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FROM THE ANALYST'S COUCH

Location of pharmaceutical innovation: 2000–2009

Yali Friedman

The growth of research capabilities in emerging economies such as India and China has led many to question the status of innovation in the current leading economies such as the United States. Indeed, lower costs in emerging economies have already led to a substantial increase in the outsourcing of some of the more routine activities involved in pharmaceutical research and development (R&D), such as compound synthesis and preclinical toxicity tests, to organizations in these countries. Similar trends are seen in other research-based industries, such as information technology.

A key question for the countries in which the leading companies in research-based industries are currently based is the extent to which an analogous shift in the volume and value of innovative science research from these countries to emerging economies occurs; for example, through the stimulation of innovation by government initiatives in these countries. Although outsourcing of process-oriented tasks could allow a greater volume of innovative R&D to be performed for a given level of investment, losing leadership in scientific innovation may result in an inability to capture value from it, and, potentially more importantly, a reduced ability to influence

the direction of innovation. For example, one benefit of being a leader in innovation is the ability to focus research activities on health conditions or engineering problems that are of particular interest to the country in question. Indeed, as the level of innovative pharmaceutical R&D in countries such as China has increased, one major focus has been on diseases that are more common in Asia than elsewhere, such as liver cancer¹.

This paper focuses on the location of innovation in the pharmaceutical sector, and differs from previous studies by using a more robust methodology to track the global distribution of R&D, which could also be applicable for future assessments to understand trends in the location of innovation.

Analysis methods

Previous studies on the location of innovation have tracked factors such as the flow of scientists between countries^{2–4} and the output of scientific literature^{2,5}. Although metrics such as these can be used to assess basic science output, they lack precision; the productivity of individual scientists and the quality and impact of research papers are generally not addressed. By focusing on patents — which can be linked to tangible outputs — global productivity in

the pharmaceutical sector can be more readily measured, and so this approach has been applied for this analysis.

The United States is the world's largest pharmaceutical market, comprising roughly 40% of the world's pharmaceutical revenues⁶. Accordingly, the majority of pharmaceuticals developed worldwide would be expected to be marketed in the United States, making it a good environment in which to examine the worldwide distribution of pharmaceutical innovation. An additional benefit to focusing on drugs marketed in the United States stems from its relatively simple regulatory structure. Approval decisions in the United States are made by a single body — the Food and Drug Administration (FDA) — which requires drug companies to list the patents that protect their drugs in the FDA Orange Book. This linkage between drugs and patents facilitates assessment of the location of innovation, because the US Patent and Trademark Office (PTO) requires that a patent lists all the inventors. The US PTO's inventor criteria are also well defined: the inventor must contribute to the conception (and not merely the reduction to practice) of the invention, and must maintain intellectual domination of the work⁷. A patent that is overly inclusive or that excludes inventors can be deemed invalid or unenforceable, which creates a strong incentive for patent applicants to strictly follow the guidelines set by the US PTO.

Other studies of global pharmaceutical innovation have used methodologies such as the location of company headquarters as a measure of the location of innovation⁸. However, such studies are inherently limited by the fact that larger pharmaceutical and biotechnology companies may have several locations in a single country, and many more around the world (any of which could be the site of the innovation). Additionally, the inventors may not live in the same country as the corporation named as the patent assignee, and the development of drugs may involve contributions from researchers in multiple countries. This study resolves such issues by focusing on the location of the listed inventors of pharmaceutical patents in the FDA Orange Book. ▶

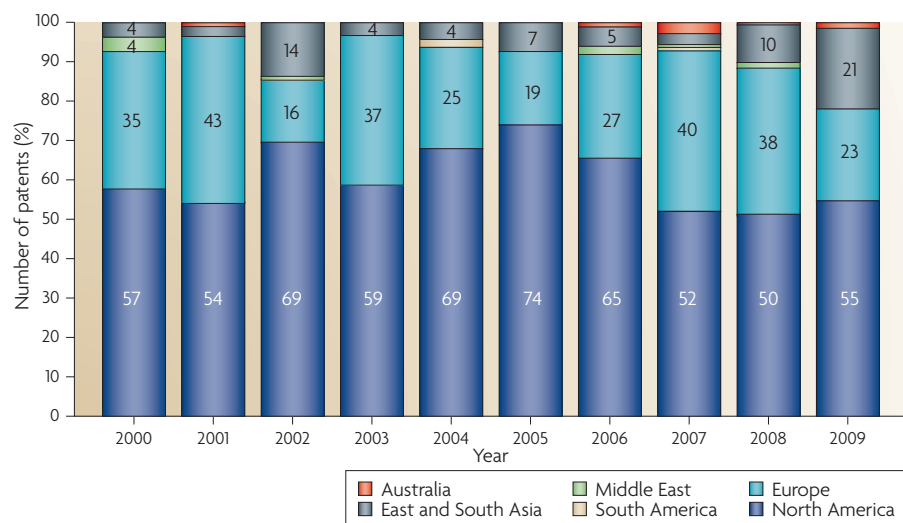


Figure 1 | **Normalized locations of drug patent inventors by region.** Each region's representation is plotted as a proportion of all patents on drugs approved in a given year. *Data for 2000 were only available from January through to June.

