MAINTAINING AMERICA'S COMPETITIVE EDGE:

GOVERNMENT POLICIES AFFECTING SEMICONDUCTOR INDUSTRY R&D AND MANUFACTURING ACTIVITY

A White Paper

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for the
Semiconductor Industry Association

March 2009

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Executive Summary

The semiconductor industry is critically important to the United States. It is the second largest U.S. exporting industry, a major source of high-wage employment, a stimulus to development in a number of U.S. regions, and provides critical enabling technology for the rest of the U.S. and global economy, for national defense, for lowering the cost and improving the delivery of health care services and for advancing overall quality of life. Semiconductors are also the enabling technology that will allow increased efficiencies for alternative energy sources, a new Smart Grid to distribute electricity, and applications such as power management that reduce energy consumption.

The U.S. semiconductor industry directly employs about 200,000 people in the United States and is the world semiconductor market share leader with 48 percent of world wide sales. Semiconductors have consistently been the first or second top U.S. export category over the past six years. This export performance reflects the fact that 85 percent of global semiconductor consumption occurs outside of the United States and 80 percent of the U.S. industry's sales is overseas. Despite this business imperative to operate globally, about three-quarters of U.S. semiconductor industry R&D spending, 77 percent of U.S.-owned production capacity, 51 percent of U.S. industry worldwide employment, and 74 percent of the compensation and benefits paid by the U.S. industry are in the United States today. The industry will be able to continue to generate these economic drivers in the United States if appropriate U.S. government policies are pursued so that U.S. producers can compete on a level playing field with their foreign competitors, whose cost structures have benefited from very favorable foreign government tax policies and other incentives.

Data indicate that an increasing number of the U.S. semiconductor industry's manufacturing and research facilities are being established outside the United States, giving rise to concerns that the United States is in danger of losing this critical aspect of its technological leadership. Overall, the share of worldwide wafer fabrication capacity in the United States has declined from 42 percent in 1980 to 16 percent in 2007. This reflects the growth of indigenous semiconductor industries in several Asian countries as well as a shift in the U.S. industry's investment patterns over time.

While some analysts believe that it makes no difference whether this industry (or any other industry) is located in the United States, that view is not shared abroad, where an intensive competition is being waged by national and regional governments to attract semiconductor manufacturing and research and development ("R&D") investment. Companies – and governments – are operating in an increasingly competitive global marketplace. In this environment, there is tremendous pressure for governments at all levels to devise winning strategies to attract new investments. Economic development is a top priority for most governments and the creation of a value proposition to attract foreign direct investment involves many factors, including skills, available infrastructure, incentives, and tax policies. Successful examples, both in the United States and outside the United States can be found in this paper. The question for the United States is what needs to be done in order to be more competitive and attract critical domestic and foreign investment in the United States.

This study presents for the first time data on the international geographic shifts in manufacturing and R&D investment by the U.S. semiconductor industry and the factors underlying those trends, with a particular emphasis on the impact of U.S. and foreign government policies. It is based on information gathered from companies representing over two thirds of U.S. semiconductor R&D and capital spending. In addition, the report offers policy options and proposed actions for federal policy makers to consider as part of an effort to ensure continued U.S. competitiveness in semiconductors.

The Congress and the Administration have included significant investments in research and technology and digital infrastructure as part of the recently enacted economic stimulus package (the American Recovery and Reinvestment Act). These policies will result in immediate direct job creation and economic stimulus as well as longer term technology advances and commercialization that will help the U.S. maintain its competitive advantage. While the short term stimulus is needed to create and sustain jobs and drive economic growth, the United States should consider ways to reinvigorate advanced research and manufacturing in this country to maintain its technology edge and the accompanying economic, social and national security related benefits. To that end, U.S. policymakers, working with the U.S. semiconductor industry, need to consider robust and sustained efforts to both attract and retain leading edge manufacturing and R&D activities in the United States.[1]

Findings. A survey of U.S. semiconductor producers reveals an industry whose center of gravity remains in the United States and that continues to lead the world in key indicia of competitiveness, but that confronts intensifying centrifugal forces in a geographic sense. The principle findings of the survey with respect to U.S. company spending are noteworthy:

- Approximately 65 percent of U.S. industry global capital spending for wafer fabrication is today directed to the United States, down 14.6 percentage points between 1997-1999 and 2005-2007.[2]
- Three-quarters of U.S. industry global R&D spending today is still in the United States, down 8.4 percentage points between 1997-1999 and 2005-2007.
- The offshore R&D spending shift in the last decade has not been to Korea, Taiwan and China but to Europe and ROW (India, Israel, Singapore, Malaysia, etc.).
- U.S. industry spending on R&D in China is very small but growing.

U.S. semiconductor producers continue to dominate world semiconductor sales, holding a market share of 48 percent in 2008, and are the undisputed technological leaders. Most

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1 The Obama Administration's FY 2010 budget proposal takes two important steps forward by proposing to make the R&D tax credit permanent and by proposing to expand the net operating loss carry back provision passed in the American Recovery and Reinvestment Act, but its proposals on income tax deferral rules for foreign income would be counterproductive.

2 The percentage point decline for wafer fabrication and R&D spending is based on a comparison of the three year average for 1995-1997 with the three year average for 2005-2007.

of their worldwide installed manufacturing and R&D capability is located in the United States. However, U.S. semiconductor industry investment in manufacturing and R&D inside vs. outside the United States has declined during the past decade.

Change in Share of Global Spending in the United States by U.S. Semiconductor Companies *1997-1999 to 2005-2007*	
Wafer fabrication	-14.6 percentage points
Assembly and test	-27.1 percentage points
Research and development	-8.4 percentage points

These trends are forecast to continue over the next five years, given current government policies and economics. Perhaps the most significant development is that competitive pressures have led U.S. companies to establish an increasing proportion of their advanced wafer fabrication facilities ("fabs") outside the United States or to rely on foreign foundry facilities rather than invest in new fabs in the United States. Because manufacturing process-related R&D must be conducted in a manufacturing environment, those research activities migrate to the countries in which the new fabs are located. Semiconductor product design-related research and development, on the other hand, is not linked to manufacturing sites. Yet a growing percentage of the U.S. industry's design-related R&D is also being located in other countries, reflecting a variety of factors, which include cost, availability of human resources and government policy.

The location of state-of-the-art wafer fabrication facilities is increasingly a function of the incentives packages put together by governments to attract semiconductor investment based on a recognition of the economic stimuli those investments foster. A state-of-the-art fabrication plant now costs $3 billion or more, but incentives (usually consisting of a mix of tax breaks and grants) commonly defray over $1 billion of the plant's cost over a ten year period. As a practical matter, any U.S. semiconductor management answerable to its shareholders must establish a new fab in a location that offers this type of incentive package or risk becoming less competitive vis-à-vis a competitor who receives such incentives. In other words, government incentives play a decisive role in determining the geographic location of advanced wafer fabrication facilities, and thus indirectly determine the location of the process R&D associated with that facility.

Design R&D (related to the design of semiconductor devices rather than the processes for manufacturing chips) requires the availability of highly educated, skilled scientists and engineers, which in turn depends on the existence of strong research universities. The United States is generally acknowledged to have the world's best system of research universities in the physical sciences and electrical engineering disciplines that are relevant to the semiconductor industry. However, today over 50 percent of students graduating from U.S. universities with master's degrees and over 70 percent of those graduating with PhD degrees in science and engineering fields applicable to the semiconductor industry are foreign nationals. U.S. immigration policy – in particular, quotas that have not been updated since 1990 which result in long waits for permanent residence status (i.e., green cards) – deters many of these talented scientists and engineers from remaining in the United States after graduation. In order to fully benefit from this talent pool, U.S. semiconductor firms have established research centers outside the United States where foreign nationals can be employed in a manner that is not subject to U.S. immigration restrictions. Foreign governments have encouraged this trend by providing incentives to U.S. firms to conduct R&D locally, by strengthening their university infrastructure, and by establishing semiconductor-specific manpower promotion programs.

The decline in the share of R&D spending in the United States from 86.2 percent to 77.8 percent over the last decade has benefited Europe and the ROW (India, Israel, Singapore, Malaysia, etc.), rather than toward Korea, Taiwan and China, where chip manufacturing is increasing most rapidly. This shift reflects the impact of foreign governmental policies aimed at attracting high-skilled activity, as well as the low cost of conducting design R&D in some jurisdictions. In addition, pockets of special skills or creative talent in areas such as modeling can best be accessed by establishing a design center where the talent resides. The lack of adequate intellectual property protection serves as a negative incentive with respect to conducting R&D in some countries, most notably in China but also in Korea and Taiwan to some extent. However, a substantial proportion of the directional shift in U.S. semiconductor R&D spending during the past decade can be attributed to the impact of government policies, including foreign government incentives and U.S. immigration rules.

While the U.S. semiconductor industry remains predominantly in the United States, it faces growing competitive pressures and incentives to locate manufacturing and R&D abroad, and these trends should be of concern to U.S. policymakers. During the early 1980s, following enactment of the R&D tax credit, the United States offered the most attractive R&D investment location in the world. That U.S. advantage has long since diminished as other countries have implemented tax, grant and other incentive programs to attract semiconductor R&D investment in recognition of the benefits such investments have for a nation's overall competitiveness. The United States now has one of the highest corporate tax rates in the world while other countries now offer a combination of significantly lower tax rates, targeted tax holidays, investment tax credits, and other tax incentives for new capital investment. Similarly, the U.S. R&D tax credit has been surpassed as a benefit by expanded research-linked tax incentives in other countries.

In addition, federal support for basic research in science and engineering has been in long-term decline as a percentage of GDP. While the increase in science funding in the American Recovery and Reinvestment Act passed in February 2009 was a welcome reversal of this trend, this commitment must be sustained beyond the FY2009/10 appropriations in that bill. The United States once enjoyed by far the largest pool of trained, creative science and engineering talent, but that situation is changing rapidly, reflecting the decline in U.S.-born enrollment in relevant degree programs, the corresponding growth in the pool of foreign talent, and investment by foreign governments in semiconductor-related manpower programs in their own countries. It is likely that as each foreign site grows to critical mass, the erosion will only accelerate, especially as quality infrastructure and educated talent become available overseas. At some point, without sufficient U.S. government support of basic R&D and supportive tax, immigration, and education policies, it may well prove to be very difficult if not impossible to reverse current trends. Moreover, given the current challenging economic environment, the ability of companies to make more effective and timely use of losses remains significant. Although addressed by the American Recovery and Reinvestment Act, its loss carry back provision was narrowly targeted and limited, and a more extensive loss provision deserves further consideration – especially if losses continue over a prolonged period of time.

Recommendations. As this study clearly demonstrates, there is no single public policy "silver bullet" that drives company decisions for R&D and manufacturing investment. In fact, several public policies work in concert to create an environment that attracts highly capital intensive R&D and manufacturing operations and supplies the engineering and technical talent they require. Tax and incentive policies, government research funding for science and technology, education and technical training, immigration policies and strategic infrastructure policies are widely recognized by policy makers in the United States and other countries around the world as necessary to attract multi-billion dollar investments from semiconductor companies. The key to future U.S. innovation is to ensure that our policies are at least as competitive as those of our trading partners.[3]

Tax and Incentive Policies to Promote Semiconductor Manufacturing and R&D

Many of the other countries considered in this study have adopted polices that have resulted in semiconductor investment and job creation in their regions. Therefore, the Congress should consider adopting tax policies that are competitive with those of our trading partners in order to encourage new investment in semiconductor manufacturing and research and development in the United States.

As noted above, foreign governments have successfully employed a number of tax and incentive measures to attract investment. Among those policies are low tax rates, specific incentives to encourage investment in research and manufacturing, tax holidays, and grants and loans.

Over the years, there has been considerable discussion in the United States about advancing U.S. long term competitiveness through tax policy. Of particular importance is a permanent and enhanced R&D tax credit and continued deferral of taxes on overseas income. These policies are the cornerstone of a competitive U.S. tax policy. The proposal by economist Robert Atkinson at the Information Technology and Innovation Foundation to improve the R&D credit to better incentivize R&D is a good starting point

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[3] *See, e.g.,* The Atlantic Century, Benchmarking EU & U.S. Innovation and Competitiveness, The Information Technology & Innovation Foundation (February 2009) (benchmarking among 40 nations/regions on 16 different indicators show that the U.S. ranks sixth in innovation and competitiveness and last in recent progress made toward developing a new knowledge-based innovation economy).

for discussion.[4] It is important to make the R&D credit permanent as soon as possible to create the certainty and predictability that companies need in making long term investments. Moreover, to encourage U.S. companies to export and compete with companies in countries that do not tax overseas income at all, tax deferral on overseas income is a critical tool that must be maintained.

Deferral of overseas income from foreign subsidiaries of U.S. companies is widely recognized as the cornerstone of U.S. tax policies designed to enable U.S. companies to compete on a level playing field in global markets, thus generating foreign income for their U.S. operations and supporting U.S. jobs and investment. Deferral is not an incentive to move jobs overseas, as has been claimed, as foreign direct investment by U.S. companies promotes increased U.S. exports and more economic activity in the United States, resulting in more jobs for Americans. An OECD study of 14 countries found that "each dollar of outward FDI [foreign direct investment] is associated with $2 of *additional* exports and with a bilateral trade *surplus* of $1.7 dollars. These results make it clear that, without outward FDI, OECD country exports would actually be smaller."[5] In addition to creating demand for U.S. exports, foreign subsidiaries of U.S. companies also increase demand for U.S. headquarters services, including management, R&D, finance and advertising. These support services grow as U.S. companies compete successfully in foreign markets.[6] In fact, ending deferral of overseas income would only put U.S. companies at a competitive disadvantage and thereby jeopardize research and manufacturing jobs in the United States.

Other important ideas could be advanced when the tax reform debate occurs to ensure long term U.S. semiconductor industry competitiveness. These ideas include lowering the U.S. combined federal/state corporate income tax to be competitive with OECD countries, enacting a 10 percent investment tax credit for new investment in qualifying high technology manufacturing facilities in the United States (similar to the investment tax credit that existed in federal law prior to the Tax Reform Act of 1986), and providing for full depreciation over three years of all semiconductor manufacturing equipment installed in U.S. fabrication facilities.

Government Research Funding for Science and Technology

Countries seeking to develop their own domestic semiconductor industry have recognized that basic scientific research is essential to promote continued innovation in semiconductor technology. The American Recovery and Reinvestment Act passed in

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4 The Alternative Simplified Credit currently provides a credit of 14 percent of the amount of qualified expenses that exceed 50 percent of the average qualified research expenses for the preceding 3 years. Among Dr. Atkinson's recommendations are a 20 percent credit on research expenses greater than 75 percent and below 100 percent of the base amount, and a 40 percent credit on expenses over 100 percent of the base amount.

5 OECD, Open Markets Matter: The Benefits of Trade and Investment Liberalization 37 (1998) (emphasis in original).

6 *See* National Foreign Trade Council, *International Tax Policy for the 21st Century* 113-114 (2001).

February 2009 was a welcome reversal of the prior trend in declining federal science investment. This change in U.S. government spending priorities to more actively promote scientific research in the physical sciences and engineering should continue. For example, the Congress should build on the American Recovery and Reinvestment Act's appropriations to fully fund and carry out the provisions of the America COMPETES Act, in particular by enacting appropriations beyond FY 2010 to double the federal investment in basic research by key science agencies, including the National Science Foundation, the National Institutes of Standards and Technology, and the Department of Energy Office of Science.

In addition, the Congress should provide specific authorizations and appropriations for nanoelectronics research and equipment to enable the United States to be the first in the world to demonstrate a nanotechnology-based electronic logic switch that is able to replace the solid state transistors that store and process information in integrated circuits. Finding a new switch should be a priority objective for the National Nanotechnology Initiative (NNI). Congress should also continue increasing basic research at the Department of Defense.

Building America's Talent Base in Engineering and the Physical Sciences

Education. Countries competing for semiconductor investment have recognized that a well-educated work force is essential for promoting increased high technology investment. In order to increase the number of Americans with advanced physical science and engineering degrees from U.S. universities, the Congress should consider a number of steps to promote education in science, technology, engineering, and mathematics (STEM) fields.

In particular, the Congress should build on the American Recovery and Reinvestment Act's appropriations to fully fund beyond FY 2010 STEM education programs authorized by the America COMPETES Act. This would include funding for: the Advanced Placement and International Baccalaureate program, which would expand low-income students' access to AP/IB coursework by training more high school teachers to lead AP/IB courses in math, science, and critical foreign languages in high-need schools; the MathNow program to improve K-8 math instruction and ensure that elementary and middle school students are fully prepared for upper level math courses; the Robert Noyce Teacher Scholarship program, which seeks to encourage talented science, technology, engineering, and mathematics majors and professionals to become K-12 mathematics and science teachers; the Math and Science Partnerships program, which develops and implements ways of advancing mathematics and science education for students; and the STEM talent expansion program (STEP), whose goal is increasing the number of students receiving associate or baccalaureate STEM degrees.

Immigration policy. The improvements to STEM education noted in the report are crucial to U.S. competitiveness in the semiconductor industry. Access to all talented graduates from U.S. universities is an important part of this measure given the large number of foreign students who have earned advanced science and engineering degrees at U.S. universities. U.S. immigration policies should encourage these highly skilled workers to stay and work in the United States, and thereby create jobs and economic growth in this country and provide a return on investment for their U.S. education. Individuals with a master's degree or PhD from a U.S. university in STEM fields should be exempt from the employment-based visa cap so they can remain and contribute in their fields in the United States. There should also be a mechanism to allow U.S. STEM master's or higher degree holders who have a job offer to transition directly from student visas to green cards.

Promoting Energy Research and Energy Efficient Manufacturing

The Congress and the Administration should be applauded for including promotion of energy efficiency and renewable energy in the recently passed economic recovery legislation. As noted above, semiconductors are a key enabling technology in renewable energy and energy efficiency. Semiconductor companies have also improved their manufacturing processes to be more energy efficient, and are working for further improvements.

Government energy policies around the world will have an impact on semiconductor manufacturing location decisions, and must be taken into account by U.S. policy makers seeking to improve U.S. competitiveness. To promote the energy-efficient manufacturing of semiconductors that promote energy efficient and renewable energy end products, policy makers should consider tax incentives for semiconductor manufacturing facilities that meet established energy efficiency and sustainability standards,[7] a tax credit for producers of semiconductor devices that will enable dramatic gains in energy efficiency (similar to the existing credits for producers of energy efficient appliances) and accelerated depreciation on expenses related to energy conservation measures. Policy makers should also recognize and support the role of semiconductor technology in promoting an energy efficient economy through increased research funding for semiconductor-enabled energy efficiency and alternative energy at the Department of Energy and through enhanced energy research tax credits.

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These policy proposals will promote economic recovery, long-term job creation, and technological leadership by leveling the playing field with our trading partners and giving America the tools needed to continue its historic leadership in semiconductors, with all the attendant benefits to the United States and its citizens.

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7 There is currently an effort to have the U.S. Green Building Council develop standards for a Leadership in Energy and Environmental Design (LEED) certificate for semiconductor manufacturing.

I. Introduction

The semiconductor industry provides the basic building blocks of the modern global economy. Semiconductor technology has revolutionized virtually every major form of human economic endeavor and made possible extraordinary increases in productivity. The industry is one of the largest job providers in the United States, the second largest exporting industry, and a major source of high wage, knowledge-intensive employment. It provides spillover benefits in municipalities and regions where semiconductor manufacturing and research activities are located.

The semiconductor industry originated in the United States, and it is perhaps taken for granted that it will always remain centered in the United States. However, globalization is placing pressure on most major industries to conduct an increasing amount of their activity in other countries, reflecting factors such as cost, the need for proximity to market, government incentives, the need to surmount trade barriers, and availability of manpower.[8] The production of some major electronics products, such as televisions and computers, has moved almost entirely offshore, and much of the research and development associated with these products is conducted outside the United States. As a result the United States, which as recently as 2000 was the largest market in the world for semiconductors, has now fallen behind markets in both Southeast Asia and Japan.

The U.S. semiconductor industry invested in foreign markets as long ago as the 1960s and has long conducted a significant portion of its lower-skill assembly and testing functions abroad, but until the past decade most high-skill, high wage wafer fabrication (the most complex aspect of the manufacturing process) and R&D was carried out in the United States. Since the mid-1990s, however, the proportion of U.S. semiconductors fabricated abroad has increased,[9] reflecting a number of factors:

- Many U.S. semiconductor firms have become “fabless” or “fab lite” and have their designs entirely or partially fabricated at foundries outside the United States;
- U.S. firms that continue to manufacture their own semiconductors (so-called integrated device manufacturers or IDMs) have had to remain cost competitive with major competitors overseas by locating an increasing share of their wafer fabrication capacity outside of the United States due to an estimated $1 billion or larger gap in the cost to build, equip and operate a new fab due to foreign government tax incentives and grants; and
- The United States is no longer the largest market in the world for semiconductors as production of electronics products from televisions to computers and cell phones have moved offshore, propelling the growth of competitors in countries such as Taiwan, Korea, Singapore and China.

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8 See testimony of Dr. Robert D. Atkinson, President, Information Technology and Innovation Foundation, before the Committee on Science and Technology, Subcommittee on Technology and Innovation, U.S. House of Representatives (October 4, 2007)

9 Wafer fabs are still being built in the United States, but are generally associated with significant state and local incentives. See Section IV.

These trends have led a number of observers to conclude that R&D functions now conducted in the United States will "follow the fabs" to locations in Asia and elsewhere, and that if present trends continue, the United States is in danger of losing this critical aspect of its technological leadership.

This study quantifies the extent to which the U.S. semiconductor industry has shifted its manufacturing and R&D investments from the United States to other countries over the decade ending in 2007, and the extent to which existing trends can be projected into the future. It addresses the question whether R&D is "following the fabs" abroad or whether U.S. semiconductor firms are conducting R&D outside the United States for other reasons. Finally, the paper attempts to assess the extent to which government policy measures in the United States and overseas affect U.S. companies' decisions about where to locate their manufacturing and R&D and recommends actions and policies federal policymakers can take that will help to ensure that the United States remains competitive in the semiconductor industry.

At present roughly two-thirds of U.S. semiconductor capital spending on wafer fabrication and three-quarters of U.S. semiconductor R&D spending is directed at activities in the United States. However, U.S. semiconductor firms face increasing competitive pressures to establish new fabs and to conduct R&D at locations outside the United States, and the proportion of capital investment and R&D conducted domestically is declining.[10] While these trends reflect a variety of factors, government policies – particularly comparative tax and human resources policies – play an important role in determining the location of U.S. semiconductor industry investments.

