RESEARCH AND DEVELOPMENT

Where Is the New Science in Corporate R&D?

A survey shows that companies conduct most new science in developed rather than developing economies for reasons that may not always characterize the U.S. situation.

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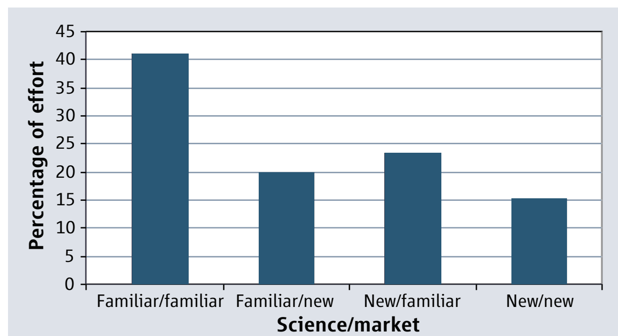
The idea that the United States dominates cutting edge science and technology is challenged by the decline in the U.S. share of patents and the growth of corporate spending on research and development (R&D) in emerging countries like China and India (*1–3*). Because scientific discovery is critical to economic growth, these trends have sparked concerns as to what is driving companies to conduct R&D in these countries and the implications for future competitiveness, particularly given problems with the U.S. patent system and improving protection of intellectual property (IP) in emerging economies (*4–9*). Similar concerns pervade European innovation policy initiatives (*10*). The popular press has fueled these concerns with reports of R&D moving to emerging countries in search of low costs (*11*).

A survey we conducted of 249 R&D-intensive companies headquartered primarily in the United States and Western Europe revealed that respondents expect their R&D to grow in emerging economies and to decline in developed economies for complex reasons (*12*, *13*). Lower R&D cost in emerging economies was not the main reason; market factors, collaboration with university scientists, and quality of R&D personnel were all at least as important as cost (*12, 14*).

Here we focus on the type of R&D conducted in different countries and argue that appropriate policies in the face of globalization should focus not only on the factors affecting location but also on the type of R&D conducted. We categorize R&D according to a taxonomy suggested by R&D executives as one they use in tracking internal R&D. This allows us to focus on the extent to which companies use cutting-edge science and show that the type of industrial R&D differs substantially in developed versus emerging country sites. An econometric model is used to relate the type of R&D at various sites to country characteristics. In the survey, respondents were asked to identify a recently established or currently planned R&D facility both outside and inside the home country. Respondents identified 145 facilities in developed economies (primarily the United States and Western Europe) and 90 in emerging economies (primarily China and India). They were asked to characterize the technological and market focus of R&D at the site. The technological focus was defined as either (i) a novel application of science as an output of the R&D (it could be patentable or not) or (ii) an application of science currently used by the firm and/or its competitors. We refer to (i) as new science and (ii) as familiar science. The market focus was defined as either (iii) to create products or services that are new to the firm or (iv) for the improvement of products or services that the firm already offers its customers or where it has a good understanding of the end use. We refer to (iii) as new markets and (iv) as familiar markets. Combining these foci gives four types of R&D: new science to create new markets, new science to improve familiar markets, familiar science to create new markets, and familiar science to improve familiar markets.



Type and purpose of R&D.

To clarify, when Pfizer developed Viagra, it was a new molecular structure with application in a market not served by Pfizer. It was new science for a new market. Cialis, based on the same molecular structure, was later developed by Lilly to serve a new market for Lilly. It was familiar science for a new market. Once-a-week versions developed by either company would be familiar science for familiar markets.

We asked respondents for the percent of effort at the site devoted to each of the four categories (see figure, above). The R&D executives we interviewed claimed this classification is more relevant to their R&D than the more "linear and sequential" taxonomy of basic or curiosity-driven research, applied research designed for specific end use, or development to improve products or processes (*15*). The two taxonomies provide different views of corporate R&D. For example, in 2004 the National Science Foundation reported that 4% of U.S. industry expenditure on R&D was for basic research, 19% was for applied research, and 77% was for development (*1*). By contrast, in our taxonomy, 38.8% of R&D at identified sites involves new science, while 61.2% is familiar science.

The focus here is on the percent of effort devoted to new science, regardless of whether it is for new or familiar markets. The histograms in the chart (p. 1548) give responses for the percent of effort devoted to new science in developed versus emerging economy sites. The percent of effort devoted to new science in developed economy sites is more evenly distributed than it is for sites in emerging economies. In the latter, almost 71% of the sites conduct 25% or less new science. On average, 49.6% of R&D effort in developed economy sites is for new science; in emerging economy sites, it is only 22%. The contrast is more striking when responses are weighted by the number of technical employees at each facility: The weighted averages for new science are 56% in developed economy sites and 11.5% in emerging economy sites.

To identify factors behind the type of science at a site, a logistic regression approach for grouped data was used to relate the ratio of new to familiar science in the identified facilities to respondent views of a variety of other country-specific characteristics (*16*). The model controls for industry, the firm's total worldwide technical employment, and whether the country of the facility is developed or emerging. Data for the other country char-

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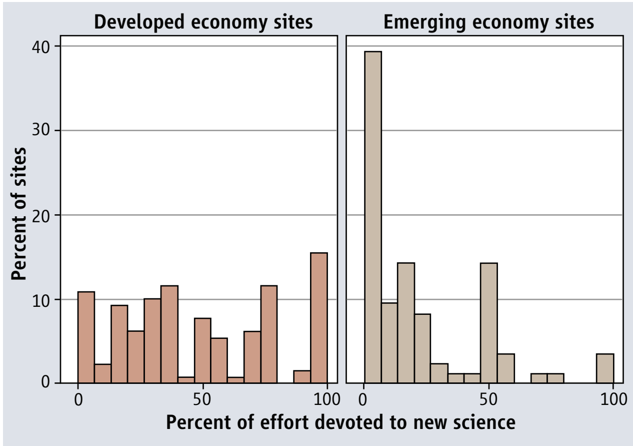
acteristics come from an index created from responses regarding a series of statements or factors that, if true for a country, would be a positive factor for locating a facility there. For each factor, respondents were first asked the extent to which they agree or disagree that the factor accurately characterizes the country in which the facility is located. They were then asked how important or central the factor was in the deliberations on location of the facility. Responses on agreement and importance were combined to create a measure of the extent to which a factor drove the location decision. We then tested the hypotheses that some of these factors are also central to the type of R&D conducted (see table below).

