachs.

While this report may discuss implications of legislative, regulatory and economic policy developments for industry sectors, it does not attempt to distinguish among the prospects or performance of, or provide analysis of, individual companies and does not recommend any individual security or an investment in any individual company and should not be relied upon in making investment decisions with respect to individual companies or securities.

### Distributing entities

This research is disseminated in Australia by Goldman Sachs JBWere Pty Ltd (ABN 21 006 797 897) on behalf of Goldman Sachs; in Canada by Goldman Sachs Canada Inc. regarding Canadian equities and by Goldman Sachs & Co. (all other research); in Germany by Goldman Sachs & Co. oHG; in Hong Kong by Goldman Sachs (Asia) L.L.C.; in India by Goldman Sachs (India) Securities Private Ltd.; in Japan by Goldman Sachs Japan Co., Ltd.; in the Republic of Korea by Goldman Sachs (Asia) L.L.C., Seoul Branch; in New Zealand by Goldman Sachs JBWere (NZ) Limited on behalf of Goldman Sachs; in Singapore by Goldman Sachs (Singapore) Pte. (Company Number: 198602165W); and in the United States of America by Goldman, Sachs & Co. Goldman Sachs International has approved this research in connection with its distribution in the United Kingdom and European Union.

**European Union:** Goldman Sachs International, authorised and regulated by the Financial Services Authority, has approved this research in connection with its distribution in the European Union and United Kingdom; Goldman, Sachs & Co. oHG, regulated by the Bundesanstalt für Finanzdienstleistungsaufsicht, may also be distributing research in Germany.

### General disclosures in addition to specific disclosures required by certain jurisdictions

Goldman Sachs conducts a global full-service, integrated investment banking, investment management and brokerage business. It has investment banking and other business relationships with governments and companies around the world, and publishes equity, fixed income, commodities and economic research about, and with implications for, those governments and companies that may be inconsistent with the views expressed in this report. In addition, its trading and investment businesses and asset management operations may take positions and make decisions without regard to the views expressed in this report.

Copyright 2010 The Goldman Sachs Group, Inc.

**No part of this material may be (i) copied, photocopied or duplicated in any form by any means or (ii) redistributed without the prior written consent of The Goldman Sachs Group, Inc.**



Global Markets  
Institute

#### President

Abby Joseph Cohen, CFA + 1-212-902-4095 (US)

#### Chair

Esta E. Stecher + 1-212-902-3490 (US)

Sandra Lawson + 1-212-902-6821 (US)

Michael A. Moran, CFA + 1-212-357-3512 (US)

Douglas B. Gilman + 1-212-902-3132 (US)

Amy C. Semaya + 1-212-902-7009 (US)

Rachel Siu + 1-212-357-0493 (US)

#### Recent Publications

Critical juncture in global accounting standard setting  
June 14, 2010

Pension review 2010: Pension palpitations refuse  
to dissipate for corporate plan sponsors  
June 11, 2010

Tax time: Plenty of charges from the health care bill,  
but changes in corporate behavior loom  
March 30, 2010

"First take": Corporate pensions end 2009 with  
improved funding but face ongoing challenges  
March 25, 2010

Dynamic approach to investment policy for corporate  
pension plans  
March 16, 2010

SEC takes action on climate change disclosures  
January 28, 2010

2010 pension preview: Headwinds remain despite  
funded status improvement  
December 18, 2009

Effective Regulation: Part 5 - Ending "Too Big to Fail"  
December 15, 2009

Health Buys Wealth  
December 3, 2009

Goldman Sachs Research personnel may be contacted by electronic mail  
through the Internet at [firstname.lastname@gs.com](mailto:firstname.lastname@gs.com)  
Goldman Sachs Global Investment Research



**Mixed Sources**

Product group from well-managed  
forests and other controlled sources  
[www.fsc.org](http://www.fsc.org) Cert no. SW-COC-001941  
© 1996 Forest Stewardship Council