[10] The labor content of wafer fabrication is very small so that location decisions are not driven by wage differences.

II. The Importance of the U.S. Semiconductor Industry for America

The economic importance of the semiconductor industry may seem self-evident, but it is worth summarizing the benefits that it conveys upon countries and regions in which it is located.[11] Semiconductors represent the basic enabling technology of the electronics and information industries, which increasingly form the core of the global economy. Continuing advances in semiconductor technology over the last several decades have accelerated the development and productivity of a wide variety of industries, both in emerging industries and traditional sectors, including communications, transportation, education, entertainment, health care, and defense systems.[12] The pervasiveness in use of semiconductors today – driven by the continuously increasing performance and decreasing cost of semiconductor components[13] – has established semiconductors as the premier general-purpose technology of the post-industrial era.[14]

A. Direct Benefits to the U.S. Economy

The U.S. semiconductor industry contributes significant direct employment, investment and international trade benefits to the U.S. economy. U.S.-based chipmakers directly employ approximately 200,000 people in the United States.[15] The U.S. industry is currently the world semiconductor market share leader, with 2008 world sales reaching $120 billion, representing 48 percent of the $249 billion world market.[16] Semiconductors were the top U.S. export category in 2003-2006 and second in 2007 (behind aircraft) and 2008 (behind petroleum refinery products).[17] See chart 1.

While approximately 80 percent of the U.S. industry's sales are outside the U.S. market, it continues to provide significant direct contributions to the U.S. economy: about three-quarters of U.S. semiconductor industry R&D spending, 77 percent of U.S.-owned

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11 The concept that the semiconductor industry, or any other industry, is special or "strategic" in economic terms is far from universally accepted in academia, a sentiment reflected in the purported comment of a former senior U.S. economic adviser that it makes no difference whether this country makes computer chips or potato chips.

12 National Research Council, *Securing the Future: Regional and National Programs to Support the Semiconductor Industry*, Charles W. Wessner, ed., Washington, DC: National Academy Press (2003) at 18-20.

13 Jeffrey T. Macher, David C. Mowrey, and David A. Hodges, "Semiconductors," *U.S. Industry in 2000: Studies in Competitive Performance*, David C. Mowrey, ed., Washington, DC: National Academy Press (1999) at 245.

14 *Securing the Future*, op.cit. (2003) at 9.

15 Employment data are total average employees for January to November 2008 (data for November are preliminary). The semiconductor industry average employment was 203,000. The automobile and light truck industry in the United States, by comparison, directly employed almost 163,000 workers. U.S. Bureau of Labor Statistics, NAICS codes 334413 (semiconductors and related devices) and 336110 (automobiles and light trucks)

16 Semiconductor Industry Association from WSTS data.

17 U.S. Department of Commerce, Bureau of Census, exports by 6-digit NAICS code.

Chart 1: Semiconductors Have Consistently Ranked First or Second Among the Top U.S. Export Industries Over Past Six Years

Export Rank	2003	2004	2005	2006	2007	2008
1	Semiconductors	Semiconductors	Semiconductors	Semiconductors	Aircraft	Petroleum products
2	Computers	Computers	Aircraft	Aircraft	Semiconductors	Semiconductors
3	Aircraft	Aircraft	Computers	Automobiles	Automobiles	Aircraft

Source: U.S. Department of Commerce Bureau of Census. Exports by 6-digit NAICS code.

production capacity, 51 percent of U.S. industry worldwide employment, and 74 percent of the U.S. industry's compensation and benefits are paid in the United States.[18]

B. Indirect Benefits to the U.S. Economy

A growing view exists among economists that the development and deployment of semiconductor-based information technology has provided the foundation for the overall acceleration in productivity growth in the U.S. economy since the mid-1990s.[19] "The mantra of the 'new economy' – faster, better, cheaper – characterizes the speed of technological change and product improvement in semiconductors, the key enabling technology."[20] See chart 2.

The presence of the semiconductor industry in a given region provides an economic stimulus that extends far beyond direct employment by semiconductor enterprises themselves.[21] Semiconductor research and manufacturing activities have proven to be a magnet for other high technology enterprises.[22] Semiconductor companies commonly

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18 Semiconductor Industry Association, "Creating U.S. Tax Environment That Lets U.S. Semiconductor Companies Compete" (April 4, 2008) and "Profile of U.S. Semiconductor Industry" (2008).

19 Dale W. Jorgenson, "The Emergence of the New Economy" in *Enhancing Productivity Growth in the Information Age*, Dale W. Jorgenson and Charles W. Wessner, eds., Washington, DC: National Academy Press (2007) at13.

20 Ibid.

21 "Increasingly, it is recognized that the engines of national economic performance are sub-national technology districts that are characterized by strong ties between regional actors. ...This work is complemented by the empirical research reviewed here that finds that knowledge spillovers from science-based activities are localized and contribute to higher rates of innovation, increased entrepreneurial activity and increased productivity within geographically bound areas." Maryann P. Feldman, "The New Economics of Innovation, Spillovers and Agglomeration: A Review of Empirical Studies," *The Economics of Innovation and New Technology* (1999), Vol. 8 at 20.

22 In 2007 Intel Corporation signed a contract with the Dalian Municipal Government in China for the local establishment of a 300mm wafer fabrication facility. Dalian Mayor Xiu Deren commented that Intel's presence was acting as a magnet for other high technology companies. "Intel's arrival has driven a large number of enterprises related to the chip manufacturing industry

contribute funding, personnel and curriculum support to local educational institutions in order to increase the supply of skilled graduates. The large number of high wage, high skill jobs by semiconductor producer stimulates demand for a wide range of products and services throughout a region.[23] In September 2008, French Prime Minister Francois Fillon, announcing his government's decision to invest about 376 million Euros in a semiconductor R&D research program in Crolles, indicated that investments in Crolles since 1992 had created 18,000 jobs in the Rhone-Alpes Region and 27,000 in all of France, despite the fact that the Crolles facility itself directly employs only 1200 people.[24]

Chart 2: Innovation Allows U.S. Companies To Do More With Less

Increased functionality and a 66% price drop in only 10 years!

SPEC	1997	Q4 2007 (GT5622)
Processor	**2nd Gen 32-bit**	**Intel E2160**
Raw Power (Normalized)	**1**	**80-120**
Clock Rate (MHz)	**75**	**1.8GHz**
Memory (MB)	**9.2**	**3GB**
Disk Storage (GB)	**0.74**	**400GB**
Modem	**No**	**56K**
Network Interface Card (NIC)	**No**	**Ethernet**
Graphics	**Add-In**	**Integrated Chipset**
CD ROM	**1X**	**Multi-Format DVD Burner**
CD RW/DVD	**No**	**None**
Media Reader	**None**	**15-in-1**
Removable Storage	**Floppy Disk (1.5MB)**	**Flash Drive 4GB**
Price	**$1,833**	**$630**

Source: Gateway January 2008

to invest in Dalian. Intel's project has attracted more investment in silicon IC designing, manufacturing, packaging and testing and follow-up projects. A dozen multinational corporations are actively communicating with Dalian. This will promote the growth of the city and revitalization of the old industrial bases in northeast China." "What Benefits Will Intel's Plant Have for Dalian?" *Renmin Ribao* (April 4, 2007).

23 A recent study by IFO Dresden, a German research institute, on the local impact of the semiconductor industry in Europe, observed that "since spillover effects of the semiconductor industry to related industries often presupposes a spatial proximity, the competitiveness of wider parts of European industry could be impaired if direct contacts between producers of semiconductors and their customers were hampered. This holds true in particular for specialized providers of microprocessors (back-end production) but also applies to the manufacturers of front-end products. Production shifts of ancillary industries could damage the economy in Europe." IFO Dresden Studies 45, *Rechtfertigurg von Ansidlungsubuentionen am Beispiel der Halbleiterindustrie* ("Justification of Location Subsidiaries – The Case of the Semiconductor Industry") Abstract (2008).

24 "French Government to Invest 565 Euros in Crolles 3," *Les Echos* (September 25, 2008). The Crolles R&D Alliance is a joint project involving Motorola, Philips and ST Microelectronics, which has received financial support from the government of France.

Furthermore, the semiconductor is perhaps the single most anti-inflationary technology ever devised. The exponential growth in semiconductor chip memory and logic capability – together with the contemporaneous decline in price – that has fueled increased productivity was first observed over 40 years ago by Gordon Moore,[25] then research director at Fairchild Semiconductor, and has since been dubbed Moore's Law

Government Responses to the Current Economic Crisis

In connection with the significant slowdown in the world economy in the second half of 2008 and early 2009, many semiconductor producers around the world are facing steep declines in sales and in prices for their products. This is especially true for makers of memory chips like DRAMs, which are used in personal computers, cell phones, digital cameras and other consumer electronics.

While the U.S. government has been focused on providing emergency assistance to financial firms and the automobile industry, a number of other governments are in the process of developing plans to aid their national semiconductor producers – a recognition of the significant role the semiconductor industry plays in promoting overall economic growth. Often these plans involve a mixture of government and private sector funding, but are driven by governmental policy decisions that local semiconductor producers are too critical to the economy to be allowed to fail.

In Taiwan, several semiconductor producers, including Powerchip Semiconductor Corp., ProMos Technology Corp., and Nanya Technology Corp. announced late in 2008 that they were seeking government bailout assistance to address mounting losses. In mid-December, the Taiwanese Ministry of Economic Affairs announced a set of guidelines under which it would provide support to local chip producers while encouraging the companies to consolidate. As part of this program, Taiwan's National Development Fund is reportedly preparing to appropriate approximately $6 billion to assist the DRAM and flat-panel display industries in Taiwan.

In Korea, Hynix Semiconductor Corp. is seeking help from its creditors, although there are conflicting reports that the company is also seeking a bailout from the Korean government. One report indicated that the South Korean Minister of Knowledge Economy said direct government aid would be provided if South Korean creditors did not provide needed loans of almost $600 million.

In the United States, the U.S. semiconductor industry has supported provisions in the stimulus legislation passed by the Congress to appropriate funds to upgrade critical research infrastructure at U.S. universities and the national labs which is critical to advancing semiconductor technology in the United States. In addition, provisions to fund application of advanced technology to improve energy efficiency, education, health care, and the electrical grid, as well as to expand broadband access for all Americans, will increase demand for semiconductor devices, thus providing an indirect stimulus to the semiconductor industry.

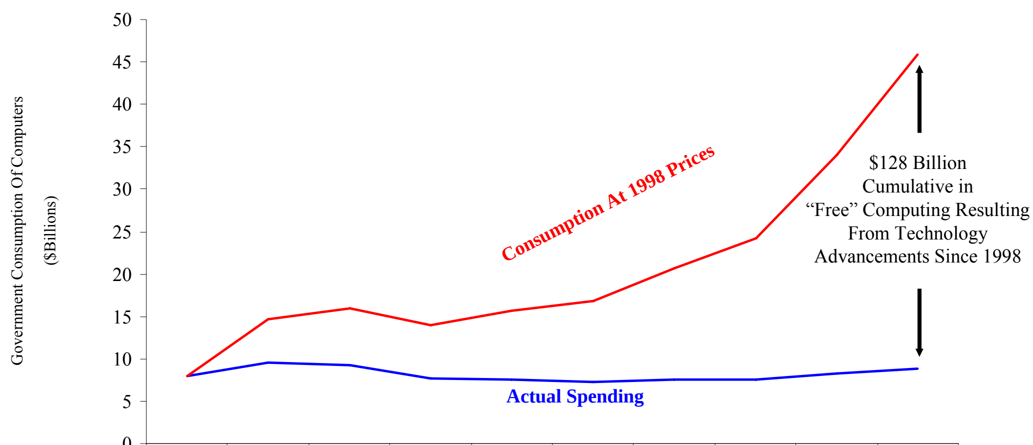
[25] Gordon E. Moore, "Cramming More Components onto Integrated Circuits," *Electronics*, vol. 38, No. 8 (April 19, 1965). Available at ftp://download.intel.com/research/silicon/moorespaper.pdf.

and updated to predict that the number of transistors on a chip will double every 18 months.[26] This equates to ever more powerful chips at ever lower prices.

The significant price declines and increases in functionality that have been seen in semiconductors due to this continuous innovation has fueled price declines in a range of products that rely heavily on semiconductor technology, such as computers and telecommunications equipment, but has also helped to reduce the costs and increase the quality and features of aircraft, automobiles, scientific instruments and a number of other products.[27] This not only benefits consumers, but helps make traditional U.S. industries more globally competitive. It has allowed U.S. federal, state and local government to do much more information technology (IT)-based work without spending more money. See chart 3.

The semiconductor-driven decline in IT prices in recent years has also produced more systemic productivity growth for the U.S. economy. The rapid increase in the use of information technology that has accompanied the drop in its price/performance ratio has contributed to enhanced workplace productivity, enabled the development of more innovative and agile enterprises, and supported the growth in the U.S. service sector as the Internet has been transformed from a communications medium to a platform for service delivery.[28]

Chart 3: Computing Price Declines Allow Government To Do More Without Spending More



	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Actual Spending	8	9.5	9.2	7.7	7.5	7.2	7.6	7.6	8.2	8.8
at '98 Prices	8	14.7	16	13.9	15.7	16.8	20.6	24.2	34	45.8

Source: Bureau of Economic Affairs (www.bea.gov/national/xls/comp-gdp.xls
Note: Includes Federal, State, and Local Governments.

26 *Enhancing Productivity Growth in the Information Age* at 65-67 (citing presentation by Kenneth Flamm at 2001 National Academies conference on semiconductors).

27 Jorgenson, "The Emergence of the New Economy" in *Enhancing Productivity Growth in the Information Age*, at 14.

28 *See* "Findings and Recommendations: The Nature of the New Economy" in *Enhancing Productivity Growth in the Information Age*, at 19-23.

Semiconductor technology offers similar benefits in the field of health care, where costs are currently increasing faster than inflation. Semiconductor-enabled information technology offers the great promise of lowering costs and improving delivery. For example, according to the Rand Corporation, the application of information technology in the health care sector could result in annual savings of $77 billion or more from efficiency alone, not counting the economic benefits of reducing medical errors and improving patient services.[29]

Semiconductors, and the information technology advances they enable, also offer significant opportunities to improve the delivery of health care services in the same way that they have done for so many other sectors of the U.S. economy. Health IT systems can provide timely access to patient information and (if standardized and networked) can communicate health information to other providers, patients, and insurers. This can result in increased safety, for example through computerized physician order entry systems for medications, which provide immediate information to physicians warning about a potential adverse reaction with a patient's other drugs.[30]

Semiconductors are also at the heart of the advanced medical imaging technologies – including MRI, CT scans, digital mammography and ultrasound – that enable modern, non-invasive diagnosis and treatment. Advancements in semiconductor-enabled medical imaging technology have the potential to change fundamentally the practice and economics of diagnostic imaging. Analog-to-digital converter chips available today allow next-generation CT (computed tomography) scanners to rapidly take more pictures so doctors can see a beating heart in a high degree of detail in real time. High performance signal processing solutions for medical applications, including analog, mixed-signal, embedded processing and MEMS technologies, are producing improved resolution in imaging systems, more sophisticated and more portable patient monitoring systems, and more accurate and reliable home monitoring equipment.

C. The Semiconductor Industry's Role in Addressing National Challenges Regarding Energy and the Environment

In addition to the direct and indirect economic benefits of the semiconductor industry itself, semiconductors are a key technology for addressing the energy challenges that face the United States and the world. Semiconductors will enable society to harness alternative energy sources more effectively, distribute it efficiently and intelligently and consume it in the most efficient manner, providing an important component to our nation's efforts to reduce the greenhouse gas emissions that cause climate change and to increase our energy security. Applications include power management and virtualization in computers and data centers, electronic controlled efficient motors in factories, light emitting diodes to replace compact florescent and incandescent bulbs in offices and homes, plug-in electric vehicles on highways, solar panels and wind turbines generating electricity, smart meters and sensors monitoring power lines

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29 RAND Corporation, *Health Information Technology: Can HIT Lower Costs and Improve Quality?* (2005), *available at* http://www.rand.org/pubs/research_briefs/RB9136/index1.html.

30 *See id.*

Semiconductors already are responsible for significant energy savings, and further advances in chip technology could greatly increase energy efficiency. In the home, semiconductor-enabled motor control technologies increasingly allow consumers to use smaller, more efficient motors with greater levels of performance in many household appliances, including refrigerators, dishwashers, and washing machines.

Similarly, the dramatic improvements in automobile fuel efficiency and emissions control that have been witnessed over the past decades have largely been delivered by changes in engine control electronics. Today's vehicles have countless chip-enabled features such as gasoline direct injection, knock detection, oxygen sensors, exhaust gas recirculation, evaporative emission control systems, misfire detection, and secondary air systems. Semiconductors also play an integral role in energy-efficient hybrid cars and further advances in semiconductor technology will be critical to expanding the utility of plug-in electric vehicles by substantially extending their range and performance.

Going forward, further advances in chip technology could produce substantial additional energy efficiencies. Semiconductor technologies are currently in development that would allow a mobile phone to run off a single battery for extended periods of time, perhaps even years. Advances in chip technologies are also being applied to solar power systems. This will enable tomorrow's laptops and other more power intensive portable devices to recharge using solar power and to operate in dim ambient indoor light.

Semiconductor technology advances in two areas of data center server activity (computation and memory) have the potential to significantly lower the energy used and heat generated by servers. During computations, which account for about 35 percent of a server's energy draw, new chip technologies allow those parts of the processor and the server not fully engaged in an application to transition to draw reduced amounts of energy. Meanwhile new chips can also reduce energy use by up to 40 percent, even in the less energy-intensive memory arena. In addition to the direct energy savings resulting from these chip-enabled server and system efficiencies in today's data centers, chip technologies also improve the efficiency of the industrial cooling systems that are used to ensure optimal data center service and also allow intelligent sensing, control and communication capabilities to exist in the other equipment found in the data center.[31]

Industrial applications of new energy-saving chip technologies could improve energy efficiency in industrial settings by up to 88 percent due to more efficient motor control and power management. Chip-enabled motion and video sensors are increasingly being used in commercial and industrial settings to control lights and heating, ventilation and air conditioning systems based on movement within a room or building. Such smart facilities take on the task of making sure the environment is suitable for the worker while saving energy.

Semiconductors also play a key role in the electronics used in both solar and wind-generated power systems, including solar inverters and wind turbines, which convert

[31] Semiconductor Industry Association, "More for Less -- Today's Chip Industry, Energy Efficiency, and the Benefit to Our Environment," (2008).

direct current from solar panels or turbines into usable household alternating current. With the latest chip technologies, system efficiency is maximized so it can be productive even on cloudy and low wind days. Chip technologies are also being researched to better use solar power – both natural sunlight and indoor ambient – in recharging the batteries of portable devices.

The advances in energy efficiency and alternative energy technologies already achieved, and those projected for the future, all depend on continued innovation in semiconductor technology, as discussed below.

D. The Need for Continued Innovation

The continued health and global success of the U.S. semiconductor industry – with the significant related benefits to the U.S. economy – depends on the continued ability of the industry to sustain the rapid pace of innovation predicted by Moore's Law. This requires investment of substantial human and financial resources to overcome the significant technological challenges associated with developing ever smaller, cheaper and more powerful chips that will serve as the foundation for the economy for the years to come.

The R&D needs of the semiconductor industry are expected to accelerate even further as the size of transistors on a chip continues to shrink. Semiconductor producers are currently manufacturing devices with features as small as 45 nanometers[32] across and are involved in R&D efforts for devices that are even smaller. The complexities of manufacturing at these scales cannot be overemphasized.

Continued innovation at the nanoscale level will require very substantial scientific and human resources including greater federal Government support for basic research in engineering and the physical sciences. As a percentage of GDP, federal support for such research has been in long-term decline (see chart 4), although the American Recovery and Reinvestment Act passed in February 2009 is a welcome reversal of this trend, at least in the short run.

The transistor is the basic building block within the semiconductor chip and can be thought of as an electronic switch or as a device to retain one bit (a one or a zero) in memory. The transistor is composed of a series of precisely etched and deposited layers of materials, and with as many as two billion transistors integrated on a single silicon chip, modern semiconductors are the most complex product manufactured on the planet.

The phenomenal advances in technology may slow drastically as semiconductor technologists have concluded that we will soon be reaching the fundamental limits of CMOS technology, the process that has been the basis of innovation for the semiconductor industry for the past 30 years. By introducing new materials into the basic CMOS structure and devising new CMOS structures and interconnects, further improvements in CMOS can continue for the next ten to fifteen years, at which time

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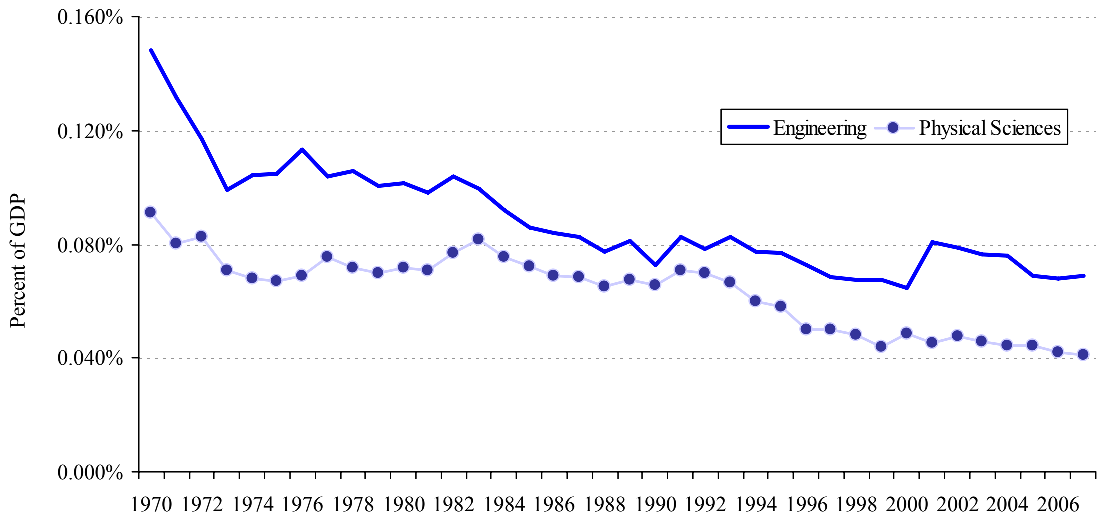
[32] A nanometer is one-billionth of a meter, and a strand of human hair is about 100,000 nanometers in diameter.

CMOS begins to reach its physical (layers only a few atoms thick) and power dissipation limits. For the U.S. economy to benefit from continued information technology productivity improvements, there will need to be a "new logic switch" to replace the current CMOS-based transistor.