Because one would expect the availability of high-quality personnel to be important for any kind of scientific research, it is not clear how the ratio of new to familiar science would vary (if at all) with the quality of personnel. Our regression analysis showed that, although quality of R&D personnel affects location decisions, it is not significantly related to the type of science. Cost was significantly related to the type of science with an increase in cost decreasing the ratio of new to familiar science. Growth potential and supporting sales were expected to be more important for familiar than new science, because R&D in those cases is likely to be product localization. An increase in market potential or a facility that supports sales is associated with a decreased ratio of new to familiar science. Results for the two IP factors were similar to those for quality of personnel, in that the IP factors were statistically important in location decisions, but were not significantly related to the ratio of new to familiar science. Thus IP protection appears to be equally important for both new and familiar science. In terms of the Viagra/Cialis example, it would not be surprising that Pfizer and Lilly consider IP protection equally important for both products, even though the former represents new science and the latter familiar.



New science in developed and emerging economy sites.

The most striking result is that the factors related to universities (presence of university faculty with special expertise and ease of collaboration with universities) had the strongest impact on the type of science conducted. Each is statistically significant in the regression, and an improvement in either leads to a substantial increase in new relative to familiar science (*16*).

The relative importance of factors is summarized in the table, left (*17*). With regard to government and university policy, these results suggest that, for developed economies to maintain an advantage for cutting-edge corporate research, the keys are maintaining excellence and accessibility of research universities. The new science at sites identified by our respondents is largely conducted in developed economies, and this is significantly related to university factors. In the survey, respondents were more likely to agree that both faculty expertise and ease of collaboration with universities are greatest in developed economies.

Relative Factor Importance

Factor*	Rank
University collaboration	1
Faculty expertise	2
Cost	3
Growth	3
Supporting sales	5
IP protection	Not important
Ease of ownership	Not important
Quality R&D personnel	Not important

*Costs of R&D are exclusive of tax breaks and government assistance; growth refers to market growth potential in that country, Ease of ownership is the ease of negotiation for ownership of IP from research relationships, and IP protection refers to its strength.

Nonetheless, there is a cautionary message. Although respondents claim it is easier to collaborate with universities in developed countries, there is mounting evidence of changing corporate sentiment. U.S. universities have become more aggressive in negotiating IP terms, enough so as to instigate policy discussions on new guidelines for corporate-university research agreements (*18*). Recent research on university industry collaboration in the European economies that have adopted U.S. policies regarding university research shows similar concerns (*19*). This dynamic will only be accentuated as the quality of universities in emerging economies improves.

References and Notes

1. National Science Foundation, *Science and Engineering Indicators* (NSF, Washington, DC, 2006).
2. J. Landefield, R. Mataloni, Working Paper 2004-06 (U.S. Bureau of Economic Analysis, Department of Commerce, Washington, DC, 2004); www.bea.gov/bea/working_papers.htm.
3. Economist Intelligence Unit, "Scattering the seeds of invention: The globalization of research and development" (White paper, Economist, London, 2004).
4. R. Nelson, *The Sources of Economic Growth* (Harvard Univ. Press, Cambridge, MA, 1996).
5. Committee on Prospering in the Global Economy, *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future* (National Academies Press, Washington, DC, 2006).
6. R. Freeman, NBER Working Paper 11457 (National Bureau of Economic Research, Cambridge, MA, July 2005).
7. A. Jaffe, J. Lerner, *Innovation and Its Discontents: Our Broken Patent System Is Endangering Innovation and Progress* (Princeton Univ. , Princeton, NJ, 2004).
8. N. Zamiska, *WSJ* (3 June 2006), p. A3.
9. L. Branstetter, *Q. J. Econ.* **121**, 321 (2006).
10. Aho Group report, *Creating an Innovative Europe* (European Commission, Brussels, 2006); http://ec.europa.eu/invest-in-research/action/ research06_en.htm.
11. Taken from 38 of 61 articles on R&D moving off-shore in the *WSJ* and *New York Times* 2002–2006.
12. J. Thursby, M. Thursby, *Here or There? A Survey on the Factors in Multinational R&D Location* (National Academies Press, Washington, DC, 2006).
13. The companies included are R&D-intensive firms large enough feasibly to have multiple R&D facilities. Because of confidentiality agreements that made this study possible, firm-specific data are not available.
14. For R&D facilities in developed economies, the same factors are important, except cost is not important and IP protection is important. Weak IP protection is a deterrent to locating in emerging economies.
15. J. Marburger, *Science* **308**, 1087 (2005).
16. Details are in the supporting online material.
17. The most important factor has rank 1. The rank is based on the absolute size of the elasticity showing the impact of the factor on the type of science. The factors ranked as "not important" are not statistically significantly related to the type of science.
18. www7.nationalacademies.org/guirr/Meetings.html
19. F. Valentin, R. Jensen, *Effects on Academia-Industry Collaboration of Extending University Property Rights* www.cbs.dk/forskning_viden/fakulteter_institutter_centre/institutter/oekonomi/biotech_business/menu/publikationer.
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