LOCATION OF PHARMACEUTICAL INNOVATION | MARKET INDICATORS

Archived FDA Orange Book data sets from December of each year were used to compile the annual set of patents (data sets for 2000 were only available from January through to June). Only patents listed in the same year as a drug's approval were considered to maintain a focus on the research that led to a drug's initial development. This focus on early patents was used to avoid including research into derivatives or enhanced formulations; the follow-on patents may be materially different from the initial patents and may therefore involve inventors in different locations than the locations of the original inventors, so including later patents could obscure trends in innovative pharmaceutical research.

For the purposes of determining the country or region of invention for patents with multiple geographically dispersed inventors, each inventor was assigned a fractional representation. For example, a patent with a single Canadian inventor would be counted

as a single patent being developed in Canada. For a patent with two Swiss and three German inventors, Switzerland would be given 40% of the credit for the patent and Germany would be given 60% of the credit.

Findings and discussion

There were 1,400 first-year patents granted to drugs approved between 2001 and 2009. Inventorship of these patents was concentrated in a small number of countries: 60% of inventors were from the United States, and 31.5% of inventors were from just seven other countries (United Kingdom, Japan, Germany, Sweden, France, Switzerland and Belgium).

A regional overview of patenting activity in the period studied is shown in FIG. 1. A modest decrease in representation of North American inventorship was observed, with oscillations in Europe being balanced by increased representation of East and South Asia. The ten countries with the greatest representation of inventors are shown in

FIG. 2, providing a greater definition of where pharmaceutical innovation occurred. An immediate observation from FIG. 2 is the strong representation of the United States and the traditional European pharmaceutical strongholds: the United Kingdom, Germany, Sweden, France and Switzerland.

So far, the emerging markets of India and China are largely absent; the key source of the East and South Asian region's representation in pharmaceutical innovation is Japan.

These data show a subtle relative decrease in pharmaceutical innovation in the United States, but the United States remains the single-largest location of pharmaceutical invention. They also show that while the established pharmaceutical countries remain strong, there is little measurable innovative activity from India (one inventor) or China (two inventors) between 2001 and 2009. Given the substantial time lag — often ~10 years or more between the initial discovery of a potential drug and its market approval — and the recent nature of the increase in investment in innovative research in such countries, this observation is not unexpected. Continued observation of inventor locations using the methodology applied in this analysis could indicate the extent to which these countries contribute to FDA-approved drugs in coming years, and can provide objective perspectives on the quantity and value of pharmaceutical innovation around the world.

Yali Friedman, Ph.D., founder of DrugPatentWatch.com, is at thinkBiotech, 3909 Witmer Rd No. 416, Niagara Falls, New York 14305, USA. e-mail: info@thinkbiotech.com

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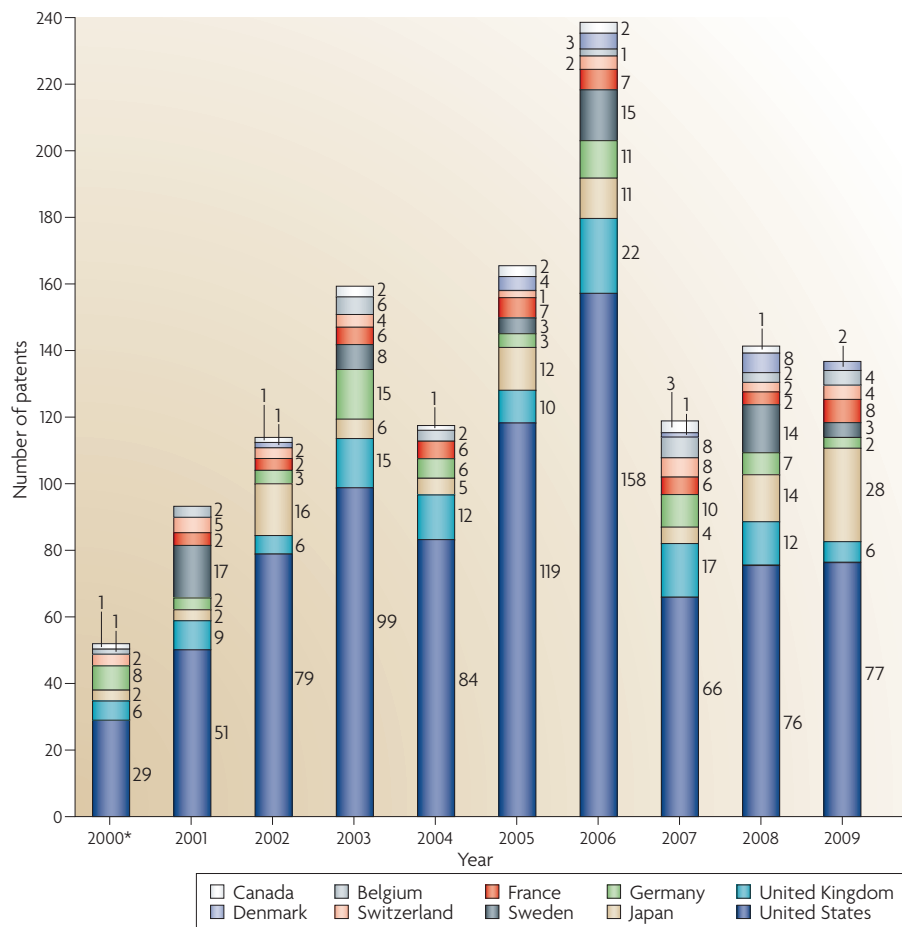


Figure 2 | Locations of drug patent inventors by country for the top ten countries. *Data for 2000 were only available from January through to June.

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Competing interests statement
The author declares no competing financial interests.