Chart 4: Federal Investment in Physical Sciences and Engineering as Share of GDP Has Declined Significantly

1970 to 2007



Source: National Science Foundation, Division of Science Resources Statistics, *Survey of Federal Funds for Research and Development.*
Note: Federal obligations for total research by fiscal years divided by U.S. GDP. Increase in engineering percentage in 2001 is result of funding reclassification, not finding increase.

There are a number of candidates for the new switch, including devices based on spintronics (changing a particle's spin) and molecular electronics (changing a molecule's shape). Scientists must address many challenges in many different basic research fields (chemistry, physics, and electrical engineering) in the search for the new switch. The challenges include:

- measuring the dimensions, shapes, and electrical characteristics of individual molecules;
- manipulating and measuring the spin of individual electrons;
- fabricating whole new classes of materials with unique electronic properties, and then characterizing their fundamental physical behavior and their long-term reliability;
- inducing novel chemical compounds to self-assemble into the precise structures needed by the new devices and architectures, and doing so in a way that can be potentially manufactured at commercial volumes;
- developing complex circuits to take advantage of, or overcome limitation of, the properties of the new devices, and
- finding ways to interconnect the devices and integrate them into our technology infrastructure in a cost-effective manner that will enable us to

continue the historical cost and performance trends for information technology.

Addressing these challenges will not only require the best minds from industry and academia, but also new equipment for fabricating and characterizing these nanostructures. This will build strongly on the existing facilities at university centers but will require significant additional investment in new specialized equipment, particularly to enable the realistic prototyping of new nanoelectronic devices and circuits which will be crucial to transitioning these into commercial and manufacturing environments.

Maintaining a healthy U.S. semiconductor industry requires a reversal of this funding trend. It also requires ensuring that all aspects of the semiconductor "innovation ecosystem" are fostered and developed in the United States. As a 2004 Report by the President's Council of Advisor's on Science and Technology (PCAST) noted, such ecosystems – which combine R&D with manufacturing – are critical to promoting continued innovation in critical industries like semiconductors.[33] But such ecosystems do not simply develop by themselves. Indeed, there is much evidence that national policies have been adopted by many governments "to attract, create and retain semiconductor industries within their national economies."[34] To remain competitive, the United States must continue to ensure its own policies promote the innovation that has fueled the success of the U.S. semiconductor industry over the past several decades.

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33 PCAST, "Sustaining the Nation's Innovation Ecosystems, Information Technology Manufacturing and Competitiveness" (2004) at 14-15.

34 *See* "Findings and Recommendations: Maintaining U.S. Technology Leadership in Semiconductors" in *Enhancing Productivity Growth in the Information Age*, at 35.

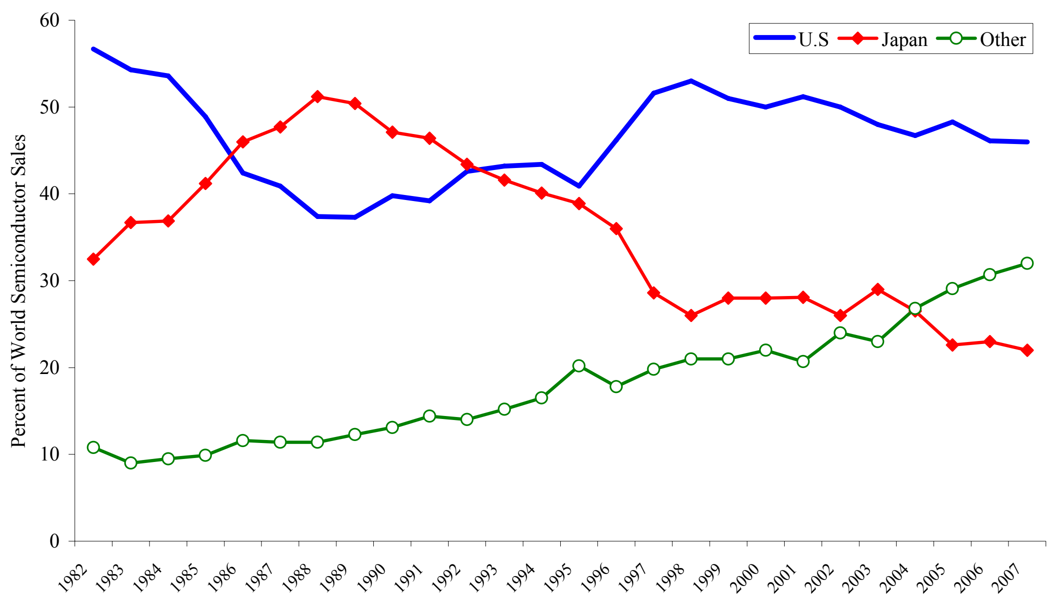
III. Current Trends in the Location of U.S. Semiconductor Industry R&D and Manufacturing Activity

U.S. semiconductor companies lead in worldwide sales and continue to position themselves for future sales leadership by remaining number one in research and development ("R&D") and capital spending. The U.S. semiconductor industry however, despite its acknowledged importance to the U.S. economy, has been slowly but steadily moving an increasing share of its manufacturing and R&D activities to other locations.

A. U.S. Semiconductor Firms Are Still the Leader in Worldwide Sales but Most New Capacity Growth Has Been in Asia

U.S. semiconductor companies have maintained a predominant share of worldwide semiconductor sales since the early 1990s, although there has been some share loss over the past decade.[35] The worldwide market share of U.S.-based firms in 2008 was just over 48 percent. The market share of Japanese semiconductor companies, after reaching over 50 percent of worldwide sales by the end of the 1980s, has been declining ever since while the share of companies in the rest of the world (primarily Korean, Taiwanese and European companies) has steadily increased. See chart 5.

Chart 5: U.S. Semiconductor Companies Have Maintained a Dominant Share of World Semiconductor Sales Since the Early 1990s



Source: WSTS

Concern has been raised that U.S. firms will not be able to maintain this global sales leadership position in the future. A recent cover story in *Electronic Engineering Times* entitled "The Rise and Fall of U.S. Chip Research" discussed "manufacturing moving

35 Data are from WSTS. Market share data are based on sales by nationality of company, not sales by location of production.

offshore to the foundries of Taiwan Semiconductor Manufacturing Co. (TSMC), Chartered Semiconductor Manufacturing, United Microelectronics Corp. (UMC) and lately to foundries in mainland China. Pessimists point to these trends and predict that semiconductor R&D will be the next to go. Others, however, say U.S. semiconductor R&D is down, but not out."[36] Overall, the share of worldwide fabrication capacity in the United States has declined from about 42 percent in 1980, to 30 percent in 1990 to about 16 percent in 2007.[37]

There are a number of reasons for the relative decline in fabrication capacity in the United States. First, the continued growth of semiconductor competitors in Asia has fueled capacity expansion there. Korea's Samsung is now the world's largest producer of memory chips and second only to Intel in worldwide sales.

Second, U.S. semiconductor producers have fabrication facilities outside of the United States, either wholly owned or joint ventures with foreign producers.[38] These facilities have generally benefited from various tax and other incentives provided by the host government.

Third, as the cost of a new fabrication facility has increased dramatically over the past 15 years (currently in the range of $3.0 billion or more each), many U.S. semiconductor firms have opted to rely on semiconductor foundries – independent contract manufacturing facilities – for some or all of their manufacturing capacity.[39] Technological trends in the industry are greatly increasing wafer fabrication and chip-design costs so that some industry observers are predicting fewer companies will be able to maintain leading edge production and design capabilities as device geometrics shrink. "In the new IC world order, fewer integrated device manufacturers (IDMs) can afford to build fabs, while only an elite group may be able to develop leading-edge IC designs over time."[40] The result has been the rapid growth of what are termed "fabless" (companies with no manufacturing) or "fab-lite" (companies with capacity to produce only a portion

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36 R. Colin Johnson, "Is the U.S. Falling Behind in Chip R&D?" *Electronic Engineering Times* (November 10, 2008) at 24-25.

37 The figures for 1980 and 1990 are based on capacity as measured in terms of estimated electrical functions that can be produced per month from Robert C. Leachman and Chien H. Leachman, "Globalization of Semiconductors," in Martin Kenney and Richard L. Florida (eds.), *Locating Global Advantage: Industry Dynamics in the International Economy* (Stanford University Press, 2004) at 210, table 8.2. The 2007 figure is from SEMI, Industry Research & Statistics Department and is based on wafer starts per month.

38 For example, in recent years Intel has built a new fabrication facility in Israel and AMD has built new fabrication facilities in Germany.

39 Six hundred of the world's 1,300 fabless companies are located in North America according to the Global Semiconductor Alliance (GSA) and nine of the top ten fabless companies by revenue in 2007 were based in the United States. Data from GSA as at http://www.gsaglobal.org/resources/industrydata/facts.asp.

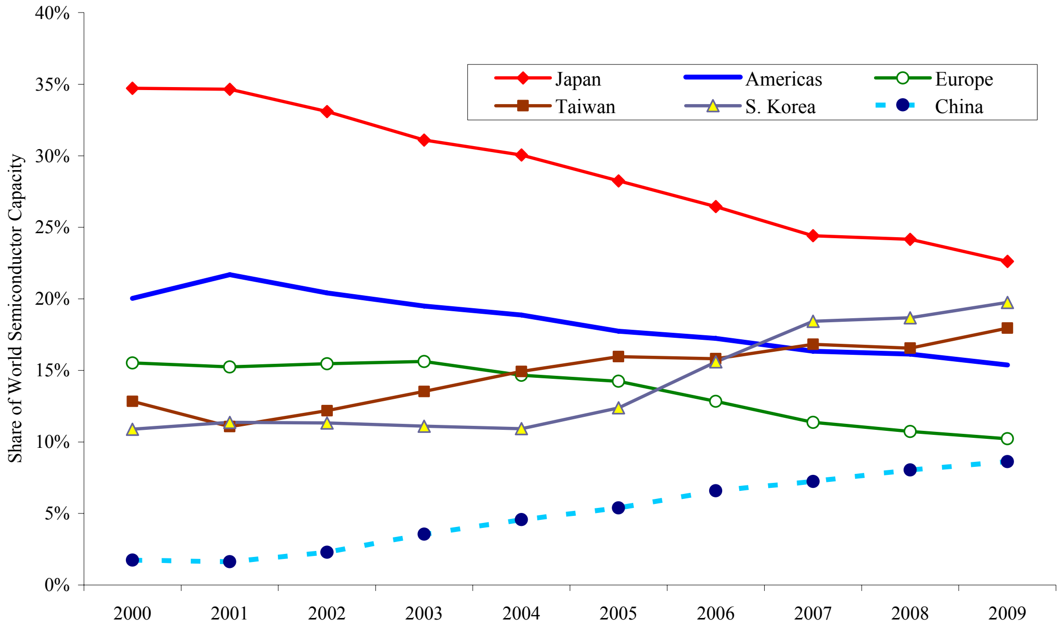
40 Mark LaPedus, "Costs Cast ICs into Darwinian Struggle," *Electronic Engineering Times* (March 30, 2007) at as http://www.eetimes.com/news/latest/showArticle.jhtml;jsessionid=W1UVYJHEKX5F0QSNDLSCKHA?articleID=198701495.

of total sales) companies. Thus the manufacturing capacities for these fabless or fab-lite firms are the foundries, which are concentrated in Taiwan, Singapore and China.[41]

Finally, an important reason for the declining share of world fabrication capacity is the lower cost of building and operating a fabrication facility outside of the United States – primarily due to government provided tax breaks, grants and other incentives. See Section IV. Recent industry studies have estimated the relative cost advantage to be about $1 to $1.7 billion over ten years.[42]

Semiconductor fabrication capacity trends by region from 2000 to 2007 and projections through 2009 from SEMI are provided in chart 6. The share of world fabrication capacity installed in Japan, the United States and Europe have all declined in recent years while

Chart 6: The Share of World Capacity Has Grown in Korea, Taiwan and China but Has Fallen in Japan, the United States and Europe



Source: SEMI, Industry Research & Statistics Department. Data beyond 2008:Q2 based on projections.

the share of capacity in Korea, Taiwan and China has increased. The share loss in just seven years, from 2000 to 2007, has been 10.3 percentage points in Japan, 4.1 percentage points in Europe and 3.7 percentage points in the Americas. The countries with the largest increase in global capacity share have been Korea with 7.5 percentage points, China with 5.5 percentage points and Taiwan with 4 percentage points. The decline in the

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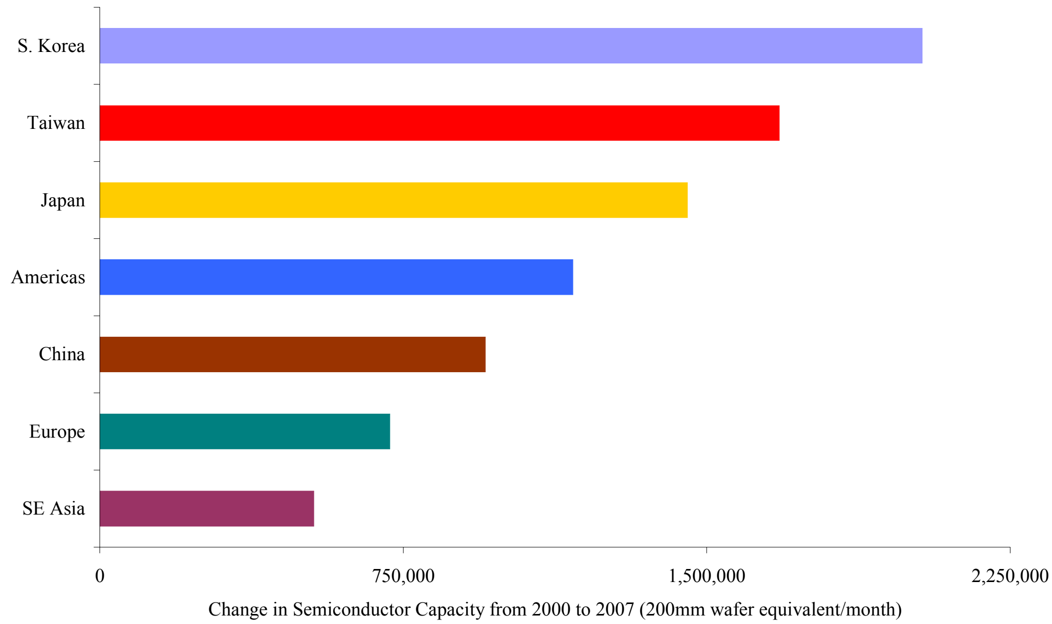
41 Foundries are estimated to account for 35 to 40 percent of installed fabrication capacity in Taiwan, Singapore and China. The foundry industry started in Taiwan with TSMC which is still the largest foundry company in the world. Other major foundry producers are UMC (Taiwan), Chartered Semiconductors (Singapore) and SMIC (China). Recently, integrated device manufacturers such as IBM and Samsung have begun offering foundry services.

42 Paul S. Otellini, “Impact of Taxes on U.S. Semiconductor Company Decisions,” Intel Corporation (March 31, 2005) and Abbie Gregg, Inc., “The Paradigm for Financing Fabs,” Albany Symposium 2005 on Global Nanotechnology (September 26-28, 2005).

relative share of worldwide semiconductor capacity in the United States, Japan and Europe has been a relative decline as actual capacity has increased from 2000 to 2007. See chart 7. Even so, at the end of 2007, eighty percent of leading edge (300mm) capacity was installed in Asia with only 14 percent in the United States and six percent in Europe (including the Middle East). See chart 8.

Chart 7: The Decline in Wafer Fabrication Capacity in the U.S., Japan and Europe Has Been Relative, Not Absolute

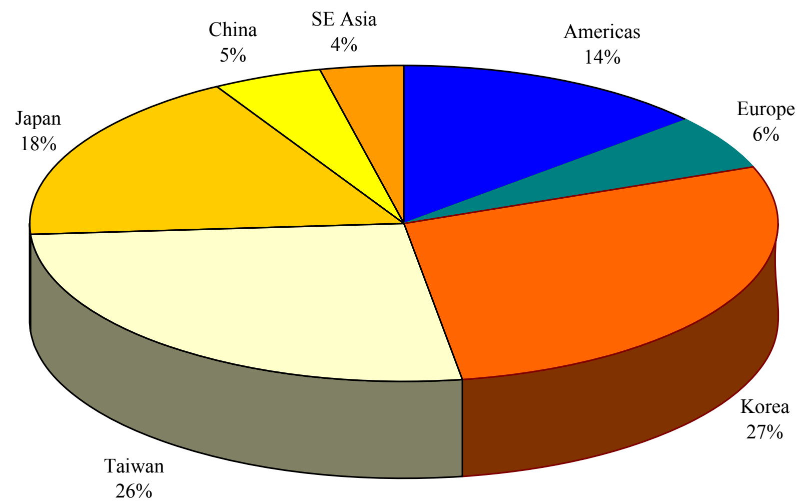


Source: SEMI, Industry Research & Statistics Department.

U.S. semiconductor companies still lead the world in total capital spending despite the relative decline in the share of manufacturing capacity installed in the United States. Strategic Marketing Associates ("SMA") estimated that U.S. companies accounted for 28 percent of total semiconductor capital spending in 2007, followed by South Korean companies at 22 percent and Taiwanese companies at 22 percent.[43] See chart 9. While U.S. semiconductor companies are still the global leaders in capital spending, as discussed in the next section an increasing share of that spending is taking place outside of the United States. U.S. semiconductor companies, as indicated by their worldwide share of semiconductor sales and capital spending, have maintained their overall competitiveness in a very challenging international environment. Yet some have questioned whether the United States is losing its advantages relative to other countries as a location for semiconductor production and R&D. Recent investment announcements by AMD and Intel indicate that the United States still retains advantages as a location for semiconductor manufacturing, including state and local incentive packages. As part of a plan to spin off its manufacturing operations into a foundry company, AMD is planning

[43] According to SMA, however, the U.S. company global spending share of 28 percent in 2007 was down from the average share of 35 percent from 1997 to 2003.

Chart 8: Eighty Percent of Leading Edge Capacity is in Asia
300mm Capacity by Region in 2007



Source: SEMI, Industry Research & Statistics Division.

to invest about $4 billion in a 300mm fab in New York with the assistance of over $1 billion in state and local incentives.[44] Intel announced in early 2009 that it intended to invest $7 billion over the next two years to "revamp existing Intel plants in Oregon, Arizona and New Mexico so they can manufacture the company's most advanced 32 nanometer chips."[45] Currently the smallest circuits on a chip being sold in the market are 45 nanometer devices so these investments by Intel would make these plants the most advanced semiconductor manufacturing facilities in the world.

B. Survey of Spending Trends by U.S. Semiconductor Industry Shows Offshore Movement of R&D and Capital Spending Over the Past Decade

In order to better understand recent trends in U.S. companies' global R&D and capital spending by location, U.S. member companies of the Semiconductor Industry Association ("SIA") were surveyed about their R&D, capital spending and R&D incentives by region from 1997 to 2007.[46] Companies representing two-thirds of total U.S. spending over the period covered responded to the survey. The survey results show

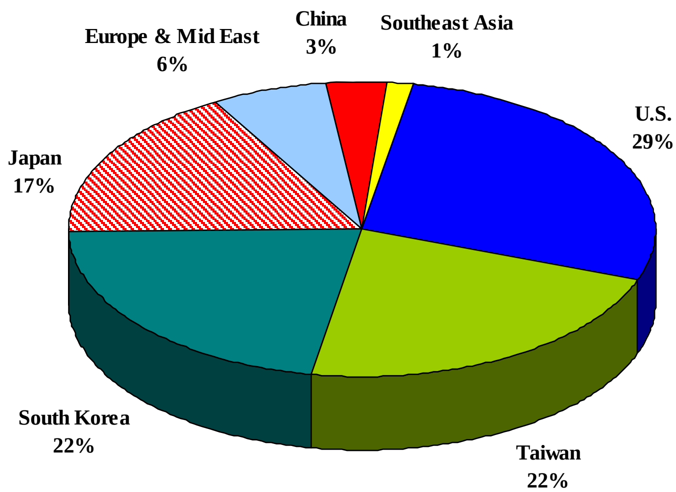
44 Governor Paterson Announces Major Investment In New York State, (October 7, 2008) as at http://www.ny.gov/governor/press/press_1007082.html.

45 Frank Davies and Steve Johnson, "Intel to Invest $7 Billion in Chip Manufacturing," *Mercury News* (February 10, 2009).

46 The regions identified for the survey were the United States, Europe, Japan, Taiwan, Korea, China and rest of world (ROW).

Chart 9: U.S. Companies Lead the World in Semiconductor Capital Spending

2007



Total Spending = $60.4 Billion

Source: Strategic Marketing Associates (June 2008)

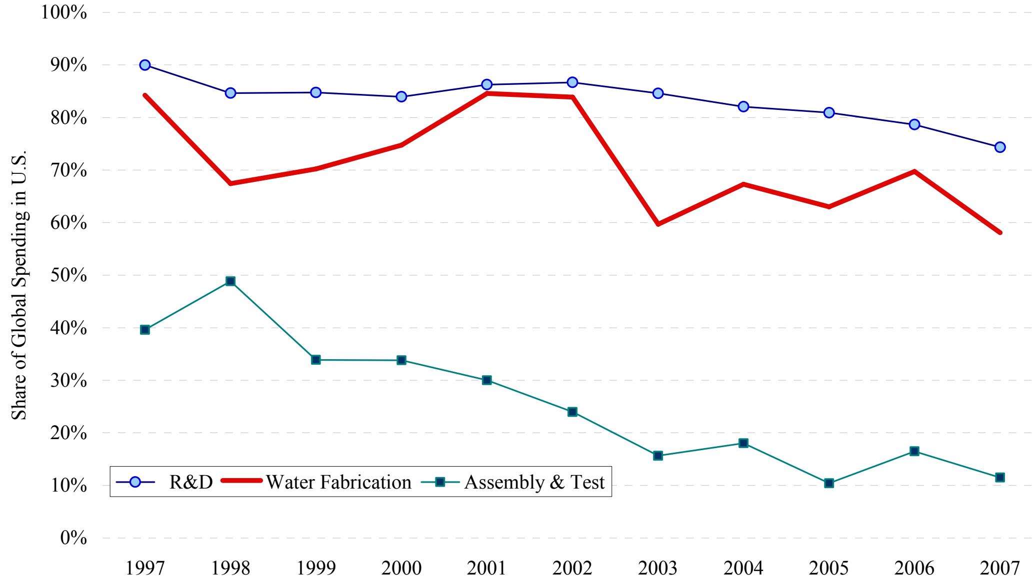
that over the past decade the share of spending in the United States by U.S. semiconductor companies has declined in all three spending categories – R&D, wafer fabrication, and assembly & test activities. See chart 10.

