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R&D and Innovation in Industry

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HIGHLIGHTS

- The last two years have seen less growth in R&D investment by U.S. industry, with 2003 showing barely more spending than 2002 in current dollars and slightly less in constant dollars. The same will be true for 2004. There will again be wide variation depending on industry. Automotive, pharmaceuticals, software, and a few profitable biotechnology companies are increasing their R&D investments. Aerospace, computer and component makers, networking equipment manufacturers, telecommunications, and chemical and process-related industries are closely controlling spending.

- Internally generated business growth opportunities, either within existing product lines or based upon newly employed platforms, will command the largest proportion of industry R&D budgets. Directed basic research and support of existing businesses will continue to diminish as proportions of overall spending. Unlike last year there will be decreased support for customer-focused technical service work. Savings in R&D expenditures will be achieved by continued reductions in technical work force, movement of technical development to India and the former Eastern bloc states, and leveraging scarce resources through alliances and joint ventures—including universities and federal laboratories.

- Within the past year, more countries and regional governments have announced initiatives to invest in and build innovation capacity as a driver for economic growth and competitiveness. The U.S. government continues to follow a long-held policy of *laissez faire*, which has served it well in the past but may need to be reexamined.

- Industrial R&D, while still dominated by in-house development work, is increasingly turning to collaborative programs, as opposed to outsourcing, with supply chain partners, universities, federal laboratories,

and even competitors. Such joint efforts are now viewed as necessary to gain more rapid access to technologies, not simply to cut costs.

R&D INVESTMENT

R&D funding by industry remained essentially steady in 2002 and 2003 after more than ten years of growth, with half of those years recording near or above double-digit percentage increases. The Battelle R&D Magazine[1] study has estimated that the increase for 2003 was 0.6 percent over 2002, taking industry's R&D investment to $179.6 billion last year. Battelle projects an increase in industry R&D funding of 0.8 percent for 2004, to $181.1 billion. IRI's Trends Forecast for 2004[2] shows 70 percent of companies expect between a 2.5 percent increase and greater than 5 percent decrease in spending year-to-year. The number of companies forecasting **reduced** spending rose significantly again. Comparing previous forecasts to actual, this information supports a slight increase in spending to $180.1 billion. The estimate is supported by anecdotal evidence gathered more recently in meetings with industrial research leaders and the advantage of seeing actual business performance and employment trends for a number of months. Although the economy shows signs of recovery, lagging consumer confidence, a large predicted federal deficit, and almost certain reduction in support for non-defense/ security basic research fuels conservative action by industrial management. It looks like another year with industrial R&D spending failing to cover inflationary costs. These estimates are reflected in Figure 1, which tracks or predicts R&D investment by industry over 10 years through 2004. Year-to-year percentage changes are shown in Figure 2.

Industry's performance of R&D in 2003 was $196.1 billion, up 0.8 percent from $194.6 billion in 2002. Battelle projects an increase of 1.0 percent during 2004, bringing industry's total R&D effort to $198.1 billion this year. Using revised estimates for the proportion funded by industry, and recognizing that government and non-profit funding for industrial research are not as volatile, we estimate that the value of R&D performed by industry will be closer to $197.1 billion, up only 0.5 percent. Thus, industry will **fund** more than 62 percent and **perform**

[1] Studt, Tim and Duga, Jules, "Federal R&D Offsetting Industrial Cutbacks," *R&D Magazine,* January 2004, pp. F1-F15.
[2] "Industrial Research Institute's R&D Trends Forecast for 2004," *Research-Technology Management,* January-February 2004, pp. 17-20.

some 68 percent of the $300 billion we estimate will be invested in U.S. R&D in 2004, a decrease of several percentage points from recent years.