The relative share of spending in the United States has declined least with respect to R&D and most with respect to assembly & test. Specifically the share of total R&D spending in the United States has declined by 8.4 percentage points over the past decade, from 86.2 percent in the three years 1997 to 1999 to 77.8 percent in 2005 to 2007. The decline in the share of spending on wafer fabrication was 14.6 percentage points, from 78.5 percent to 63.9 percent. The decline in the share of spending on assembly & test was 27.1 percentage points, from 40.2 percent to 13.1 percent. See chart 11.

While the relative share of total spending in the United States declined in all three categories, there was an absolute increase in the dollars spent on R&D and wafer fabrication over the decade taking the average for the years 1997 to 1999 compared to the average for 2005 to 2007. Spending on R&D in the United States increased by 54.2 percent in real terms during this period. Wafer fabrication spending, which includes upgrades of existing fabs, increased by 10.6 percent. Total spending on assembly & test activities declined by 21.4 percent over the same period. See chart 12.

Chart 10: The Share of R&D and Capital Spending by U.S. Semiconductor Companies in the United States is Declining

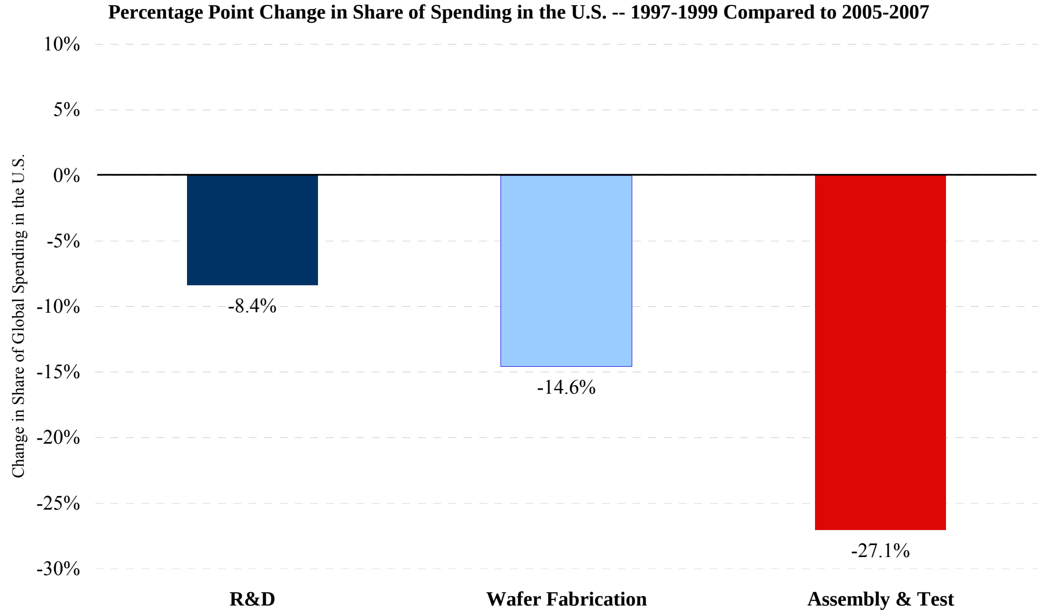
Share of Total Global Spending in the United States



Source: Survey of U.S. Semiconductor Companies.

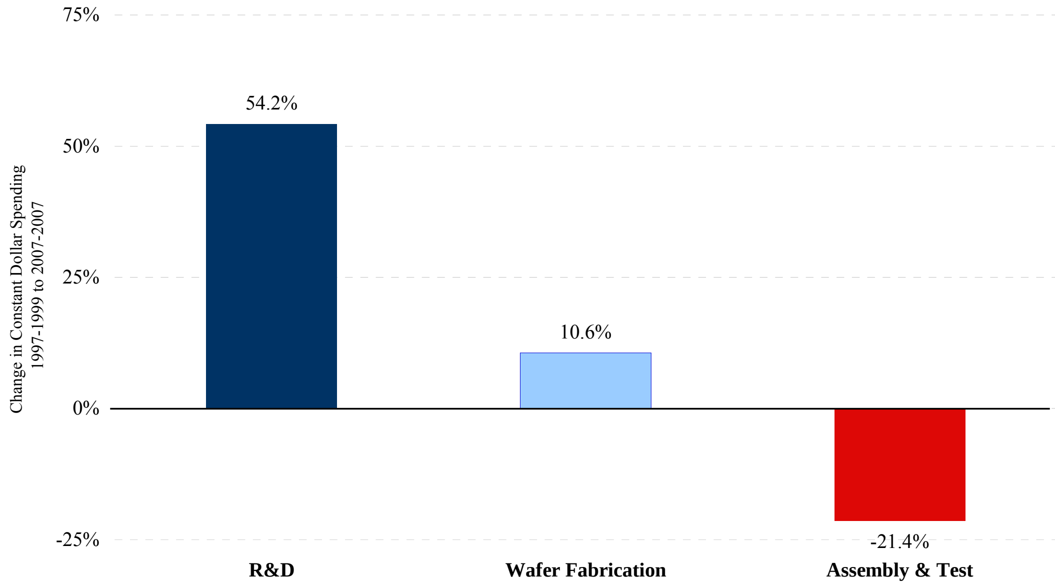
Chart 11: The Share of R&D Spending in the United States Has Declined Less Than Wafer Fabrication and Assembly & Test

Percentage Point Change in Share of Spending in the U.S. -- 1997-1999 Compared to 2005-2007



Source: Survey of U.S. Semiconductor Companies.

Chart 12: The Absolute Amount of Spending on Semiconductor R&D and Wafer Fabrication in the United States Has Increased



Source: Survey of U.S. Semiconductor Companies.
Note: Constant dollar based on GDP deflator.

The principle findings of the survey with respect to R&D spending are noteworthy:

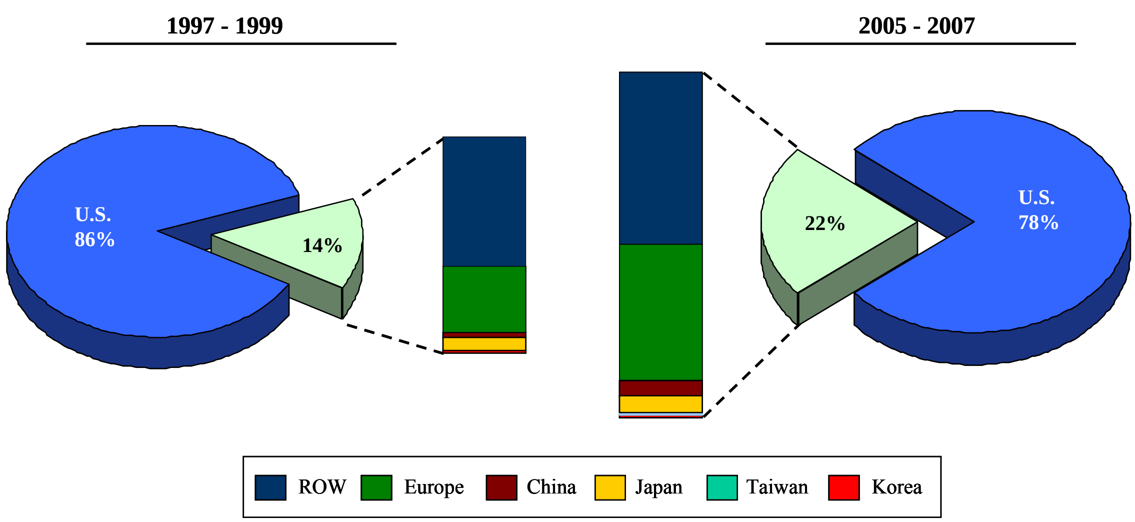
- Three-quarters of U.S. industry global R&D spending today is still in the United States;
- The offshore R&D spending shift in the last decade has not been to Korea, Taiwan and China but to Europe and ROW (India, Israel, Singapore, Malaysia, etc.);
- U.S. industry spending on R&D in China is very small but growing; and
- Government incentives were correlated with the location of R&D spending.

Over the last decade the share of global R&D spending outside of the United States by U.S. semiconductor companies has increased from 14 percent to 22 percent. See chart 13. But the allocation of most of the offshore spending has remained concentrated in Europe and ROW. The two regions accounted for 90.6 percent of offshore spending in 1997-1999 and 90 percent in 2005-2007. Europe gained the largest increase in offshore spending share with a 4.5 percentage gain followed by the ROW at 2.8 percentage points and China at 0.6 percentage points. See chart 14.

Chart 15 presents R&D incentives received by U.S. semiconductor companies from 2005 to 2007 as a percent of R&D spending by region. Incentives represented 4.4 percent of spending in the United States compared to 6.6 percent in Europe and 7.6 percent in ROW. And even though R&D spending has been relatively small in China – and thus incentives

Chart 13: Change in the Geographic Distribution of R&D Spending by U.S. Semiconductor Companies

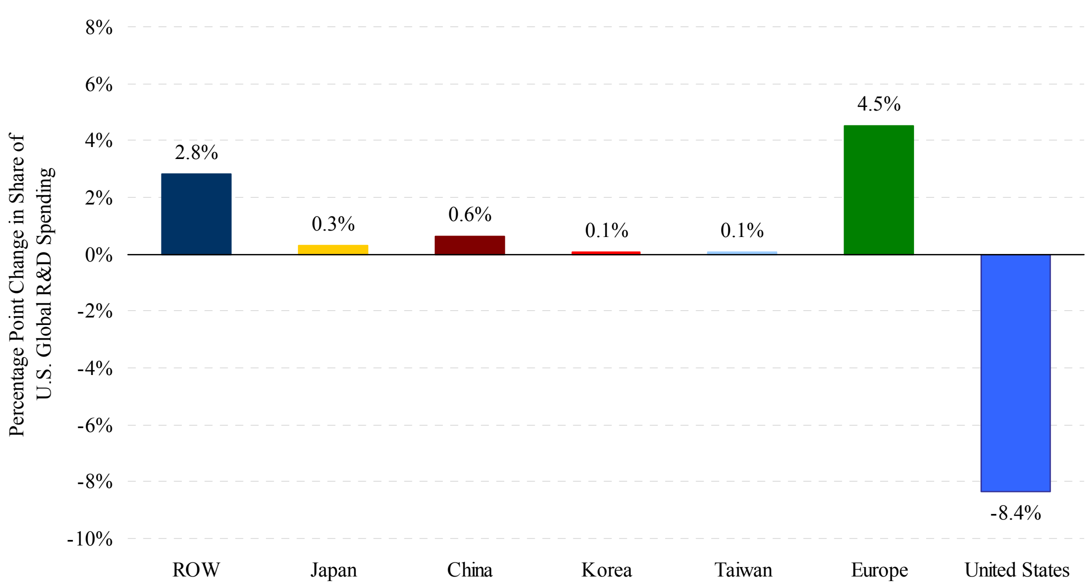
Share of Total Spending by Region



Source: Survey of U.S. Semiconductor Companies.

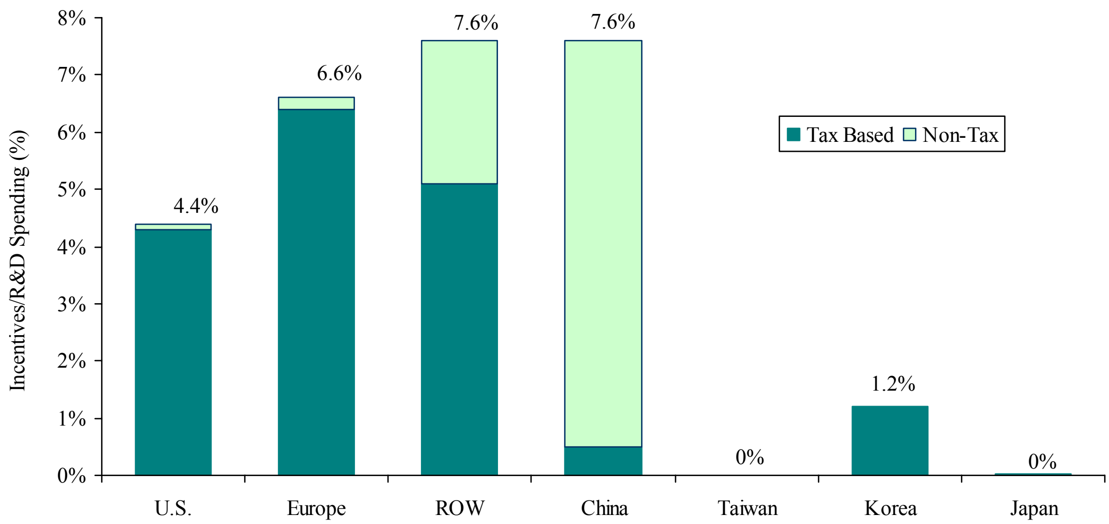
Chart 14: Change in Share of R&D Spending by Region by U.S. Semiconductor Companies

1997-1999 Compared to 2005-2007



Source: Survey of U.S. Semiconductor Companies.

Chart 15: R&D Incentives As a Percent of
R&D Spending Received by U.S. Companies (by Region)
2005 to 2007 Average



Source: Survey of U.S. Semiconductor Companies.

received are small in dollar terms – as a percent of spending they are 7.6 percent. As discussed below, the perceived inadequacy of intellectual property protection in China has limited U.S. industry R&D spending in that country significantly.

The other notable fact is that a significant proportion of the R&D incentives received in the ROW region were not tax-based but were direct financial incentives. Almost all of the incentives received in China were direct financial incentives rather than tax-based. Tax-based incentives, such as investment tax credits or tax holidays, reduce the tax liability of corporations while non-tax based incentives refer to measures such as the provision of preferential loans or direct operating subsidies that provide a direct cash benefit.

The survey also asked the SIA companies about the expected regional allocation of R&D spending over the next five years, from 2009 to 2013. U.S. semiconductor companies expect a continued shift in the proportion of R&D spending out of the United States resulting in a further loss of 9.3 percentage points. The vast majority of the shift is expected to be toward Europe, with smaller gains in China, Japan and Korea. See chart 16. If these expectations prove accurate, the overwhelming majority of R&D spending by U.S. companies will remain in the United States and Europe.[47]

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[47] R&D spending in the two regions was 86.5 percent of total worldwide spending for 2005-2007 declining to an estimated 84.7 percent for 2009-2013 period.

Chart 16: Expected Regional Allocation of R&D Spending by U.S. Semiconductor Companies Over Next Five Years
Share of Total R&D Spending by Region

	Actual 2005-2007	Expected 2009-2013	Change percentage points
United States	77.8%	68.5%	-9.3
Europe	8.7%	16.2%	+7.5
ROW	11.1%	10.9%	-0.2
China	1.0%	2.2%	+1.2
Japan	1.1%	1.6%	+0.5
Taiwan	0.2%	0.2%	0.0
Korea	0.1%	0.4%	+0.3

Source: Survey of U.S. Semiconductor Companies.

C. Survey of Key Factors Affecting Location Decisions by U.S. Semiconductor Producers

The trend in U.S. semiconductor R&D and manufacturing offshore represents continued erosion in the semiconductor "innovation ecosystem" for the United States economy. To better understand the reason for these trends, interviews were conducted with U.S. semiconductor company officials responsible for location decisions, especially with regard to R&D activities. The interviewees were asked to rank the importance of various factors in company decision-making about research spending, and to comment on the major trends affecting the location of semiconductor industry research activities. The essential importance of some factors, such as the availability of engineering talent, is an obvious prerequisite for conducting R&D. The importance of other factors, such as immigration policy, might not be as obvious. The ranking of factors related to R&D spending decisions gathered during the interviews is set forth in chart 17.

Process versus design R&D. A consistent theme of respondents was that a distinction must be made between research and development activities related to semiconductor manufacturing processes ("process R&D") and research and development activities related to the design of semiconductor devices ("design R&D"). Because of the relationship between process R&D and manufacturing, these research activities are generally located near commercial wafer fabrication facilities where the processes are put into operation, or near one of the semiconductor research consortia that are focused on process R&D (and generally are co-located with a fabrication facility).

Two prominent consortia operating pilot fabrication facilities for research purposes are the IBM-led consortium (which includes AMD, Freescale, Chartered Semiconductor of Singapore, Samsung of Korea, Infineon of Germany, and ST Microelectronics of Europe) based in East Fishkill, New York, and IMEC in Leuven, Belgium. IMEC is a research

Process R&D and Design R&D

Process R&D refers to the research and development activity required to develop the technology to manufacture an integrated circuit. The process technology is a group of sequential operations that provides the "recipe" for making an integrated circuit. These sequential operations include e-beam lithography, thermal deposition and reactive ion etch. The process technology or manufacturing recipe for an integrated circuit can encompass over 300 individual manufacturing operations, using multiple pieces of equipment, and is one of the most complex manufacturing activities in modern society.

Design R&D is an electrical engineering activity that occurs prior to manufacturing that designs, tests, and verifies the instructions that an integrated circuit is to perform. Modern integrated circuits are extremely complex and can contain billions of transistors so they are designed with extensive use of automated design tools. Design R&D can either be digital design for devices such as microprocessors and memory chips or analog design for linear regulators and oscillators.

consortium that contracts with private firms and governments to conduct semiconductor-related R&D was founded by the regional government of Flanders in Belgium. The government entered into a contract with IMEC in 2002 to provide the consortium with annual grants of 33.3 million euros for the next five years. The government also made a one-off grant to IMEC of 37.2 million euros to finance the construction of a new clean room. The Flemish government based its decision on a "very positive evaluation of IMEC's operations following an audit by external consultants." The government stated that "IMEC has to remain a center of excellence in the international microelectronics scene and it has to cooperate with universities and with Flemish industries and small and medium-sized businesses."[48]

Location of process R&D affected by incentives for wafer fabrication. Because of the strong linkage between the location of process R&D and wafer fabrication location, government investment incentives for building new fabrication facilities (particularly newer generation 300-mm wafer fabs) often determine the location of process R&D activities.[49] In this sense, process related R&D does "follow the fabs," and any factor affecting the location of state-of-the-art fabs necessarily determines where process R&D will be conducted. As of 2007 Singapore, with a population of only 4 million, had an

48 "Flemish Government to Subsidize IMEC Microelectronics Research Center," *Groot Bijgaarden De Standaard* (July 1, 2002). The IBM-led consortium benefited from New York State incentives.

49 R. Colin Johnson, "Is the U.S. Falling Behind in Chip R&D?" *Electronic Engineering Times* (November 10, 2008) at 25-26. See Section IV below.

Chart 17: Factors Related to R&D Spending Decisions

(1 = not important; 2 = important ; 3 = essential)

Factor	Rank
Availability of engineering talent	3
Proximity to wafer fabrication -- process R&D	3
Intellectual property protection (China)	2.9
Access to local university/research institutes	2.5
U.S. Immigration Policy	2.5
Government support for education	2.5
Cost of establishing/operating R&D facility	2.4
Existing R&D facility in country	2.3
Financial and tax-related R&D incentives	2
Proximity to downstream industries	2
Proximity to wafer fabrication -- design R&D	1

Source: Survey of U.S. Semiconductor Companies.

"incredible" total of 5 state-of-the-art 12-inch (300-mm) wafer fabs. The CEO of Qimonda, the German semiconductor maker, which operates one of the fabs, described the rationale for locating it in Singapore: "In Singapore, we have found excellent conditions. The overall package of low taxation, incentives and factors such as highly skilled labor and strong infrastructure makes Singapore our place of choice to implement our fully-owned volume production in the Asian market."[50]

In 2006 Craig Barrett, then CEO of Intel, the world's largest semiconductor maker, testified on the cost pressures his company faces in deciding where to locate a fab and the role played by incentives in affecting the location decision:

> *The cost to build and equip a new wafer fabrication facility today is $3 billion or more. Where, and when, to build a fabrication plant is the largest ongoing financial decision a semiconductor CEO must make … [I]t costs $1 billion more to build, equip, and operate a factory in the U.S. than it does outside the U.S. …[M]ost of the $1 billion cost difference (about 70%) is the result of lower taxes; also, if the taxes were combined with capital grants, then as much as 90 % of the cost difference occurs [as a result as government policies](emphasis added).*[51]

50 "Resurrection of 12" Fabs in Singapore," *Sikod* (April 27, 2007).

51 Statement of Craig R. Barrett before Subcommittee on Select Revenue Measures, House Ways and Means Committee (June 22, 2006).

Chart 18 depicts specific incentives that have played a role in decisions by U.S semiconductor producers to locate state-of-the-art wafer fabrication facilities at sites outside the United States.

Design R&D driven by access to manpower and knowledge base. The location of semiconductor design R&D, by contrast, is generally considered to be independent of wafer fabrication location. Industry interviews indicate that design R&D location is most closely tied to the available talent and knowledge base in a given region. Proximity to manufacturing operations is regarded as marginally relevant or not relevant to the location of semiconductor design activity. The principal factor of concern to most U.S. semiconductor enterprises is ensuring the availability of qualified engineers, without which the research activities simply cannot be performed. Thus, while government incentives are not as influential in determining location in a direct sense, government support for education in science, technology, engineering and math (STEM), and encouraging the number of advanced degree graduates in these fields, can play a critical indirect role by ensuring the availability of a local pool of trained talent. In the United States, the availability of engineering talent is also affected by immigration policy, given the significant percentage of U.S. master's degrees and PhDs in semiconductor-related engineering fields that are awarded to foreign students who may only work in the United States upon graduation with the appropriate visa or green card status.

A closely-related factor driving locational decisions for design R&D is the proximity of a leading research university. Research universities provide important sources of new engineering talent, as well as opportunities for companies and university professors to collaborate on research projects. Practical operational considerations affect the geographic allocation of company spending on semiconductor R&D. It is usually more efficient and less costly to add new researchers at existing design centers than to open up entirely new design centers, and in any given year most of the growth in R&D spending levels reflects this type of incremental growth at existing facilities. In the not-distant past most U.S. semiconductor R&D was conducted at centers located in the United States, but as the number of foreign centers has increased, it is only natural that these established facilities are sharing in the incremental growth of R&D spending by U.S. companies. Factors that lead to the establishment of those foreign centers in the first place, therefore, help to explain the rising proportion of U.S. company design R&D spending that is directed outside of the United States. These include the availability of specific skill set sets in certain geographies, the rising overall quality of foreign design talent, U.S. immigration policy, and cost factors.

Many companies cited the high quality and particular talents of specific pools of foreign engineers as a factor in their decision to establish or expand research operations abroad. In some cases, firms have discovered pools of available high quality talent in other countries, such as Russia, where the downsizing of the post-Soviet military has freed up

Chart 18: Major US Fabs Built Overseas and Foreign Governments' Incentives

Location/ Date	Fab	Incentive Packages from the Host Countries
Dresden, Germany. Announced in 4thQ 2003. Tool installed in 4thQ 2004	"Fab 36" for 45-65nm processing on 300mm wafers.	The Federal Republic of Germany and the Free State of Saxony provided the following support to cover costs incurred for Fab 36, including the total $2.4 billion construction cost. - Up to approximately $798 million of subsidies consisting of grants and allowances, depending on the level of capital investments by Fab 36. Of the subsidies, $541 million of cash provided by December 29, 2007. - Up to approximately $386 million of subsidies consisting of grants and allowances, depending on the level of capital investments in connection with expansion of production capacity at the company's Dresden site. Of the subsidies, $17 million of cash provided by December 29, 2007. - A loan guarantee of 80 percent of the losses sustained by the lenders.[52] The amount of grants offered by the German government was "one of the factors that made the chipmaker decide on the location of the facility."[53]
Dresden, Germany.	"Fab 38" for 45-65nm processing for 300mm wafers.	The Federal Republic of Germany and the Free State of Saxony provided grants and subsidies for the conversation from a 200mm fab to 300mm fab. Approximately $38 million of Dresden deferred grants and subsidies as of December 29 2007 are associated with converted fab.[54] The maximum amount of grants and subsidies were not disclosed.
Kiryat Gat, Israel. Announced in 4thQ 2005. Tools installed in 3rdQ 2007.	"Fab 28" for 45nm processing on 300mm wafers.	The Israeli government offered the following incentives totaling more than $1 billion: - The government's grant of $525 million for the new plant ("Fab 28") whose building costs totaled $4.4 billion. - Another $660 million in the form of tax benefits for upgrading "Fab 18," which was built in Kiryat Gat in 1996, to enable 90nm process production.[55] A company spokesman said that if Israel had not increased the government grant from the original deal, the company "would not have built the fab in Israel." A senior company official attributed the choice of Israel to a combination of three factors – People, Infrastructure, and government incentives.[56]

52 AMD, *2007 Annual Report and 10-K*.

53 "AMD Grants Win EU Approval," *CNET Network* (February 6, 2004).

54 AMD, *2007 Annual Report and 10-K*.

55 "Intel Announces Fab 28 in Israel," *ARS* (December 2, 2005).

56 "Intel VP: Extra Aid Brought Fab 28 to Israel," *Israel Business Arena* (December 1, 2005).

engineering talent, with certain specific skill sets, and Israel, where engineers have proven adept at rapid, low-cost designs.[57] ESilicon, a rapidly-growing fabless producer of ASICs, has established its principal design center in Bucharest, Romania, and in 2008 it announced plans to expand this facility despite the current economic downturn. An ESilicon executive commented that "Romania will evolve in chip design, particularly in analog and mixed signal areas. There seems to be a greater skill set of these disciplines in Romania than in other locations."(Emphasis added)[58]

In addition to specific skill sets available in some countries and regions, the overall quality and quantity of foreign engineering talent in microelectronics-related fields has increased dramatically. Emblematic of this trend, in September 2008 it was disclosed that, for the first time in history, an entire microprocessor had been designed in India. The feat was achieved at Intel's Design Enterprise Group in Bangalore, where a 7400-series Xeon processor was designed in a project code named "Dunnington." An entirely Indian team "designed the chip from scratch," which represented the world's first six-core x86 processor (all prior versions have featured 2 or 4 cores). Praveen Vishakantaiah, President of Intel India, said that "Within six years of the inception of the India Design Centre, it has rolled out a chip from design to tape out. This is the fastest ramp up in the history of Intel." (Emphasis added)[59] The India Semiconductor Association recently estimated that the total workforce in India engaged in semiconductor design in 2007 was

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57 Rockwell established a semiconductor design center in Heszliya, Israel in 1996 because of the "unique capabilities" of Israeli engineers. A Rockwell executive said that "A lot of companies want to capitalize on the ability of Israeli engineers to improvise, handle research and design in a short time and yet be efficient and cost effective." "Rockwell Wants Israel's Unique Engineers," *Jerusalem Post* (June 27, 1996).

58 "ESilicon to Expand Romania Chip Design Operation," *EE Times Eastern Europe* (November 13, 2008); "ESilicon Accelerates Expansion in Europe," *Hugin* (October 28, 2008). "ESilicon Expands in Europe, Says India Overrated," *EE Times* (March 10, 2005). Freescale Semiconductor characterizes its Bucharest software design operations in Bucharest as "one of the company's most strategically important operations in the Europe, Middle East and Africa (EMEA) region." "Freescale Expands Presence in Romania; invests in State-of-the-Art Software Development Center," *Business Wire* (June 29, 2006). ESilicon entered Romania in 2005 when it acquired a small design team called Sycon. ESilicon's CEO spoke about the locational advantages offered by central Europe in 2005: "Being in the same time zone is critical to our success. Overnighting work to India doesn't work. Romania has a very low cost structure, IP protection is very good, and you can drink the water. Basically India is overrated as a location for engineering and Central Europe has been neglected. Romania is half the cost of India and there's almost nobody there poaching your stuff, unlike India … They are well educated and the work ethic is fantastic."

59 "India Inside Intel Chips," *Financial Express* (September 25, 2008); "Intel India Tea, Lofts a Sixer," *The Hindu* (September 21, 2008). In 2007 a design team at Intel's R&D center in Haifa, Israel completed work on a 45 nanometer processing chipset, codenamed Penryn, with technological features that Intel co-founder Gordon Moore called "the biggest transistor advancements in 40 years." Among other things the chipsets were built using an entirely new transistor formula that alleviates electricity leaks and eliminates eco-unfriendly materials like lead and halogen. Intel CEO Paul Otellini commented that "the intellects, physics and designs that went into solving one of the industry's most daunting challenges are awe-inspiring and I congratulate the Intel teams for this breakthrough achievement." "Intel Takes the Silicon Out of Chips." *Jerusalem Post* (November 13, 2007).

130,000.[60] It should be noted that India has been a location for U.S. company semiconductor design R&D for a number of decades. TI was the first U.S. semiconductor company to establish an R&D facility in India (Bangalore) in August, 1985.[61] TI India engineers have filed over 415 patents from India, the most from any technology company in India.

Immigration policy. U.S. immigration policy has also played an important role in R&D locational decisions by U.S. semiconductor firms. Increasingly, graduates from U.S. universities with master's and PhD degrees in science and engineering relevant to the semiconductor industry are foreign born. Foreign nationals comprise half of the master's degree candidates and 71 percent of the PhD candidates graduating from U.S. universities in the engineering fields needed to design and manufacture integrated circuits and other semiconductor devices.[62] Indeed, most engineering PhD graduates from U.S. universities received their bachelor's degrees in other countries. See chart 19. The leading university, Tsinghua University in Beijing, had 421 students who went on to earn PhD's from U.S. universities in 2006, which was greater than the 241 students from all California universities combined. At the same time, the number of these U.S.-educated graduates who are able to obtain green cards (permanent residency) is limited by U.S. immigration policy, and the number of foreign nationals with the requisite scientific and engineering skills who can stay in the United States pursuant to temporary H-1B visas is similarly limited.[63]

Taken together, these restrictions serve to inhibit U.S. semiconductor firms from growing research programs in the United States that depend on being able to hire the best and the brightest talent. U.S. semiconductor companies seek permanent resident status for 97 percent of their H-1B hires. The industry is currently seeking permanent residency for about 3,800 employees, of which almost 1400 were hired three or more years ago. While these numbers are relatively small in absolute terms, they belie the important role that foreign workers play in the success of U.S. semiconductor companies.[64]

These foreign born but U.S. educated professionals play an important role in performing the research to continue to increase the density of circuits on each chip, finding ways to lower manufacturing costs, developing and launching new products, and providing applications expertise to help customers to design-in new semiconductors in their

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60 "India Sees 21.7% Annual Growth in Semiconductor Design, Embedded Software," *Nikkei Microdevices* (May 8, 2008).

61 TI, Company in Information, *Texas Instruments India* as at www.ti.com/in/company_info.html.

62 National Science Foundation, Division of Science Resources Statistics at http://www.nsf.gov/statistics/ .

63 The H-1B visa is a non-immigrant visa available only to workers in "specialty occupations" requiring the theoretical and practical application of a body of highly specialized knowledge.

64 These highly-skilled foreign nationals are often essential to ongoing research to increase the density of circuits on each chip, finding ways to lower manufacturing costs, developing and launching new products, and providing applications expertise to assist companies to design-in new semiconductors in new electronic systems. As a result, these foreign-born, but U.S.-educated engineers often create jobs in other parts of the companies in which they work.

electronic systems. These foreign workers are therefore vital to the success of

Chart 19: Most Engineering PhD Graduates from U.S. Universities Received Their Bachelors Degrees in Other Countries

Numbers in parentheses refer to total research doctorates in engineering from U.S. universities who received a bachelor's degree from the listed university in 2006.

1.	**Tsinghua University (421)**	**11.**	**Yonsei University (63)**
2.	**Seoul National University (107)**	**12.**	**Middle East Technical University (61)**
3.	**Shanghai Jiaotong University (98)**	**13.**	**U of Mumbai (58)**
4.	**Indian Inst. Of Tech (IIT) – Madras (79)**	**14.**	**Huazhong U of Science& Technology (58)**
5.	**Beijing University (75)**	**15.**	**UC Berkeley (56)**
6.	**Zhejiang University (75)**	**16.**	**U of Illinois – Urbana Champaign (56)**
7.	**Xian Jiaotong University (69)**	**17.**	**Indian Inst. Of Tech (IIT) – Kharagpur (55)**
8.	**Tianjin University (66)**	**18.**	**Indian Inst. Of Tech (IIT) – Bombay (52)**
9.	**National Taiwan University (63)**	**19.**	**(Arya Mehr) Sharif U of Technology (52)**
10.	**Massachusetts Inst. Of Technology (63)**	**20.**	**U of Science & Technology China (50)**

Source: NSF data on PhD original bachelors degrees, 2008.

semiconductor companies. Furthermore, by lending their particular talents, these foreign employees are creating jobs in other parts of U.S. companies, such as in administration and production.

The ability of U.S. companies to hire foreign-born high-skilled workers has long been restricted by U.S. immigration policy.[65] Efforts to reform this policy met some temporary success,[66] but in the long run have proved fleeting. This long-term problem, coupled with the concern that U.S. immigration restrictions were being tightened even further in the wake of the September 11, 2001 attacks, served as a "wake-up call" to U.S. semiconductor producers who had been relying on being able to hire the best and brightest from around the world to work in the United States. In order to hedge future risk, these firms began opening up R&D centers outside the United States where foreign nationals could be employed in a manner that would not be subject to the vagaries of U.S. immigration policy. These centers, formed in the early and mid-2000s, now form the basis for further incremental growth in U.S. R&D spending based on the ordinary economic efficiencies associated with expansion at existing locations versus establishment of entirely new centers.

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[65] The number of H-1B visas issued each year is subject to a Congressionally-established quota, normally 65,000 visas per year with 20,000 additional visas for foreign workers with U.S. advanced degrees. In 1998 the quota was increased to 115,000 and in 2000, to 195,000. In 2004, however, it dropped to 90,000 (with certain exemptions above the cap) and H-1B visas became increasingly difficult to obtain. The entire quota for 2007 was exhausted in less than two months at the end of 2006.

[66] See id.

The percent of H-1B graduates hired by U.S. semiconductor companies compared to total graduating hires has dropped from 57 percent in 2005 to 40 percent in 2007. This decrease may be in part attributable to companies hiring foreign students and assigning them to offshore facilities where U.S. immigration restrictions are not a limiting factor. Significantly, foreign jurisdictions competing with the United States to lure high technology investment cite their own immigration policies, which are less restrictive than that of the United States, as a selling point.

The European Union is in the process of approving its own "blue card" system to attract highly-skilled immigrants to take jobs in EU economic sectors suffering from skill shortages. The intent of the plan is to provide a fast track for these highly-educated workers to obtain residency in the EU. In announcing this plan, the President of the European Commission declared: "With the EU Blue Card we send a clear signal: Highly skilled people from all over the world are welcome in the European Union."

The Canadian province of Ontario is actively promoting the "Ontario Technology Corridor" as an alternative to investment in U.S. high tech areas. An Ontario Technology Corridor delegation briefed British economic and technical advisory groups in November 2008 as to why technology companies should locate in Ontario. One of the delegation's talking points was that "Canadian immigration policy is more worker-friendly than in the U.S. It's far easier to staff technology companies with imported talent, and spouses of imported workers can receive work visas." [67]

Cost factors. Cost factors were also cited by several companies as an important consideration for design R&D location decisions. Engineer salaries, rate of salary inflation and rate of attrition of more seasoned engineers were cited as important cost factors by several companies, with the availability of government incentives playing a somewhat less central role. Access to high quality, but relatively low-cost engineering talent in such diverse locations as Brazil, Eastern Europe, India and several Southeast Asian countries made these locations attractive for design R&D activities. Several companies indicated that while government incentives were a significant decisional factor, they would be considered only after a site first proved to be attractive on the basis of available talent and university support. Advanced Micro Circuit Corp. (AMCC)'s VP-Engineering said in a recent published interview with respect to his company's decision to locate a new design center in Vietnam that "we got a very attractive incentive package from the government, and this helped also in deciding to locate in Vietnam."[68]

Intellectual property protection. The importance of adequate intellectual property protection as a locational decision factor was highlighted by every company surveyed. Most companies surveyed indicated that they would not locate their most advanced and critical R&D activities in China, despite encouragement and even pressure by the government to do so, and regardless of the availability quality and size of incentives, due to concerns about the inadequacy of intellectual property protection in that country.

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67 "Ontario Technology Corridor Myth Busters Brief UK Economic Advisors on Why Ontario is North America's Innovation Gateway," *M2 Presswire* (November 19, 2008).

68 "AMCC Sees Potential In Vietnam," *EE Times Asia* (October 16, 2008).

While intellectual property protection issues occasionally arise in other jurisdictions, industry respondents indicated that in general sufficient safeguards could be devised to permit certain R&D activities to take place. No jurisdiction other than China was identified as particularly problematic from this perspective. At the same time, companies indicated they did or planned to conduct some design R&D in China, and the data indicate that the proportion of total R&D spending in China has increased (chart 14) and is expected to grow further in the next five years (chart 16):

- In 2008 Intel announced that it would set up a semiconductor design center in China to conduct R&D on products directed at the Chinese market.[69]
- In December 2008 Atmel opened a new semiconductor design center in Shanghai, "setting the foundations for future branch offices and design centers throughout China."[70]
- Freescale opened a design center in Chengdu in 2007 to serve as its "primary operations for the development of TD–SCDMA technologies."[71]
- Semtech, a U.S. producer of analog and mixed-signal semiconductors announced in 2008 that it would open a new design and application center in Shenzhen.[72]
- Intersil Corporation announced in 2008 that it would open a new design and application center in Hangzhou to develop designs for advanced analog semiconductors.[73]

The next section discusses what the governments of other countries are doing to attract U.S. semiconductor R&D and capital spending.

69 "Intel to Set Up Chip Design Center in China." *SinoCast* (June 26, 2008).

70 "Atmel Corp. Announces Opening of New Centre in Shanghai," *Asia Pulse* (December 4, 2008).

71 "Freescale Technology Helps Switch on TD-SCDMA Networks in China," *Business Wire* (November 5, 2008).

72 "Sematech Unveils New Design Center in Shenzhen, China," *Wireless News* (July 29, 2008).

73 "Intesil Expands Footprint in China with New Design Center in Hangzhou," *Marketwire* (February 28, 2008).

IV. Government Incentives for Semiconductor R&D and Manufacturing

It is now generally recognized that the presence of semiconductor production can have extraordinarily beneficial effects in the countries and regions in which they are located in terms of foreign direct investment ("FDI"), gross domestic product ("GDP"), and other measures. A 2006 World Bank study of the effects of the establishment of four semiconductor assembly and test facilities in Costa Rica drew the following conclusions:

> *In recent years, Costa Rica has significantly outperformed all other countries in Latin America in FDI … The period following [the semiconductor] investment shows significant GDP growth, staggering increases in exports, and otherwise generally positive outcomes … [and] is responsible for a shift in the country's top exports, from coffee and bananas to electrical and electronic products. Electronics is now Costa Rica's largest sector … The industry employs 12,000 and exports US$1.65 billion in products a year.*[74]

An Indian proponent of attracting semiconductor investment recently pointed out the positive transformative effect on regions in which semiconductor R&D and manufacturing are present:

> *A turnaround has been witnessed in most economies where chip manufacturing has come up. Setting up chip manufacturing units around Zhujing River delta circling Guangzhou and Shenzhen revolutionized China's economy … [semiconductor investment] in Dresden, Germany in 1998 has also turned around the area, which is now known as the chip hub of Europe.*[75]

As awareness has spread of the benefits arising out of local semiconductor manufacturing and R&D, many national and sub-national governments have developed incentives to attract semiconductor investment. See chart 20. As a recent study by the German research institute IFO Dresden concluded, "competition in location subsidiaries [to the semiconductor industry] serves the purpose of selecting the most efficient site. Ultimately, location subsidies are no more than bids at an auction."[76] In the competition to attract semiconductor investment, by far the most significant incentives for semiconductor manufacturing involve tax concessions, but direct grants are also playing a role in influencing locational decisions. With respect to research, the most important government programs involve support for education and training, including the strengthening of local universities.

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[74] World Bank Group, *The Impact of Intel in Costa Rica: Nine Years After the Decision to Invest* (May 2006) at 25.

[75] Harsimran Singh, "Carrots to Chip Makers 40% Lower Than Global Norm," *The Economic Times* (February 24, 2007).

[76] IFO Dresden, *Rechtfertigung von Ansiedlungssubuentionen,* op.cit. (Abstract, 2008)

Chart 20: Comparison of Business Environment and Major Incentives Enjoyed by Semiconductor Companies Internationally

	Ease of Doing Business	Corporate Income Tax Rate	Significantly Reduced Corporate Tax Rate or Holiday	R&D Tax Credit or Other R&D Measure	Grants	Project Equity	Central Gov. Loans	Manpower
United States	3	39	○	◒	○			●
India	122	34	●	●			●	●
Germany	25	30			●	●	●	
Israel	30	27	●	●	●			
Malaysia	20	26	●	●				●
China	83	25	●	●	●	○	●	
Taiwan	61	25	●	●		●		●
Singapore	1	18	●	●		●		●
Ireland	7	12.5		●	●			●

Ease of Doing Business ranking from World Bank. Tax rates are statutory rates as of 2008. (Many rates are changing and grandfathering arrangements exist). Rates are before repatriation to a foreign shareholder. The U.S. rate is before any withholding tax is applied to outbound payments of dividend. Blank space refers lack of any specific information found during research on specified incentives.

● signifies full measure

◒ signifies measure is temporary, or some other mitigating characteristic

○ signifies not "significant" (e.g., U.S. 9% manufacturing credit) or at the sub-central government level only

Recent wafer fabrication investments in the United States have all involved significant state and local tax abatements. The most recent incentive package was approved by the New York State Public Authorities Control Board on December 17, 2008. See chart 21. The $1.2 billion in state economic development incentives are to be provided to The Foundry Company, a partnership between AMD and the Advanced Technology Investment Company (ATIC) of Abu Dhabi, for a $4.6 billion wafer fabrication facility in Saratoga County, New York. "The incentives include a $650 million cash payment by the state, Empire Zone tax credits, and infrastructure investment."[77]

A. Tax Policy

In 2006 Brazil's Minister of Development, Industry and Foreign Trade commented in an interview about the Brazilian government's ongoing efforts to attract foreign semiconductor investment. He said that

> *Our team has been working in the area of semiconductors and the attraction of investments since the industrial policy was introduced. We visited Israel, Japan, South Korea, Europe, the United States and Costa Rica to study ways of attracting semiconductor companies to Brazil. The conclusion we reached was that no country has attracted investments without offering tax incentives … What we did was present a specific [tax*

[77] Stephen Williams, "Transfer of AMD Incentives OK'd" *Daily Gazette* (December 2, 2008) at http://www.dailygazette.com.

> *exemption] proposal in the area that is already part of our job of promoting innovation, investment at the creation of jobs.*[78]

In fact, every country with a significant semiconductor industry offers some kind of incentives for R&D and/or other semiconductor-related investment, and those incentives play a significant role in locational investment decisions by management. Significantly, the United States, which in the early 1980s arguably offered semiconductor producers the world's most favorable tax treatment (following enactment of the R&D tax credit) now lags behind most other major semiconductor producing countries. Several factors underlie this shift:

- the United States now has one of the highest corporate tax rates,
- the United States does not offer incentives for semiconductor investment comparable to tax holidays and accelerated depreciation available in other locations, and
- the U.S. R&D tax credit has been surpassed as a benefit by research-linked tax incentives offered in other countries.

1. Corporate Income Tax Rates

Semiconductor companies operating in the United States face the threshold problem of a very high statutory corporate income tax rate—one of the most common measures of burden imposed on corporations—relative to companies operating in other jurisdictions.[79] Among 30 OECD countries, the United States today has the second highest average corporate income tax rate, 39.3 percent, after Japan and compared to an OECD average of 30.4 percent when federal and state-level taxes are taken together.[80] Some 24 states have a combined corporate tax rate higher than top-ranked Japan.[81] See chart 22. The United States ranked 46th in the World Bank's *Ease of Doing Business* with respect to

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78 Interview with Luiz Fernando Ferlan, "No Country Has Attracted Investments Without Offering Tax Incentives," *O Estado de Sao Paulo* (August 15, 2006). A 2008 Analysis noted that "Brazil has become one of the high tech industry's hottest locations, in part because of tax incentives offered to the semiconductor industry," "Cadence Opening Brazil IC Design Center," *Executive Quote and Information Service* (May 5, 2008).

79 Taxation of Corporate and Capital Income (2008), Table II.1 Corporate Income Tax Rate, OECD Tax Database. Office of Tax Policy, U.S. Department of Treasury, "Approaches to Improve the Competitiveness of the U.S. Business Tax System for the 21st Century" (December 20, 2007) at 6.

80 Peter R. Merrill, "Competitive Tax Rates for U.S. Companies: How Low to Go?" PricewaterhouseCoopers LLP (February 24, 2009). The 29 country (excluding the United States) OECD average of 30.4 percent is weighted by GDP. The un-weighted average is 26.2 percent. The World Bank *Doing Business 2009* estimated a "book" measure of effective tax rates and determined that the United States was the seventh highest out of 30 OECD countries.