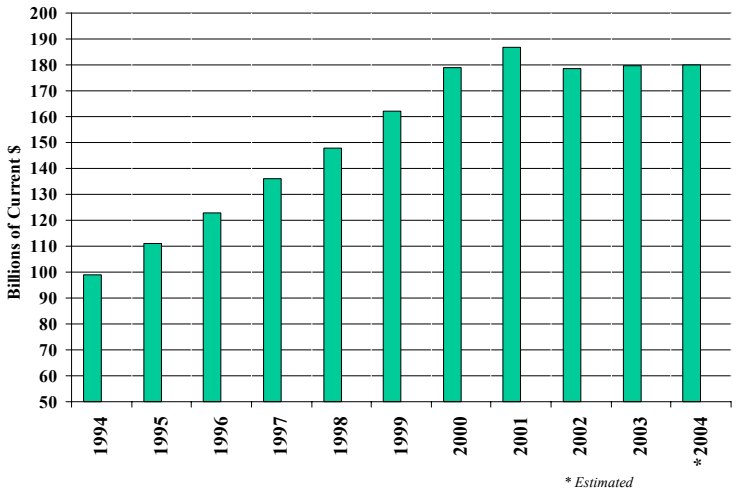

Figure 1. R&D Investment by Industry, 1994-2004

R&D TRENDS FOR 2004

The Industrial Research Institute (IRI) R&D Trends Forecast, based on replies from 98 IRI member companies during the third quarter of 2003, continues to forecast a minor retreat from the historical pattern of continued growth in R&D of the late 1990's. It clearly suggests a reduction in support of existing business R&D and directed basic research. The forecast reduction in directed basic research must be tempered by the understanding that this data set does not include an appropriate proportion of respondents from the biotechnology enterprises and other small companies built on emerging technologies, which invest significantly in this category. It does include traditional pharmaceutical companies, whose support of directed basic research is strong, both in-house and in universities. Likewise, even though the auto industry is increasing its research budget, much more is being placed into moving the next models with high technology more quickly to the marketplace and less on futuristic concept vehicles.

As with the 2003 data, there is recognition that internal R&D has the potential to create new businesses, possibly in a more cost-effective manner than acquisition, thus creating sustainable technological competitive advantage. And in response to the recognized difficulty initiating new businesses within an existing corporate structure (crossing the "valley of death"), more companies are spinning out new business ventures spawned by their technology platform development successes.

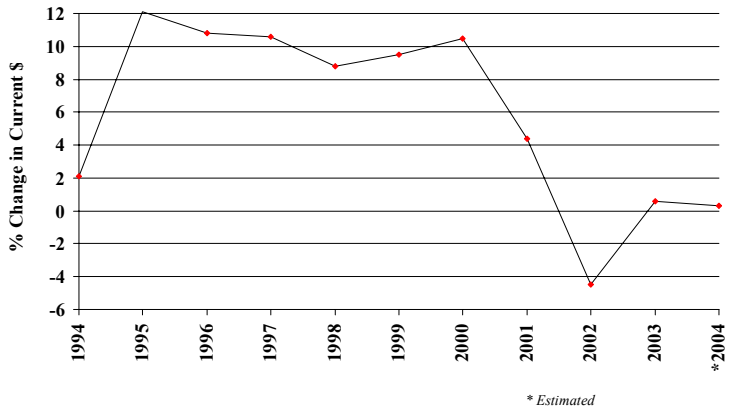

Figure 2. Change in Industrial R&D Investment, 1994-2004

IRI's forecast suggests that, in addition to support of new business growth, member companies will invest in partnerships and new ventures, at an increasing rate. Continuing to reduce staff, companies are indicating a much greater willingness to leverage their core talent with investments in partnerships within their supply chain and with competitors. Companies have balked at new requirements to support government as well as partnership work under arrangements with the national laboratories. Because of increasing difficulty reaching agreement on intellectual property rights under partnerships with universities, many companies expect to negotiate with fewer separate entities. There is concern that industry's support for university work is skewing the academics' focus and students' training away from basic research toward more short-range efforts.

The drop in industrial R&D spending during difficult times is not wise, according to some studies. However, major advances have been made in high-throughput methodologies of research, advanced modeling techniques to reduce expensive experimentation and scale-up, and the whole field of informatics. This means more efficient research. U.S.-based companies are increasingly outsourcing software and other research to Indian companies. The reduced costs and abundance of talented scientists and engineers is appealing. The downside is a real potential to lose intellectual property as Indian professionals start their own businesses with what they have learned in U.S. companies. This is very similar to success stories of the last few decades within the U.S. Another strategy, rarely cost-driven, is the location of laboratories in emerging markets, such as the People's Republic of China.

After a three-year period with no significant change, it appears that capital spending for R&D will decrease. Likewise, forecasts for staffing levels and hiring of new graduates are more pessimistic than last year.

GLOBAL INNOVATION STRATEGIES

Countries all over the world are taking a close look at their innovation systems, tuning or revamping them, to insure economic security. Those that recognize and plan for a global economy are most likely to thrive.

United States: Over the past ten years, a new informal innovation system evolved in the U.S., with support from government and industry for basic research in universities, nurtured by rapid growth in venture capital, and implemented by industrial firms through strong investments in R&D, capital equipment, and information technology. This highly complex system of innovation is also based on close collaborations and increasing alliances among industry players, universities, and government labs. There are now stresses in this proven formula.

The major discontinuity in venture capital funding following the collapse of the Internet bubble has not been reversed. Many entrepreneurial businesses are still waiting in the wings for seed capital. But the U.S. still has a more robust system of early stage capital than most economies.

Unfortunately, our government continues its pressure to eliminate the Advanced Technology Program (ATP) and Manufacturing Extension

Partnership (MEP) at the National Institute of Standards and Technology (NIST; see Chapter 13). ATP provides a unique source of early stage support of emerging technologies, those still at a stage in their evolution too risky for any but angel investors. Although the program awardees provide most of the research funds, the small ATP grant helps reduce the risk in undertaking necessary advanced work. MEP allows small and emerging enterprises to share facilities and expertise that would be prohibitively expensive in early stages of business development. Their elimination would adversely affect efforts to create jobs in the U.S.