81 "U.S. States Lead the World in High Corporate Taxes," Fiscal Fact No. 119, Tax Foundation, (March 18, 2008).

paying taxes, lagging behind Singapore, Ireland, the United Kingdom, Canada, Malaysia, South Korea, and others.[82]

Chart 21: Recent Investments in 300mm Fabs in the United States Have All Involved Significant State and Local Incentives

Start Date	Location	Incentive Package
2010-2012	Malta, NY	$1.2 billion in states incentives of which $650 million capital grant, Empire Zone tax credits and infrastructure investments.[83]
October 2007	Chandler, AZ	Passage by the Arizona legislature in 2005 of sales factor legislation providing an alternative formula for calculating state income tax liabilities which bases the company's liability to a greater extent on its in-state sales and to a lesser extent on in-state payroll and property. The investment was aided by the homeland investment dividends under the 2004 American Job Creation Act, allowing firms to repatriate income at a reduced tax rate if invested in U.S. manufacturing.[84]
June 2007	Austin, TX	$233.4 million in tax abatements and other incentives from state and local governments.[85]
February 2007	Lehi, UT	A $100 million local and county property tax incentive, according to a Lehi City administrator based on a 1995 commitment to Micron when it originally built the facility. (The local jurisdictions renegotiated these property tax incentives 11 years later.) In addition, Utah's Economic Development Board approved an Economic Development Tax Increment Financing (EDTIF) rebate for new incremental state revenues on a post performance basis over 5 years up to a maximum incentive of 30 percent of new state revenue from the date of announcing operations over the 5 year life of this deal. An Economic Development Zone was established for Lehi City for purposes of supporting the fab's location.

82 World Bank, "Doing Business Measuring Business Regulation: Economy Rankings," as at http://www.doingbusiness.org/EconomyRankings/.

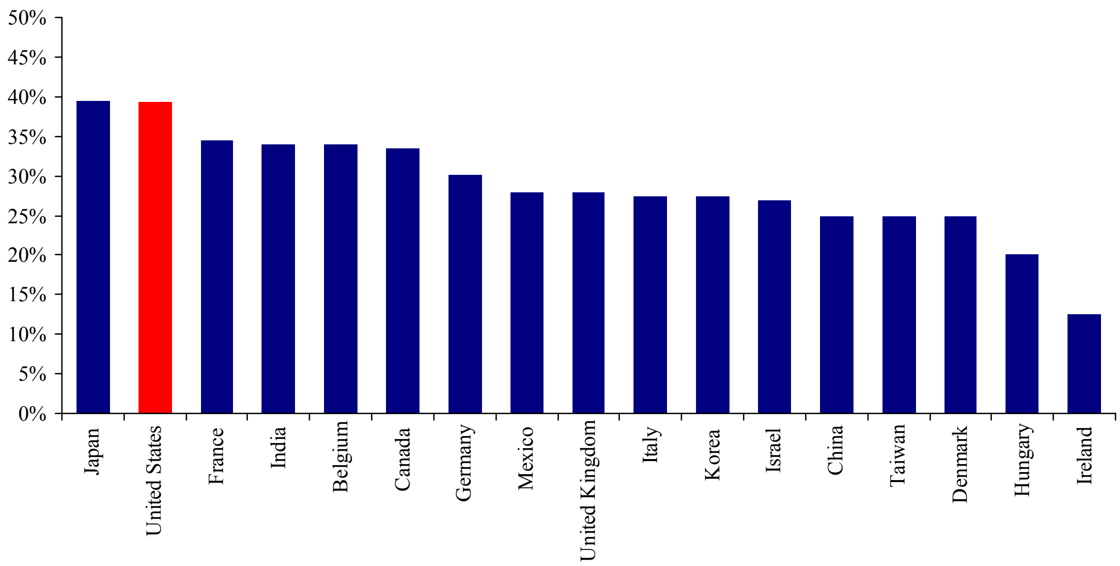
83 New York State Public Authorities Control Board, *Resolution No. 08-UD-1401* (December 17, 2008) and "Transfer of AMD Incentives OK'd" *Daily Gazette* (December 2, 2008) at http://www.dailygazette.com.

84 Statement of Craig R. Barrett, PhD, Chairman of the Board, Intel Corporation, Before the subcommittee on Select Revenue Measures House Committee on Ways and Means (June 22, 2006).

85 Kirk Ladendorf, "Samsung Picks Austin for $3.5 Billion Plant," *Austin American Statesman* (April 14, 2006).

Fiscal policy experts observe a general downward trend in corporate income tax rates over the last two decades and intensified competition across jurisdictions to attract inbound foreign direct investment as restrictions on cross-border capital flows have loosened and globalization has increased.[86] While the United States had a low statutory income tax rate relative to other developed nations in the mid-1980s and for about a decade thereafter as a result of the Tax Reform Act in 1986, statutory rates in other OECD countries have been consistently declining on average since that time and today the United States is again considered a "high corporate tax rate country."[87] Chart 23 depicts a steady U.S. corporate income tax rate as against a declining median rate among 18 OECD countries since the mid-1980s. The U.S. rate also compares unfavorably against tax rates in emerging markets: the statutory corporate income tax rate in China as of 2008, for example, was 25 percent, while in India it was 34 percent.[88]

Chart 22: US Starts with High Corporate Tax Rate Relative to Competitor Nations



Note: OECD countries account for local/state tax rates.

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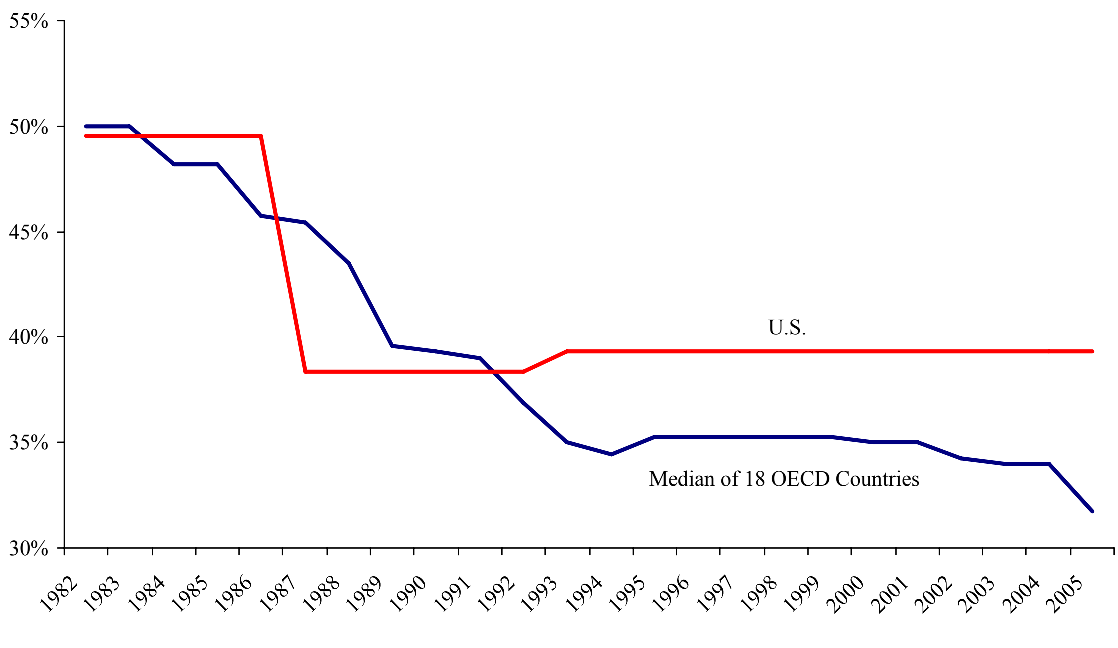
[86] "Tax Effects on Foreign Direct Investment: Recent Evidence and Policy Analysis," OECD (2007) at 14; "Tax Competition," Alexander Klemm, Institute for Fiscal Studies; Office of Tax Policy, U.S. Department of Treasury, "Approaches to Improve the Competitiveness of the U.S. Business Tax System for the 21st Century" (December 20, 2007) at 3.

[87] Office of Tax Policy, U.S. Department of Treasury, "Approaches to Improve the Competitiveness of the U.S. Business Tax System for the 21st Century" (December 20, 2007) at 6.

[88] Statutory income tax rates in China were reduced in 2008 due to the introduction of a revised income tax law. India's corporate income tax rate for domestic firms is 34 percent, while for foreign firms it can run between 42 and 45 percent. Office of Tax Policy, U.S. Department of Treasury, "Approaches to Improve the Competitiveness of the U.S. Business Tax System for the 21st Century" (December 20, 2007) at 10.

This downward trend in corporate tax rates in other nations is expected to continue.[89] The process is interactive and dynamic, with competitor nations' initiatives motivating each other's rate reductions. Large EU countries such as Germany and the U.K. are making major reductions currently. Germany is cutting its corporate rate from 38 to 30 percent in 2008 and the United Kingdom from 30 to 28 percent[90] Smaller OECD countries such as Ireland, Hungary, Poland, Korea, have all reduced their rates in recent years, while non-OECD countries are also making cuts. China's rate fell from 33 percent to 25 for most companies and Malaysia's from 27 to 26 percent in recent years.[91] Israel is reducing its rates from 34 percent in 2005, to 31 percent in 2006, 29 percent in 2007, 27 percent in 2008, 26 percent in 2009 and 25 percent in 2010. The corporate income tax rate is already very low in Ireland, at 12.5 percent, and Ireland has a very favorable R&D tax credit.

Chart 23: U.S. Becomes High Tax Rate Country Relative to OECD Countries
(1982-2005)



Source: Institute for Fiscal Studies

The trend is a concern to the U.S. Treasury Department. Treasury concluded in a 2007 study recommending an overhaul of U.S. business taxes that "the U.S. business tax

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89 Office of Tax Policy, U.S. Department of Treasury, "Approaches to Improve the Competitiveness of the U.S. Business Tax System for the 21st Century" (December 20, 2007) at 3.

90 "Issues in Business Taxation," Alexander Klemm, Institute for Fiscal Studies, p. 139 and "What Has Been the Tax Competition Experience of the Last 20 Years," Rachel Griffith and Alexander Klemm, Institute for Fiscal Studies, at 1-4.

91 "The 2008 Worldwide Corporate Tax Guide," Ernst & Young, p. 432.

system imposes a burden on U.S. companies;" "places a higher cost on investment" compared to trading partners; and "disrupts and distorts business and investment decisions." The Treasury Department cautions further that "the U.S. tax system may actually slow the pace of technological innovation" here and recommends a tax overhaul designed specifically to help U.S. companies and workers compete better globally.[92]

Further tax reductions abroad make U.S. burden heavier. U.S. competitiveness as an investment location for semiconductor firms is further undermined by substantial tax and financial incentives widely available to semiconductor companies locating abroad. Investment location decisions are not made solely based on the availability of tax and related investment incentives.[93] Proximity to the customer and market size tied to purchasing power of the domestic population, fit with the multinational's global supply chain, and certain other factors critical to semiconductor companies, such as intellectual property protection and the ability to influence global-standards-setting activities, all factor into the decision-making process. However, when other factors in the decision-making process are roughly equal and when a firm has already fully exploited its domestic market, tax and other financial incentives are critical determinants in the decision whether and where to locate overseas.[94] As ties binding U.S. semiconductor manufacturers to the United States are frayed and attenuated, these government incentives overseas gain in importance and accelerate the push to locate overseas.

2. Tax Holidays and Other Investment Tax Incentives

Investment incentives are fiscal measures employed by governments worldwide to attract foreign direct investment. The United States is no exception. Semiconductor companies locating in the United States enjoy certain state-level incentives and states compete vigorously for potential investors through incentives. But the basic difference between the U.S. state incentive programs and those available elsewhere is that the investors in the United States never qualify for a "holiday" from U.S. federal corporate income tax, which is considerably higher than state taxes, and the state-level programs are not administered as part of a larger, coordinated, national industrial policy to foster strategic industries.

The U.S. federal government has enacted certain tax measures that are advantageous to the semiconductor industry and other high technology sectors, most notably the R&D tax credit and the 3.15 percent tax deduction for domestic manufacturing activities (the American Jobs Creation Act of 2004). But the R&D tax credit is only enacted on a temporary basis, lasting one to two years before having to be renewed, and there is no

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[92] Office of Tax Policy, U.S. Department of Treasury, "Approaches to Improve the Competitiveness of the U.S. Business Tax System for the 21st Century" (December 20, 2007).

[93] OECD "Tax Effects on Foreign Direct Investment: Recent Evidence and Policy Analysis," (2007), p. 11; Pricewaterhouse Coopers, "China's Impact on the Semiconductor Industry 2006 Update," (2007) at 4, 34; Pricewaterhouse Coopers, "China's Impact on the Semiconductor Industry 2008 Update" (2008) at 6.

[94] OECD "Tax Effects on Foreign Direct Investment: Recent Evidence and Policy Analysis" (2007) at 14.

U.S. counterpart to the outright tax holidays offered in China, Taiwan, Malaysia, and Singapore, or drastically reduced rates offered by jurisdictions such as Israel and India that in some cases allow semiconductor firms investing there to operate ten years or more without paying any corporate income tax at all. Some of the more extreme examples of outright exemption from federal-level taxation are described below.

China: 5+5 tax holiday and 15 percent reduced rate for high-tech companies. Under China's law of taxation in effect in 2007, qualifying semiconductor manufacturers were entitled to receive a 5-year tax holiday with respect to corporate income tax beginning in the first year the business was profitable, and another 5 years of taxation at half the applicable rate pursuant to *Several Policies to Encourage the Development of the Software and Integrated Circuit Industry* (Circular 18, June 24, 2000).[95] Although a new Enterprise Income Tax Law came into effect in 2008, that law provides a five-year transition period for businesses receiving preferential treatment under the old regime.[96] In addition, the new law provides that firms qualifying as high-technology companies are entitled to a permanent reduced rate of 15 percent.[97] In addition, qualifying semiconductor manufacturers are entitled to a full exemption from income tax for five years from the first year of positive accumulated earnings and a 50 percent reduction for the following five years under the new law.[98] This combination of tax abatements has led Semiconductor Manufacturing International Corp., which has been operating in China as its principal locus of operations since 2000, to disclose in 2007, "Our income tax obligations to date have been minimal."[99]

Taiwan: 5 year tax holiday. Taiwan promulgated the *Statute for Upgrading Industries* in 1990 and later amended that statute in 2003.[100] The statute provides for a five-year corporate income tax holiday applicable to companies in the manufacturing and technology service industries "in order to encourage the incorporation and expansion of the newly emerging, important and strategic industries."[101] The five-year holiday applies to all income when the company is newly incorporated, and when the company is a pre-

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95 This benefit is extended by Article 42 of the Circular, which provides that the IC industry is eligible for he same tax preferences as the energy and communication sectors, which receive the 5/5 holiday/reduction. The Circular by its terms limits this benefit to IC firms with investments in excess of RMB 8 billion and design rules of under 0.25 microns.

96 Article 57, Enterprise Income Tax Law of the People's Republic of China, (March 16, 2007); Semiconductor Manufacturing International Corp. Form 20-F/A for the Period Ending December 31, 2007 at F-40-41.

97 Article 28, Enterprise Income Tax Law of the People's Republic of China, (March 16, 2007).

98 Notice of the Ministry of Finance and State Administration of Taxation of Tax Concerning Certain Enterprise Income Tax Preferential Policies [Caishui No. 1 2008], (February 22, 2008).

99 Semiconductor Manufacturing International Corp. Form 20-F/A for the Period Ending December 31, 2007, at 59.

100 Statute for Upgrading Industries, Taiwan Presidential Decree, (December 29, 1990), amended February 6, 2003.

101 Article 8, Statute for Upgrading Industries, Taiwan Presidential Decree, (December 29, 1990), amended February 6, 2003.

existing qualifying enterprise, the five-year holiday applies to all incremental income derived as a result of new construction or expansion.[102]

The *Statute for the Establishment and Administration of Science Parks* also provides for a zero-percent business tax rate on any products produced for export in a designated science park, in addition to exemption from import duties and commodity taxes on machinery and equipment, raw materials, and other inputs in the productive process.[103] While the *Statute for Upgrading Industries* is due to expire in 2009, under a grandfather clause recipients can continue to receive the five-year tax holiday provided investment plans are approved by the Republic of China tax authorities before the statute expiry date. Taiwan Semiconductor Manufacturing Co. Ltd. (TSMC), located in Taiwan's Hsinchu Science Park, has been enjoying the benefits provided under these statutes.[104] As of 2007, TSMC posted almost $900 million in investment tax credits in four categories of exemption: research and development, purchase of machinery, personnel training, and investments in technology-based enterprises.[105] Proposals have been advanced to revise and extend the expiring *Statute for Upgrading Industries* as a new measure, the *Statute for Creating New Value for Industries*.[106]

Taiwan's tax incentives are particularly important in the semiconductor industry since Taiwan companies represent about two-thirds of worldwide foundry capacity. A U.S. company which is seeking to expand output can either expand its own factory in the United States and pay a 35 percent tax on the return on capital from that investment, or utilize a Taiwan foundry to make the product and indirectly take advantage of the zero tax on the Taiwan foundry. Obviously, this is a big disincentive to in-house production in the United States. Singapore, Malaysia, India and Israel offer their own versions of corporate income tax exemptions to attract investors.

- ***Singapore***. Firms qualifying as "pioneer companies" may be exempt from income tax on qualifying income for up to 15 years, and thereafter for another five years may enjoy a rate as low as five percent pursuant to a development and expansion incentive.[107] In 2006 Intel and Micron announced that their joint venture, IM Flash, would build a new plant in

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102 Article 9-2, Statute for Upgrading Industries, Taiwan Presidential Decree, (December 29, 1990), amended February 6, 2003.

103 Article 20, Statute for the Establishment and Administration of Science Parks, (July 24, 1979), and last amended on January 20, 2004.

104 Taiwan Semiconductor Manufacturing Co. Ltd. 20-F for the Period Ending December 31, 2007 at 35.

105 Notes to consolidated accounts, *TSMC Annual Report 2007* (1) at 71.

106 "MOEA to Submit Draft Bill for Revised Version of Statute for Upgrading Industries," December 25, 2006, Department of Investment Services, Ministry of Economic Affairs, Taiwan.

107 "The 2008 Worldwide Corporate Tax Guide," Ernst & Young, at 836.

Singapore. About the decision to locate in Singapore, an IM Flash official stated, "It really came down to tax incentives…."[108]

- ***Malaysia***. Firms qualifying for "pioneer status," meet the definition of high-techonology company, and that engage in a "promoted activity" are eligible for full income tax exemption for five years.[109] Companies qualifying for "multimedia status" are granted a full income tax exemption for five years, with an option for an additional five-year exemption.[110]

- ***Israel***. Foreign investors in Israel are eligible for a ten-percent corporate income tax rate, and if located in central Israel, can also be eligible for a two-year full exemption from that tax.[111] The full tax exemption can increase to as much as ten years if the company locates outside of central Israel. In 2005, the Israeli government reportedly granted $660 million in tax benefits for retooling for 90nm process production for a fab, originally built in Kiryat Gat, Israel in 1996.[112] In conjunction with the retooled facility, Israel was able to attract a new factory to the country by providing a combination of three factors – people, infrastructure, and government incentives.[113]

- ***Vietnam***. Vietnam has extended a 4-year tax holiday in connection with the establishment of a new semiconductor assembly and test facility that will become operational in 2009.

- ***India***. A ten-year tax deduction is available for 100 percent of profits derived from the export of certain products by new qualifying industrial businesses that locate in a Free Trade Zone, Electronic Hardware Technology Park, Special Economic Zone, or Software Technology Park, and to a "100 export oriented" business for ten years beginning in the year the industrial business begins manufacturing activities.[114] The deduction

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108 "Success Done in a Flash," *The Salt Lake Tribune*, (November 10, 2008).

109 Section 1.C, Promotion of Investment Act 1986, Malaysia Ministry of Finance.

110 Section 1.E, Promotion of Investment Act 1986, Malaysia Ministry of Finance.

111 "Business Operations in Israel," Tax Management, Bureau of National Affairs, at A-40; "Investment Incentives," Ministry of Industry, Trade, and Labor as at http://www.investinisrael.gov.il/NR/exeres/08348DA2-83D3-47B1-B043-ED418D9AA846.htm; OECD Investment Policy Reviews, Israel, OECD, (2002) at 97-99.

112 "Intel Announces Fab 28 in Israel," *ARS* (December 2, 2005).

113 "Intel VP: Extra Aid Brought Feb 28 to Israel," *Israel Business Arena*, (December 1, 2005).

114 "Corporate Taxes: India Tax Incentives," PricewaterhouseCoopers Worldwide Tax Summaries, as at October 4, 1007. The 2008 Worldwide Corporate Tax Guide," Ernst & Young, p. 379. Any park set up in accordance with the Electronic Hardware Technology Park (EHTP) Scheme or the Software Technology Park Scheme notified by the Government of India in the Ministry of Commerce.

is calculated by applying to taxable income the ratio of export revenues to total revenues. This exemption is not available indefinitely however.

3. Research and Development Tax Incentives

The United States currently offers on a temporary basis a tax credit for research and development, which seeks to stimulate increased R&D investment by reducing the firm's after-tax cost when it undertakes research *in the United States*.[115] The incentive entails a traditional credit that has been in the statute since 1981 equal to 20 percent of qualifying research and development expenses in excess of a base amount calculated as a percentage of gross receipts dedicated to R&D expenditures in the four preceding years.[116] In 2006, Congress extended the credit by enacting a 12 percent alternative credit for qualifying R&D expenditures above 50 percent of the average qualified research expenditures over the three years before the credit year. In 2008, Congress increased this alternative simplified credit rate to 14 percent.[117]

U.S. research and development tax credit entered the tax code as a temporary provision through the Economic Recovery Act in 1981.[118] At the time, Congress' intention was to reverse a decline in spending in research and development by the private sector as a share of U.S. gross domestic product that commenced in the late 1960s and continued thereafter.[119] Congress concluded that the credit was needed "to overcome the reluctance of many ongoing companies to bear the significant costs …which might be incurred to initiate or expand research programs in a trade or business."[120] Some analysts linked the low productivity growth of the 1970s and loss of U.S. competitiveness to the decline in R&D spending.[121]

Since its enactment, the research and experimentation tax credit has never been a permanent element of the U.S. tax code and has expired and/or been extended over a dozen times. The most recent extension was a retroactive two-year extension passed

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115 Section 41, Internal Revenue Code (U.S. Code of Federal Regulations, Title 26).

116 The traditional credit is calculated using a fixed-base percentage (FBP) calculated by dividing QREs over the period 1984-1988 divided by total gross receipts during the same period. The taxpayer's base amount in the current credit year is then calculated by multiplying the FBP times the average gross receipts for the four years proceeding the current credit year. Qualifying expenditures include in-house wages and supplies, 65 percent of contract research expenses, certain time-sharing costs for computer use, etc. "Supporting Innovation and Economic Growth: The Broad Impact of the R&D Credit in 2005," Ernst & Young, (April 2008) at 2.

117 Title III, Section 301 C, Public Law 110-343.

118 "Research Tax Credit: Current Status, Legislative Proposals in the 109th Congress and Policy Issues," Congressional Research Service, updated September 22, 2006, CRS-10.

119 "Research Tax Credit: Current Status, Legislative Proposals in the 109th Congress and Policy Issues," Congressional Research Service, updated September 22, 2006, CRS-10.

120 U.S. Congress, Joint Committee on Taxation, General Explanation of the Economic Recovery Act of 1981, joint committee print, 97th Congress, First Session, at 120.

121 "Research Tax Credit: Current Status, Legislative Proposals in the 109th Congress and Policy Issues," Congressional Research Service, updated September 22, 2006, CRS-10.

pursuant to the Emergency Economic Stabilization Act of 2008 (PL 110-343) in October 2008.[122] The credit's lack of permanence is its biggest weakness, according to critics. Critics argue that most R&D projects extend beyond a year or two and that managers' budgeting decisions will not be influenced by the prospect of a credit that they cannot depend on.[123] In addition, critics argue that the multiple formulas make planning around the credit difficult and that the average company claiming the credit realizes a very low *effective* credit rate of only approximately six percent[124]

Many countries that are home to semiconductor firms offer measures to promote research and development, including, but not limited to, income tax credit schemes. These incentives are additive to the tax holidays described above and some of the more salient examples are provided by Ireland, India, Israel, China, Taiwan, Malaysia and Singapore, etc:[125]

- ***Ireland: 25 percent R&D tax credit***. A research and development tax credit was introduced in Ireland pursuant to the Finance Act of 2004 that provides for a tax credit of 20 percent for incremental qualifying research and development expenditures incurred in the European Economic Area.[126] The credit regime was strenghtened in 2008 by increasing that credit from 20 to 25 percent, and by providing that any remaining credits be refunded to companies by the Irish revenue service over a three-year period.[127] Certain real property such as buildings may also qualify pursuant to the 2008 amendment for a related proportional credit under certain conditions. The credit is in addition to any existing deduction or capital allowances for research and development expenditures and thus brings effective tax relief to 37.5 percent effective January 1, 2009.[128] Upon passage of the strenghtened credit, Ireland's Department of Enterprise, Trade and Employment stated: "this measure will enhance our comeptitiveness as a location for new internationally mobile research-related investment."[129]

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122 Public Law 110-343 (October 3, 2008), 122 Stat. 3765.

123 "Research Tax Credit: Current Status, Legislative Proposals in the 109th Congress and Policy Issues," Congressional Research Service, updated September 22, 2006, CRS-18.

124 "International R&D Tax Incentives," Ernst & Young, (April 2008).

125 It should be noted that some of the incentives described below may not be granted in certain countries if the taxpayer affiliate charges the cost to the parent, or particularly if the ownership of the associated intellectual property leaves the country.

126 "Fostering Ireland's 'Knowledge Economy," Ian Collins, Ernst & Young, undated.

127 "R&D Tax Credit Regime," Tax Alert Ireland, Ernst & Young, (November 25, 2008).

128 "R&D Tax Credit Regime," Tax Alert Ireland, Ernst & Young, (November 25, 2008).

129 "Science Technology and Innovation Investment Now Nine Times What It Was in 2000—R&D Tax Credit Increased," Department of Enterprise, Trade and Employment, (October 14, 2008).

- ***India: 10-year tax holiday and 150 percent deduction.*** India offers a ten-year tax holiday equal to 100 percent of taxable profits to companies registered in India that carry on scientific research and development and that have been approved as of a date certain by the relevant authority.[130] In addition, a company engaged in electronic equipment manufacturing, among selected other products, may deduct 150 percent of research and development expenses incurred except when those expenses involve land or buildings.[131]

- ***Israel: full deduction for capex and 20-50 percent R&D financing grants.*** Section 20A of Israel's Income Tax Ordinance of 1981 allowed for the full deduction of R&D expenses including capital expenditures in the year in which the expenditures were made.[132] This provision was amended in 1983, continues in force today.[133] In addition, according to Section 28 of the Law for the Encouragement of Industrial Research and Development 1984, a qualified research and development plan renders the R&D company eligible for grants ranging from 20 to 50 percent of R&D expenditures, depending upon the amount of local production and the contribution of the R&D to Israeli research. The percentage grant available increases to 60 percent if the R&D company locates in Israeli development zone A and 70 percent if carried out along the northern border of Israel.[134] Finally, a full capital gains tax exemption is available to non-Israeli residents for the sale of shares in an "Intensive Research and Development Company."[135]

China, **Taiwan**, **Malaysia**, and **Singapore** likewise offer tax-related research and development incentives.

- ***China 50 percent super deduction.*** China provides that companies incurring research and development expenses in the production of new technologies, products, or techniques may enjoy a 50 percent "super-deduction" over and above the actual expense deduction when the

[130] "Industrial R&D Promotion Programme," DISR Annual Report 2007-2008, Department of Scientific and Industrial Research, India, p. 21; "The 2008 Worldwide Corporate Tax Guide," Ernst & Young, at 379.

[131] Article 35. Expenditure on Scientific Research, India Income Tax Act of 1961, as amended by the Finance Act of 2007.

[132] "Business Operations in Israel," Tax Management, Bureau of National Affairs, at. A103.

[133] "Business Operations in Israel," Tax Management, Bureau of National Affairs, at A104.

[134] "Business Operations in Israel," Tax Management, Bureau of National Affairs, at A104.

[135] "Business Operations in Israel," Tax Management, Bureau of National Affairs, at A105.

expenditure is not capitalized.[136] When the expense is capitalized as an intangible asset, 150 percent of actual costs may be amortized.

- ***Taiwan 35 percent R&D credit.*** Taiwan provides that a company may take a 35 percent credit for R&D expenses and personnel training against income tax payable for five consecutive years beginning in the relevant current year provided certain criteria are met.[137] In addition, when the above expenditure exceeds the average of the preceding two years, 50 percent of that excess amount may be offset against income tax payable that year.

- ***Malaysia 100 percent investment allowance.*** Malaysia offers several research and development-related tax incentives: a 10-year investment tax allowance of 100 percent for capital expenditures of an R&D company with potential for another 10-year 100-percent capital expenditure allowance and a double deduction for non-capital expenditures when the research is undertaken with the direct approval of the Minister of Finance.[138] Approved R&D expenditures incurred during a company's tax holiday period due to "Pioneer Status" can be accumulated and deducted after the tax holiday period.

- ***Singapore 5-year exemption.*** Singapore grants a 5-year tax exemption on foreign-sourced royalties or income used for R&D in Singapore under its Research and Development and Intellectual Property Management Hub program.[139]

4. Local Tax Incentives

In many countries local taxes are equal to or greater than corporate taxes at the national level, and their abatement can also be a factor in determining location of a semiconductor manufacturing facility. In the United States, states and localities often offer tax incentives to semiconductor manufacturers, although they cannot offset the impact of federal taxation.

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[136] Article 30(1), Enterprise Income Tax Law of the People's Republic of China, March 16, 2007 and Article 95, "Implementation Rules of Enterprise Income Tax Law of the People's Republic of China," State Council Decree No. 512, (December 6, 2007).

[137] "Business Operations in the Republic of China (Taiwan)," Tax Management, Bureau of National Affairs, at A-32.

[138] Section 6.1 (i) and (iv) and Section 6.2(1), "Incentives for Research and Development, Incentives for Investments, Malaysian Industrial Development Authority.

[139] "The 2008 Worldwide Corporate Tax Guide," Ernst & Young, at 837.

In 2000 for example, IBM committed to investing $2.5 billion in its Building 323 fabrication facility, located in East Fishkill, New York.[140] The project was billed as the "largest private sector investment in New York state history" and the "largest private-sector investment in the United States since 1995" and New York State's incentive package was reportedly critical to IBM's decision at the time. The state reportedly gave IBM "a full outline of New York State assistance from infrastructure, to permits, to incentives" during the decision-making process. Specifically, IBM's East Fishkill 300-mm (12-inch) wafer plant reportedly became eligible in 2000 for $475 million in Empire Zone incentives.

IBM reportedly became eligible for another $156 million in Empire Zone sales tax incentives over ten years.[141] That $156 million was to include local tax breaks and other benefits. Alone, the $475 million in tax breaks and incentives equated to $475,000 for each of the fab plants 1,000 new jobs, and altogether IBM reportedly was to benefit from some $660 million in incentives. IBM's own estimate of its cost savings at the time was $500 million.[142]

A particular pernicious effect of U.S. federal government policy is that it undercuts state efforts to attract investment in the United States. If a state provides a tax credit or grant (see below) that increases a company's profits by $10 million, the federal government tax increases by $3.3 million. Effectively the federal government dilutes the impact of state tax incentives by about one-third. While this may have limited impact for a company choosing to locate in one U.S. state rather than another, it can have a much more substantial effect when the choice is between a factory located in the United States or overseas.

B. Grants and Loans

While tax relief is by far the most powerful incentive in affecting locational decisions by the semiconductor industry, government grants and loans have played a significant role in some cases, involving fabs and assembly and test facilities. Grants and other forms of direct financial assistance appear to have affected the decisions by AMD and Intel to establish fabs in Germany and Israel, in particular. Recent debates in India over the scale of incentives required to attract semiconductor manufacturing investments concluded that grants on the scale of 32 to 35 percent of the total investment were needed to be competitive.[143]

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140 Governor's Office of Regulatory Reform Press Release, October 10, 2000 in http://www.siteselection.com/issues/2001/may/p273/ and www.gorr.state.ny.us/gorr/10_10_00gov_ibm.htm.

141 "Top 10 Deals of 2000: Chip Plants Deliver Big Bucks," *Site Selection,* (May 2001).

142 "New York State Continues Aggressive Semiconductor Manufacturing Initiative—'SEMI NY,' Empire State Development," Future Fab, Vol. 12, (February 2, 2002).

143 "Carrots to Chip Makers 40% Lower than Global Norm," *The Economic Times* (February 24, 2007).

In 2007 the government of India established a Special Incentives Package Scheme (SIPS) to encourage investments in semiconductor manufacturing.[144] Under this scheme, investors establishing qualifying wafer fabrication facilities in India involving a minimum of $550 million will quality for government grants of 20 percent of total capital expenditure for the first 10 years.[145] As of late November 2008, the government had received 17 proposals from investors seeking grants in connection with proposed establishment of semiconductor manufacturing facilities.[146] One of the proposals reportedly involved a proposed investment of $7.5 billion by India's Reliance Industries to establish two wafer fabrication facilities, one to be located in Gujarat and the other location yet to be determined "as it will depend on the type of incentive to be offered by a state government."[147]

When the IBM East Fishkill, New York facility reportedly became eligible in 2000 for $475 million in Empire Zone incentives, some $28.75 million of that was in the form of New York state grants and loans. In 2001 when IBM began participating in a program launched by Governor Pataki called Centers of Excellence, which established the Center of Excellence in Nanoelectronics and Nanotechnology (CENN) at Albany among other centers, the project originally drew $50 million in funding from the state.[148] In 2008, IBM announced a new $1.5 billion investment to expand chip manufacturing and keep the company's research efforts in New York. The investment reportedly involved three complimentary plans to invest in expansion of IBM's operations at the CENN, the creation of a new, advanced semiconductor packaging research and development center, and the upgrading of IBM's East Fishkill facility.[149] The State will reportedly provide a total of $140 million in economic development grants in conjunction with this project.

In 2008, Advanced Micro Devices and its Abu Dhabi-based investment affiliate, Advanced Technology Investment Company, announced their intention to make a $4.6 billion investment in Luther Forest Technology Campus, Saratoga Country.[150] This announcement builds off an agreement reached between New York State and AMD in June, 2006 whereby New York State agreed to provide a $650 million capital grant for construction and research and development activities connected with the Luther Forest fabrication facility. The project is also eligible for benefits through the Empire Zone

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144 *Ministry of Communications and Information Technology*, Guidelines for Operation of the Scheme No.3(I)2007 – IPHW (SIPS); "SIPS Proposals for Semiconductors," *Business Line* (September 21, 2008).

145 "Incentive Scheme to Lure Chipmakers to India," *EE Times Asia* (April 16, 2007); "Big Bucks Chase Chip Units," *The Hindustan Times* (April 3, 2008).

146 "Raja Pitches for Three Year Extension of STPI Tax Stops," *Business Line* (November 26, 2008).

147 "Reliance to Invest $7.5bn for Two Microchip Units," *Indo-Asian New Service* (April 3, 2008).

148 "Centers of Excellence," http://www.nylovesbiz.com/High_Tech_Research_and_Development/centers_for_excellence.asp.

149 Section 2: Market Assessment, Operating, and Finance Plan, Saratoga Associates. "A Sweet IBM Deal," NY Loves Nanotech: News & Events, (July 15, 2008).

150 Governor Paterson Announces Major Investment In New York State, (October 7, 2008) as at http://www.ny.gov/governor/press/press_1007082.html.

program, which are currently estimated to total nearly $600 million over a 14-year period. These incentives were approved on December 17, 2008.[151]

C. Manpower Programs and Research Initiatives

Countries seeking to promote the establishment and expansion of semiconductor industries have recognized that an adequate pool of trained manpower is a prerequisite to investment, and their university system must be able to provide industry with a steady stream of trained graduates. Achieving this has required the overhaul of university systems, expansion of faculty, creation of new curricula in semiconductor technology and design, and establishment of programs for collaboration between universities and the industry. In virtually every country undertaking such an effort, the model used has been that of the United States, and in general these countries have benefitted substantially from support provided by U.S. semiconductor companies and by U.S. universities. Most countries promoting indigenous semiconductor development have implemented programs to encourage the return of students studying abroad (most commonly from the United States and Europe) and to attract foreign nationals with semiconductor expertise.

a) United States

In the United States, the semiconductor industry, the government, and universities have long collaborated in basic research and development, and that collaboration – "ideal" in the words of one Japanese admirer – is seen as an important aspect of the industry's global technological leadership.[152] In 1982 the Semiconductor Research Corporation (SRC) was formed by the U.S. semiconductor industry to conduct silicon-based semiconductor R&D in U.S. universities, and four U.S. government organizations collaborate with SRC and contribute to its funding.[153]

In 1997 the semiconductor industry initiated the Microelectronics Advanced Research Corporation's (MARCO) Focus Center Research Program, a subsidiary of the SRC, to fund and operate university-based research centers in microelectronics. Under this Program, U.S. Department of Defense spending each year is matched by industry funds to support semiconductor-related research. Each Focus Center is a team of U.S. universities assigned to conduct long range basic research on problems that must be solved for semiconductor technology to advance to its ultimate physical limit (described as "Ultimate CMOS" in semiconductor parlance). Students in these programs interact

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151 New York State Public Authorities Control Board, *Resolution No. 08-UD-1401* (December 17, 2008).

152 "Japanese Manufacturers to Launch Joint Research on New Chip Technology to Counterattack U.S. Manufacturers," *Ekonomisuto* (October 31, 1995).

153 The government organizations are the U.S. Army Research Office, the National Institute of Standards and Technology, the National Science Foundation, and the Defense Advance Research Projects Agency. Wayne Clough, the President of the Georgia Institute of Technology, commented that "SRC has served as a model for collaborative research between industry, government and universities. To our knowledge, no other organization has developed the policies and operational methods that mesh them so effectively." "SRC Awarded 2005 National Medal of Technology" *www.src.org/member/news/feature-techmedal.asp*

with leading companies in the semiconductor industry, who use the program to recruit interns and full-time employees. In 2008 the U.S. Defense Department allocated $20 million in federal funds – matched by $20 million in industry funds – to support semiconductor R&D at U.S. universities through the Focus Center Research Program – a record high level for this program.[154] The Focus Center program currently involves 41 universities, 333 faculty and 1215 doctoral graduate students. Each Focus Center involves an annual investment of about $7 million.

While the Focus Center Program seeks to allow technology to advance to ultimate CMOS, a second industry-government university program, the Nanoelectronics Research Initiative ("NRI"), is researching "beyond CMOS' to find a new technology to replace traditional CMOS devices before they reach their ultimate limits around 2020. The NRI pulls together semiconductor companies,[155] the National Science Foundation ("NSF"), the National Institute of Standards and Technology ("NIST"), state governments, and over 30 universities in 13 states. The industry contribution through the NRI is over $5 million per year. The research activity is organized within four multi-university centers in California, New York, Texas and Indiana, plus NRI and NSF supplemental co-funding of nanoelectronics projects at 10 existing NSF university centers. In 2007, NIST concluded an open competition by entering into partnership with the NRI to accelerate research in nanoelectronics. Under the partnership, NIST and NRI will jointly provide $18.5 million over five years toward high-priority university research projects identified by industry and NIST researchers.

The United States, however, confronts a prospective shortfall in the human resources needed to sustain a growing semiconductor industry within its boundaries. U.S. universities are graduating fewer students with degrees in chemical and electrical engineering,[156] and of these a growing percentage consists of foreign nationals who will return home, either by choice or because they cannot remain in the U.S because of immigration-related restrictions.

The U.S. recently acted to reverse this trend by including in the American Recovery and Reinvestment Act of 2009 an additional $5 billion for the NSF, NIST, and Department of Energy's Office of Science to be spent over FY 2009 and FY 2010. This not only will help strengthen America's science base in the long term, but it will create and maintain jobs in the short term. The $1.3 billion in spending on research infrastructure alone

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154 "Record Federal Commitment to U.S. Universities' Semiconductor Research L* by SRC," *Business Wire* (February 7, 2008)

155 The semiconductor companies funding the NRI are Advanced Micro Devices, Freescale, IBM, Intel, Micron Technology, and Texas Instruments.

156 A recent comparative study conducted under the auspices of the Indian Institute of Technology at Mumbai found that the growth rate in engineers per civilian population in 2004 (or most recent year for which data was available) was increasing in the following countries: India (9.7%), China (7.6%), Korea (6.2%), Japan (2.1%), Germany (2%) and the U.K. (4.5%). Only the United States had a negative growth rate (-1.4%) of the countries surveyed. Rangan Banerjee and Vinayak P. Muley, *Engineering Education in India* (September 14, 2007), Figure 1.22.

would create or retain 26,000 jobs.[157] This was an important first step, and could signal a turning point if it is followed up with increased appropriations for these agencies in subsequent years and if it is coupled with education and immigration reforms to ensure that talent is grown, attracted, and remains in the United States.

b) Taiwan

Taiwan launched perhaps one of the most unusual engineering manpower initiatives among countries reviewed. The Si-Soft Project, launched in 2002, is intended to promote Taiwanese human resources in the microelectronics field, open a semiconductor "design park" comparable to the island's science-based industrial parks, and invest roughly $250 million in R&D funds in optoelectronics, embedded processor design, and wireless technology.[158] It was the centerpiece of Taiwan's new strategy in this decade pertaining to microelectronics. The project's goal was to promote the creation of intellectual property by Taiwanese IC design houses, particularly System-on-Chip (SOC) technologies. The project was to be financed 30 percent from public and 70 percent from private sources.[159] According to Tsai Ching-yen, a minister-without-portfolio in charge of science technology development, the project had the potential to more than double Taiwan's share of the world semiconductor market (from 16 to 33 percent) by 2010.[160] Si-Soft had at least two important elements:

- ***Expansion of university-based training.*** Taiwan planned to increase its university faculty staff by 85 positions annually for three years, for a total of 255 new university instructors specializing in VLSI education by 2006. Taiwan will create new undergrad and graduate level university courses in semiconductor design and "will cultivate thousands of design engineers every year."[161] Some key aspects of this program include: (1) Compulsory system-on-a-chip design for all students in electronics and electrical engineering, allowing "even bachelor graduates [to] be able to engage in IC design;" (2) making semiconductor-related courses mandatory for all engineering students in Taiwan; and (3) the development of expertise in intellectual property rights and marketing.[162]

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157 Estimate based on study by Daniel Castor and Rob Atkinson, Information Technology and Innovation Foundation, *Stim-Novation: Investing in Research to Spur Innovation and Jobs,* (January 27, 2009).

158 Shojiro Mori, "Taiwan's Design Parks," *Nikkei Microdevices* (January 2003).

159 Chun-Yen Chang and Charles V. Trappey, *The National Si-Soft Project* (Undated mimeo, National Chiao Tung University).

160 Deborah Huo, "Taiwan Developing Major Silicon-Oriented Industrial Plan," *Taipei Central News Agency* (10:14 GMT, September 30, 2001).

161 Deborah Huo, "Taiwan Developing Major Silicon-Oriented Industrial Plan," *Taipei Central News Agency* (10:14 GMT, September 30, 2001).

162 "Government Aims Project at Boosting Taiwan's IC Design Capabilities," *Electronic Engineering Times*, (December 16, 2001).

- ***IC Design Park.*** The Si-Soft project launched a new system-on-a-chip IC design park to be networked with Hsinchu and Tainan Science-Based Industrial Parks and Nankang Software Park. The Nankang Integrated Chip Design Science Park opened in July 2003, with sites for IC design firms, an incubation center for start-ups, an open lab, and a service and management section. The main purpose of the new park was to "incubate" start-up design houses with up to 35 employees.[163] The Executive Yuan worked with the National Chiao Tung University to develop the design park, and "the Executive Yuan will support these IC design houses looking for business opportunities."[164]

At least one Taiwanese semiconductor maker, TSMC, boasts approximately $4 million in tax credits for its engineering manpower initiative that meet government subsidy requirements.[165]

c) Ireland

Ireland's approach toward formulating policy for and funding basic research in science and technology shifted fundamentally with the launch of its National Development Plan (NDP) 2000-2006.[166] Under the NDP, €11 million was devoted to establishing a new SFI Centre for Science, Engineering and Technology (CSET) at Trinity College Dublin in partnership with University College Cork (UCC) and University College Dublin. An additional €10 million grant was allotted for research at the center itself.[167] CSET partially funds the Centre for Research on Adaptive Nanostructures and Nanodevices (CRANN) to develop the human capital and tools and techniques needed to build new structures and devices at the nano-level. Next generation microelectronics technologies is a key research focus at CRANN and Intel Ireland Ltd., is one of CRANN's principal industry partners.[168]

Liberal work permit program. Work-permit policies in the 27 European Union countries vary[169] and Ireland is an example of a country with a liberal work-permit policy.[170] In the past, there has not been a quota imposed on the aggregate number of work permits issued

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163 Shojiro Mori, "Taiwan's Design Projects," *Nikkei Microdevices* (January 2003).