In spite of a congressional mandate to the national laboratories to partner with industry, funds for partnership programs have been disappearing. On the positive side, funds for federal R&D continue to grow and provide more appropriate support for physical sciences and engineering through support for the National Science Foundation.

It is imperative that the whole **system** of innovation in the U.S., and its competitiveness opposite increasingly popular global venues for research, is studied, understood, and enhanced. This approach, to increase the attractiveness of the U.S. to both foreign direct investment and our own global companies, is far more likely to succeed than a retreat to protectionism.

Europe: The economic situation in Europe remains difficult, constraining decision-making as far as R&D is concerned. The actions taken at the Lisbon and Barcelona summits (aiming for a significant increase in R&D investment by the private sector in support of a more competitive knowledge-based economy) remain high on the political agenda. However, it is hard yet to discern any resulting decisions that will lead to more investment by companies in R&D within Europe.

The main change factors for industrial research include: the consequences of limited market growth in Europe; the opportunities to invest elsewhere either in support of new markets or in search of top talent; and the world of "open innovation" in which collaboration between companies and with public research organizations takes on a more important role.

There is no particular evidence that sectors are making different decisions about the extent of their R&D investment; merely about its location and nature. There seems to be some decline in the use of

corporate venturing for the time being, after sharp growth a couple of years ago. Globalization is being driven (in the pharmaceutical sector particularly) by the need to be near concentrations of excellence in North America, by the opportunities for market growth (in several sectors), and by the establishment of standards and local visibility that are now possible in India and China. Costs are secondary considerations.

Some countries, particularly the United Kingdom, are undertaking major reviews of their innovation policies. The "social consensus" of free access to universities for all is under strain as governments struggle to balance the desire for more education with the realities of research excellence. There is general public desire to see a large number of new jobs (800,000 by 2010) created in R&D, but not yet widespread recognition that this can only happen and be sustainable if the right market conditions exist that will justify training and then employing more people in this way. In a number of major European countries, public investment in R&D is very tight, leading to labor unrest, for example in France and Italy.

Latin America: A movement is underway to initiate a "Framework for the Americas" based on the European model. Its purpose is to develop and nurture entrepreneurs at the grass roots. Many structural elements within the innovation and financial systems of the various countries will need to be addressed before or during such an ambitious initiative.

Asia: The political leadership of the People's Republic of China (PRC) encourages investment in R&D by Chinese and foreign companies through tax credits, support of universities and institutes, establishing science/industry parks, and increasing funds to support small and medium enterprises. It has openly emulated the ATP with its 8-6-3 partnership program. The "rule of law" in business and intellectual property rights (IPR) is gaining ground through education of the populace to the long-term benefits that accrue to all by observing these rights. In spite of the difficulties, U.S. companies have learned to deal with most of the concerns about IPR, the workforce, partnerships within the PRC, and government regulations. Most are expanding their labs.

Japan, by focusing on manufacturing, is emerging from its long depression. Research prioritization and improved efficiency, matching funds from the government, and partnerships with universities have all

helped. Implementing control of IPR flow and manufacturing know-how into neighboring countries has encouraged repatriation.

Japan is striving to be "an advanced science/technology-oriented nation" and this is reflected in its top five sectors: pharmaceuticals, communication and electronic instruments, precision machining tools and practices, electric appliances, and chemicals. Some support for basic and directed basic research has been redirected toward development. Japan is in the second five-year term of its "Science and Technology Basic Plan," focusing now on actualizing the technologies developed in the first term, developing inter-organizational partnerships consistent with "open innovation," improving the business processes of R&D, expanding "management of technology" training, and globalizing R&D.

Korea spent $14.4 billion in 2002 for R&D, up 7.2 percent. Basic, directed basic, and development efforts were proportioned similarly to other industrialized countries. Korea will again increase R&D expenditure 14.6 percent in 2004, focusing on telecommunications, electronics, computers, and medi-optical equipment. These investments, despite the economic turndown, demonstrate a commitment to innovation. A significant number of Korean firms moved manufacturing facilities offshore, mainly to China. However, no R&D has yet relocated. The government's R&D policy is to strengthen domestic R&D, to transform the economy toward higher value-added products, to accelerate the next generation growth engine, and to ultimately become a technologically powerful country. The plan includes focusing on ten next-generation technologies, creating a core technology research pool of 10,000 people, and supporting innovation with an appropriate governmental R&D budget.

CONCLUSIONS

The year 2004 will again be difficult for the U.S. industrial research establishment. In spite of economic malaise, international threats, and the growing deficit, industry must initiate bold steps to prepare themselves to thrive and to structure the nation to again be the premier R&D site for global technology-based companies. We know what needs to be done.

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