164 "World's First System on Chip Design Center Will Open in Taiwan Industrial Park," *China Post* (April 23, 2003). The government is providing incentives "for the enlisting companies to lower the overhead cost." "Nankang Integrated Chip Design Park Opens," *China Post* (July 10, 2003).

165 Notes to consolidated accounts, *TSMC Annual Report 2007* (1), at 71.

166 "Strategy for Science, Technology, and Innovation 2006-2013," Department of Enterprise, Trade and Employment.

167 "SFI" in Focus," Science Foundation Ireland, Winter-Spring 2004, p.1; "Strategic Plan 2008-2013," Center for Research on Adaptive Nanostructures and Nanodevices, p. 8, 13.

168 "Intel," Trinity College Dublin, undated as at http://www/crann/ted/ie/index/PeopleAndPartners/IndustrialPartners/intelpartner#intel.

169 Free Movement of Workers, Enlargement—Transitional Provisions, as at ec.europa.eu.

170 Migration Information Source – Ireland, as at www.migrationinformation.org.

in Ireland, and the actual number issued was simply determined by employers' demand for migrant workers.[171] A new Employment Permits Act of 2006 came into force in January 2007 to tighten up the Irish work-permit system, but overall the system contrasts in several important ways that contrasts with U.S. policy.

The Irish Employment Permit Act of 2006 sets out in essence a two-tiered structure for permits, replacing a Work Visa/Work Authorization Scheme that has been discontinued.[172] One tier is the "green card," which applies to more highly-skilled workers at a higher salary level (over €60,000), and the other tier applies to employees at lower skill levels, with a salary of at least €30,000.[173]

Irish "green card" has none of the restrictions of U.S. H1-B. Ireland's "green card" work permit is closest to the U.S. H1-B visa in that it is issued for higher-paid employees with an annual salary over €60,000. However, applicants do not have to meet a specialty occupations requirement, and no education requirement is specified in the statute. Employees earning in the €30,000 - €60,000 range will be granted the green card status if employed in the engineering, IT, or select other sectors. No advertising of the position is required, and after the initial two years, the green card holder can apply for permanent residence. While the statute allows Ireland's Minister of Enterprise to cap the number of green card permits issued in a given period, no cap is specified in the statute. The only quota-like restriction is the requirement that the employer firm's European Economic Area workforce must be at least 50 percent of the firm's total.[174] Immediate family reunification is permitted with the green card. Processing time for the green card visa is only 6 weeks.

Provisions for advanced degree students. In addition, a Third Level Graduate Scheme was implemented in the 2006 Employment Permits Act that provides that non-European Economic Area students who graduated with a degree from an Irish third-level educational institution may be permitted to remain in Ireland for six months, to find work, actually work, and apply for green card status.[175]

Intra-company transfer. In addition, a new intra-company transfer arrangement has been provided for that is designed to facilitate the transfer of senior management, key personnel, and trainees who are foreign nationals from an overseas branch of a multinational corporation to its Irish branch.

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171 "The Potential of Temporary Migration Programmes in Future International Migration Policy," International Labour Review, (January 1, 2006).

172 "New Economic Migration Arrangements: Main Features," Department of Enterprise, Trade and Employment, (January 24, 2007).

173 Employment Permits Act, Number 16 of 2006.

174 Employment Permits Act, Number 16 of 2006, Section 104 (b).

175 OECD, International Migration Outlook: SOPEMI 2008 Edition.

National Microelectronics Research Centre ("NMRC").[176] The NMRC was established at University College, Cork, in 1982. The Centre has a dual mission: performing world-class research and, as a key part of the National Science, Technology and Innovation infrastructure, providing support both to Irish Industry and Government Agencies. NMRC has created a dynamic and visionary R & D environment for advanced ICT-based research with a broad research agenda from microelectronics and photonics to microsystems and nanotechnology. NMRC incorporates the National Microelectronics Research Centre, the National Nanofabrication Facility, ESA Microelectronics Technology Support Laboratory, Optronics Ireland Research Centre, Science Foundation Ireland Photonics Theory Group, PEI Technologies Research Centre and is Ireland's only EU Designated Research Infrastructure.

d) India

During India's Ninth Five-Year Plan (1997-2002), India's Department of Information Technology ("DIT") set out to increase India's share of the global VLSI design market from 0.5 percent to 5 percent, for a VSLI design turn-over of US$1 billion. To meet the plan objective, DIT launched in1998 a manpower program that today is the core of India's efforts to promote a favorable environment for micro-electronics engineering talent: The "Special Manpower Development Program in the area of VLSI Design and Related Software."[177]

VLSI manpower initiative. The "Special Manpower Development Program in the Area of VLSI Design and Related Software," involves creating, designing, and offering new courses of study specifically geared to graduating engineers specializing in microelectronics software design and original funding was devoted to training faculty and technicians in VLSI design software and establishing design laboratories for the purposes of teaching VLSI and related software design. The program offers the following degrees: B.E/B.Tech level, M.E/ M.Tech level in the areas of Electronics, Communications, Computer Science, Instrumentation, etc.; M.E/M.Tech in VLSI design & Microelectronics; and PhDs in various aspects of VLSI and related software design.[178] The cost of the Phase I program was approximately $3 million (Rs.14.99 crores) for an initial duration of five years (1998-2002). This program was extended by one-year, and a second phase was instituted through 2009 at a cost of $770,000 (Rs. 3.5 crorers).

Indian Technology Institutes. The VLSI Manpower program operates through 19 public institutions throughout India, including through India's approximately eleven Indian Institutes of Information Technology ("IIIT")[179] and seven Indian Institutes of

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176 http://www.entemp.ie/corporate/foi/glossary.htm.

177 "Special Manpower Development Programme for VLSI Design & Related Software (SMDP) – Ongoing Project of DIT," Department of Information Technology, HRD Division.

178 Special Manpower Development Programme for VLSI Design & Related Software (SMDP) – Ongoing Project of DIT.

179 *See* the websites of the IIITs: IIIT Hyderabad, http://www.iiit.net/; IIIT Bangalore, http://www.iiitb.ac.in/; IIITM Gwalior, http://www.iiitm.ac.in/iiitm/index.htm; IIIT Allahabad, http://www.iiita.ac.in/; IIITM Kerala, http://www.iiitmk.ac.in/home.jsp; IIIT Pune,

Technology ("IIT"), established since 1950.[180] The information technology institutes focus on software engineering and programming. In terms of microelectronics development both the technology and information technology institutes are involved in the VLSI Manpower initiative. IIIT Allahabad, IIIT Hyderabad, IIIT Gwalior, and IIIT Pune all offer coursework or advanced degrees in VLSI design and microelectronics,[181] while IIT Madras offers master's degree and doctorate opportunities in the fields of microelectronics and VLSI.[182] Additionally, IIT Madras carries out research in the fields of microelectronics and VLSI and has laboratories for each.[183] IIT Madras is classified as a resource center under the Special Manpower Development Program in VLSI.[184] The IIT's are involved in the Microelectronics and Nanotechnology Development Programme, a DIT program that funds numerous research and development projects in microelectronics and nanotechnology.[185]

VLSI Penetration Programme. Launched as a pilot program in Tamil Nadu emphasizing integrated circuit design, process characterization, and testing, Ministry of

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http://www.isquareit.ac.in/; IIIT Bhubaneswar, http://www.iiit-bh.in/; IIIT Delhi, http://www.iiitd.ac.in/; IIIT Nuzvid (no website); IIITDM Kancheepuram, http://www.iiitdm.iitm.ac.in/; IIITDM Jabalpur, http://www.iiitdm.in/.

180 IITs in Mumbai, Kanpur, Chennai and Dehli were established in 1961 by order of the Institutes of Technology Act and more recently, IIT Guwahati and the University of Roorkee were granted status in 1994 and 2001, respectively. India Education, Indian Institutes Of Technology (IIT), *available at* http://www.indiaedu.com/iit-in-india/index.html (last visited Nov. 10, 2008); *see also* IIT Alumni, About IIT Alumni – Overview, *available at* http://iit.org/about-iit *(*last visited Nov. 10, 2008); "The Institutes of Technology Act, 1961," *available on the website of IIT Bombay at http://www.iitb.ac.in/legal/IITsAct.pdf*. The seven Indian Institutes of Technology ("IIT") are more established research institutes, with the first IIT, located in Kharagpur in 1950.

181 Indian Institute of Information Technology Allahabad, Academics, Undergraduate Programmes, *available at* http://www.iiita.ac.in/inner.php?conf=ugrad (last visited Nov.10, 2008); Indian Institute of Information Technology Hyderabad, Academic Programmes, *available at* http://www.iiit.net/overview.php (last visited Nov. 10, 2008); Indian Institute of Information Technology and Management Gwalior, Academics, Programmes, *available at* http://www.iiitm.ac.in/iiitm/Programmes.htm (last visited Nov. 10, 2008); Indian Institute of Information Technology Pune, Programs Offered, School of Information Technology, *available at* http://www.isquareit.ac.in/soit.htm (last visited Nov. 10, 2008).

182 Indian Institute of Technology Madras, Department of Electrical Engineering, Academics (*see* M. Tech and PhD pages), *available at* http://www.ee.iitm.ac.in/academics/academics-mtech.html (last visited Nov. 10, 2008).

183 Indian Institute of Technology Madras, Department of Electrical Engineering, Research, Microelectronics/VLSI, *available at* http://www.ee.iitm.ac.in/divisions/divisions-micro.html (last visited Nov. 10, 2008).

184 Indian Institute of Technology Madras, VLSI Group, About SMDP, *available at* http://www.ee.iitm.ac.in/vlsi/smdp/start (last visited Nov. 10, 2008).

185 Government of India, Ministry of Communications & Information Technology, Department of Information Technology, "Information Technology Annual Report 2007-08," at 38-39, *available at* http://mit.gov.in/download/annualreport2007-08.pdf.

Information Technology representatives suggested its possible extension to 100 engineering colleges throughout India.[186]

Indian state programs. The Indian state of West Bengal recently deployed an array of incentives and concessions directed at the semiconductor industry. It has undertaken construction of a $25 million 20-story facility dedicated to incubation centers, start-ups and manufacturing. The state government will also provide seed capital, a 20 percent state tax holding for 10 year, and a training subsidiary of 20,000 Rupees per employee. A high-level committee of the State government is reportedly meeting with universities in the state "to chalk out a five-year programme for churning out thousands of graduates and skilled manpower for the software and hardware sectors of the new economy."[187]

e) Brazil

In April 2008 Cadence Design Systems, a U.S.-based maker of semiconductor design tools, in collaboration with the Brazilian Ministry of Science and Technology, opened the "IC Brazil Training Center" in Porto Alegre, Brazil, to train over 1,500 Brazilian integrated circuit designers over the next three years. Cadence is developing curriculum and training, while the Brazilian government provides scholarships to qualified university graduates "to receive the training and prepare themselves for high technology careers." This is the first of four such IC design centers that will be established by Cadence and the Brazilian government.[188]

f) Czech Republic

Czechinvest, an investment promotion arm of the Czech Republic's government, created a Center of Excellence for microelectronics in 2006, "Chipinvest," to "supply top engineering talent from Central and Eastern Europe and Russia to leading and emerging chip companies worldwide."[189] An adviser to Czechinvest commented that "Our Center of Excellence goes beyond typical incubators by providing a formal network for training and talent-gathering for the international microelectronics industry. It's like placing a magnet in am electric field. We are directing knowledge-flow to one place – the Czech Republic."[190]

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186 Government of India, Ministry of Information Technology, X Plan Study Team on HRD, "Presentation of the Study Team Report on Human Resource Development for the Xth Five Year Plan (2002-2007) at 55, *available at* http://unpan1.un.org/intradoc/groups/public/documents/APCITY/UNPAN010003.pdf.

187 West Bengal Hard Sells Kolkata to Semiconductor Industry," *Indo-Asian News Service* (February 21, 2008).

188 "Cadence Opens First IC Design Center in Brazil" *EE Times Asia* (May 5, 2008).

189 Czechinvest, the Investment and Business Development Agency, is am agency of the Ministry of Industry and Trade with the mission of attracting foreign investment to the Czech Republic and developing Czech companies.

190 "New Czech Centre of Excellence for Microelectronics Connects Talent From Central, Eastern Europe and Russia," *Market Wire* (May 31, 2006).

g) Singapore

In 2007 the Singapore government Economic Development Board (EDB) announced that it would invest $8 million in a new program to encourage undergraduates to specialize in semiconductor wafer fabrication, with the objective of training 900 engineers over a 3-year period. Additional funding is being provided by semiconductor manufacturers. Students taking advantage of the program receive a monthly stipend of $1,080, and all participating students are guaranteed jobs after graduation.[191]

[191] "EDB Invests $8m to Train Wafer Fab Engineers – Programme to Encourage Students to Specialize in the Wafer Fab Industry," *The Business Times* (May 3, 2007).

V. Policy Implications and Recommendations

It is clear from the foregoing analysis that many other countries are seeking to attract semiconductor manufacturing and R&D through government programs that are specifically designed to create the innovation ecosystems that are critical to promoting innovation in information technology industries such as the semiconductor industry. Many incentive programs are modeled after – and are more generous than – ones originally implemented by the U.S. government. Survey data collected from U.S. semiconductor companies indicate that the impact of these programs and policies has been a gradual, relative decline in R&D investment in the United States. The good news is that it is not too late to halt or reverse this course. Indeed, the increase in science funding in the American Recovery and Reinvestment Act passed in February 2009 was a welcome reversal of the previous downward trend in federal R&D funding. But this commitment must be sustained beyond the FY 2009/10 appropriations in that bill.

It is also clear that there is no single public policy "silver bullet" that drives company decisions for R&D and manufacturing investment. In fact, several public policies work in concert to create an environment that attracts highly capital intensive R&D and manufacturing operations and supplies the engineering and technical talent they require. Tax and incentive policies, government research funding for science and technology, education and technical training, immigration policies and strategic infrastructure policies are widely recognized by policy makers in the United States and other countries around the world as necessary to attract multi-billion dollar investments from semiconductor companies. The key to future U.S. innovation is to ensure that U.S. policies are at least as competitive as those of our trading partners.[192]

Tax and Incentive Policies to Promote Semiconductor Manufacturing and R&D

Many of the other countries considered in this study have adopted polices that have resulted in semiconductor investment and job creation in their regions. Therefore, the Congress should consider adopting tax policies that are competitive with those of our trading partners in order to encourage new investment in semiconductor manufacturing and research and development in the United States.

As noted above, foreign governments have successfully employed a number of tax and incentive measures to attract investment. Among those policies are low tax rates, specific incentives to encourage investment in research and manufacturing, tax holidays, and grants and loans.

Over the years, there has been considerable discussion in the United States about advancing U.S. long term competitiveness through tax policy. Of particular importance is a permanent and enhanced R&D tax credit and continued deferral of taxes on overseas

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[192] *See, e.g.,* The Atlantic Century, Benchmarking EU & U.S. Innovation and Competitiveness, The Information Technology & Innovation Foundation (February 2009) (benchmarking among 40 nations/regions on 16 different indicators show that the U.S. ranks sixth in innovation and competitiveness and last in recent progress made toward developing a new knowledge-based innovation economy).

income. These policies are the cornerstone of a competitive U.S. tax policy. The proposal by economist Robert Atkinson at the Information Technology and Innovation Foundation to improve the R&D credit to better incentivize R&D is a good starting point for discussion.[193] It is important to make the R&D credit permanent as soon as possible to create the certainty and predictability that companies need in making long term investments. Moreover, to encourage U.S. companies to export and compete with companies in countries that do not tax overseas income at all, tax deferral on overseas income is a critical tool that must be maintained.

Deferral of overseas income from foreign subsidiaries of U.S. companies is widely recognized as the cornerstone of U.S. tax policies designed to enable U.S. companies to compete on a level playing field in global markets, thus generating foreign income for their U.S. operations and supporting U.S. jobs and investment. Deferral is not an incentive to move jobs overseas, as has been claimed, as foreign direct investment by U.S. companies promotes increased U.S. exports and more economic activity in the United States, resulting in more jobs for Americans. An OECD study of 14 countries found that "each dollar of outward FDI [foreign direct investment] is associated with $2 of *additional* exports and with a bilateral trade *surplus* of $1.7 dollars. These results make it clear that, without outward FDI, OECD country exports would actually be smaller."[194] In addition to creating demand for U.S. exports, foreign subsidiaries of U.S. companies also increase demand for U.S. headquarters services, including management, R&D, finance and advertising. These support services grow as U.S. companies compete successfully in foreign markets.[195] In fact, ending deferral of overseas income would only put U.S. companies at a competitive disadvantage and thereby jeopardize research and manufacturing jobs in the United States.

Other important ideas could be advanced when the tax reform debate occurs to ensure long term U.S. semiconductor industry competitiveness. These ideas include lowering the U.S. combined federal/state corporate income tax to be competitive with OECD countries, enacting a 10 percent investment tax credit for new investment in qualifying high technology manufacturing facilities in the United States (similar to the investment tax credit that existed in federal law prior to the Tax Reform Act of 1986), and providing for full depreciation over three years of all semiconductor manufacturing equipment installed in U.S. fabrication facilities.

Moreover, given the current challenging economic environment, the ability of companies to make more effective and timely use of losses remains significant. Although addressed by the American Recovery and Reinvestment Act, its loss carry back provision was

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193 The Alternative Simplified Credit currently provides a credit of 14 percent of the amount of qualified expenses that exceed 50 percent of the average qualified research expenses for the preceding 3 years. Among Dr. Atkinson's recommendations are a 20 percent credit on research expenses greater than 75 percent and below 100 percent of the base amount, and a 40 percent credit on expenses over 100 percent of the base amount.

194 OECD, Open Markets Matter: The Benefits of Trade and Investment Liberalization 37 (1998) (emphasis in original).

195 *See* National Foreign Trade Council, *International Tax Policy for the 21st Century* 113-114 (2001).

narrowly targeted and limited, and a more extensive loss provision deserves further consideration – especially if losses continue over a prolonged period of time.

Government Research Funding for Science and Technology

Countries seeking to develop their own domestic semiconductor industry have recognized that basic scientific research is essential to promote continued innovation in chip technology. The American Recovery and Reinvestment Act passed in February 2009 was a welcome reversal of the prior trend in declining federal science investment. This change in U.S. government spending priorities to more actively promote research in the physical sciences and engineering should continue. For example, the Congress should build on the American Recovery and Reinvestment Act's appropriations to fully fund and carry out the provisions of the America COMPETES Act, in particular by enacting appropriations beyond FY 2010 to double the federal investment in basic research by key science agencies, including the National Science Foundation, the National Institutes of Standards and Technology, and the Department of Energy Office of Science.

In addition, the Congress should provide specific authorizations and appropriations for nanoelectronics research and equipment to enable the United States to be the first in the world to demonstrate a nanotechnology-based electronic logic switch that is able to replace the solid state transistors that store and process information in integrated circuits. Finding a new switch should be a priority objective for the National Nanotechnology Initiative (NNI). Congress should also continue increasing basic research at the Department of Defense.

Building America's Talent Base in Engineering and the Physical Sciences

Education. Countries competing for semiconductor investment have recognized that a well-educated work force is essential for promoting increased high technology investment. In order to increase the number of Americans with advanced physical science and engineering degrees from U.S. universities, the Congress should consider a number of steps to promote education in science, technology, engineering, and mathematics (STEM) fields.

In particular, the Congress should build on the American Recovery and Reinvestment Act's appropriations to fully fund beyond FY 2010 STEM education programs authorized by the America COMPETES Act. This would include funding for: the Advanced Placement and International Baccalaureate program, which would expand low-income students' access to AP/IB coursework by training more high school teachers to lead AP/IB courses in math, science, and critical foreign languages in high-need schools; the MathNow program to improve K-8 math instruction and ensure that elementary and middle school students are fully prepared for upper level math courses; the Robert Noyce Teacher Scholarship program, which seeks to encourage talented science, technology, engineering, and mathematics majors and professionals to become K-12 mathematics and science teachers; the Math and Science Partnerships program, which develops and implements ways of advancing mathematics and science education for students; and the STEM talent expansion program (STEP), whose goal is increasing the number of students receiving associate or baccalaureate STEM degrees.

Immigration policy. The improvements to STEM education noted in the report are crucial to U.S. competitiveness in the semiconductor industry. Access to all talented workers from U.S. universities is an important part of this measure given the large number of foreign students who have earned advanced science and engineering degrees at U.S. universities. U.S. immigration policies should encourage these highly skilled workers to stay and work in the United States, and thereby create jobs and economic growth in this country and provide a return on investment for their U.S. education. Individuals with a master's degree or PhD from a U.S. university in STEM fields should be exempt from the employment-based visa cap so they can remain and contribute in their fields in the United States. There should also be a mechanism to allow U.S. STEM master's or higher degree holders who have a job offer to transition directly from student visas to green cards.

Promoting Energy Research and Energy Efficient Manufacturing

The Congress and the Administration should be applauded for the promotion of energy efficiency and renewable energy in the recently passed economic recovery legislation. As noted above, semiconductors are a key enabling technology in renewable energy and energy efficiency. Semiconductor companies have also improved their manufacturing processes to be more energy efficient, and are working for further improvements.

Government energy policies around the world will have an impact on semiconductor manufacturing location decisions, and must be taken into account by U.S. policy makers seeking to improve U.S. competitiveness. To promote the energy-efficient manufacturing of semiconductors that promote energy efficient and renewable energy end products, policy makers should consider tax incentives for semiconductor manufacturing facilities that meet established energy efficiency and sustainability standards,[196] a tax credit for producers of semiconductor devices that will enable dramatic gains in energy efficiency (similar to the existing credits for producers of energy efficient appliances) and accelerated depreciation on expenses related to energy conservation measures. Policy makers should also recognize and support the role of semiconductor technology in promoting an energy efficient economy through increased research funding for semiconductor-enabled energy efficiency and alternative energy at the Department of Energy and through enhanced energy research tax credits.

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These policy proposals will promote economic recovery, long-term job creation, and technological leadership by leveling the playing field with our trading partners and giving America the tools needed to continue its historic leadership in semiconductors, with all the attendant benefits to the United States and its citizens.

[196] There is currently an effort to have the U.S. Green Building Council develop standards for a Leadership in Energy and Environmental Design certificate for semiconductor manufacturing.