Competing for the Future:
Patterns in the Global Location of R&D Centers by the World's Largest Firms

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Innovation is critically important in contemporary economies. It is a key driver of the improvement in consumers' living standards, the growth and success of firms, and the wealth of nations. Investment in research and development (R&D) is essential for firms and nations to produce innovations and compete for the future. However, in recent years, observers and policy makers have raised concerns about whether R&D will follow manufacturing and service jobs offshore [(1-5)] instead of staying local as some economists suggest [(6)]. These concerns are especially salient in the case of large multinational corporations. Multinationals play dominant roles in driving R&D in their respective home countries, but given their international scope, they are also likely to offshore R&D [(7-8)]. Multinational firms' decisions to locate R&D activities in emerging nations can repatriate brain power to and spur economic development in those nations [(9)]; but it can also lead to a loss of high-paying jobs, intellectual capital, and valuable innovations in developed economies [(10)]. The recent turmoil in the U.S. and in European economies and the politicization of offshoring have underscored the importance of multinational firms' location of R&D.

Despite the importance of this issue, current data on offshoring of R&D by multinationals is scarce. We do not know where multinationals currently locate their R&D centers, which nations have the most R&D centers, and which nations have the highest net gains (inbound minus outbound) from multinationals' R&D offshoring [(12-13)]. Moreover, much R&D offshoring activity has occurred in the past few years, whereas most existing research is based on information collected prior to this period. Conclusions based on outdated data can lead to misguided policy on an important, rapidly-changing economic issue. Moreover, while the focus of recent reports has been on outbound R&D activity from the US, these reports have ignored the issue of inbound R&D, which may balance or exceed outflows. Focusing on only outbound R&D (offshoring) provides an unbalanced picture that might result in overly alarmist conclusions leading to incorrect and even harmful scientific policy.

We examined the R&D locations of the 500 largest multinationals globally as compiled by *Fortune* magazine in its *Fortune Global 500* listing. Prior research on the topic has relied primarily on survey response. However, surveys suffer from low response rates and problems of bias, about which scholars have warned [(14-15)]. In contrast, we collected data from several archival sources [see supporting online material]. Our analysis of the data shows which nations have the most multinational R&D centers, which have most outbound and inbound R&D, and which have the highest net gains in R&D centers. Our analysis also shows variations across industries in these patterns and the key drivers of inbound R&D decisions.

R&D No Longer Stays Near Home: China and India Rising

"Figure Distribution of Global R&D Facilities here"

While developed nations, notably the U.S., Germany, Japan, and the U.K. with 502, 153, 151, and 109 R&D facilities, respectively, continue to host most large MNCs' R&D activity, China and India already rank 5th and 7th with 98 and 63 R&D facilities, respectively. The results are surprising because China with 24 and India with 6 host only a fraction of the 500 largest multinational firms. These findings also run counter to past research that suggests that when multinationals go across borders they locate primarily in developed nations [(16)]. Our data shows multinational corporations increasingly choose to locate their R&D facilities in developing nations and that R&D offshoring to India and China is substantial. The practice also runs counter to normative recommendations that multinationals should locate their R&D facilities in their countries of origin, close to headquarters, to maintain secrecy and exploit implicit knowledge [(3)].

U.S. multinationals offshore a smaller proportion of their R&D facilities than their Japanese and Western European counterparts. Specifically, US multinationals locate more R&D facilities at home than do multinationals in other developed economies: more than half of all R&D facilities of US multinationals are based in the US. In contrast, Dutch and French multinationals locate less than a third of their R&D facilities in their home economies.

Inbound R&D Facilities: The US Dominates

"Figure Countries Benefiting from Multinational R&D Offshoring here"

The USA attracts by far the largest number of R&D facilities from foreign multinational firms (227). China, the UK, and Germany each attract about one-third the number of R&D facilities as the US (73, 72 and 72 respectively). India attracts more inbound R&D facilities from the largest foreign multinational firms than do other prominent nations such as Japan, France, Canada, and Brazil.

As of today, India attracts more R&D facilities from U.S. multinationals in the *Fortune 500* than any other nation. The second largest target for US multinational R&D facilities is China, followed by the UK and Germany. The US attracts the most R&D facilities from Japanese, German, and French multinationals.

However, the US also acts as the greatest source of R&D facilities to other nations and, thus, ends up with a negative net gain from global R&D offshoring. After the US, Japan acts as the second largest source of multinational R&D facilities to other nations but it only ranks 6^{th} in attracting R&D facilities from foreign multinational corporations.

Indeed, our findings show some striking patterns in current global R&D. China, India, and Brazil have received the largest net gains (the number of inbound minus outbound R&D centers) in multinational R&D activity. On the other hand, France and Japan have the lowest net gains in multinational R&D centers.

Patterns of R&D Location Vary Substantially by Industry

Network/communications equipment and electronics are the industries responsible for the most offshoring of MNCs' R&D centers [supporting online material]. In addition to computers/software and pharmaceuticals, automobiles also contribute to the offshoring of MNC R&D centers. General Motors' very first R&D lab outside the US, for example, was established in India in 2003. In contrast, personal products, aerospace/defense, and telecommunications services have among the highest R&D concentration in home countries across industries (39%, 32%, and 26% respectively). In contrast, network equipment and electronics firms locate 74% and 66% of R&D facilities outside their home countries, respectively. Indeed, the US does not experience a net outflow of R&D centers across all industries. Contrary to popular belief, the US has a net gain of inbound R&D from large multinationals in electronics, telecommunications services, and industrial/farm equipment.

Science & Engineering PhDs Matter

What explains the decisions by multinational firms to locate R&D centers outside their borders? Why are some countries more successful in attracting R&D centers than others? Although the answers to these questions are undoubtedly complex, some tentative conclusions emerge from regression analyses of the drivers of inbound R&D [see supporting online material]. We examined a number of independent variables that may help predict a country's ability to attract MNCs' R&D centers from foreign multinationals. Among these are size of the economy (measured by each country's GDP), economic growth (measured by each country's GDP growth), intellectual property protection (measured using data from the World Economic Forum), and availability of an advanced scientific workforce (measured by number of science and engineering PhD graduates). Contrary to past commentaries[2-3] that suggest that economic growth or intellectual property protection drive the influx of R&D centers in a country, our analysis shows that a country's attractiveness to multinational R&D centers is primarily driven by the number of available science and engineering PhDs in that country. Economic performance, economic growth, and intellectual property rights did not significantly influence inbound R&D activity.

Conclusions

Our findings have several implications for research and policy. First, contrary to the conclusions of much academic literature, R&D is no longer based at home alone. Instead, countries like China and India are increasingly attractive R&D locations for Western and

Japanese multinationals. Despite this trend, however, the alarmist view that such increases come at the expense of R&D in the West is mistaken. As our second set of results show, the US remains the most favored nation in terms of inbound R&D for foreign multinationals around the globe. The alarmist view is further undermined when one examines the differences that exist across industries. Specifically, as our results show, some industries are simply more global in their R&D location choices than others. For these industries, the large number of R&D centers in China and India is accompanied by a large number of such centers in the US and Western Europe. For industries that are not globalized, and these are considerable, the US remains the most favored nation. Finally, our results suggest that a major factor behind the choice of a country for R&D is the availability of PhDs in science and engineering in that country. For any country to attract R&D activity in the future, maintaining a strong flow of science and engineering PhDs is crucial. For this purpose, two pathways seem equally important: 1) high school and undergraduate training that strongly encourages research careers and graduates programs that stay competitive with the labor market for undergraduates and 2) an immigration system that enables PhD granting institutions to attract and retain the best talent globally to complement and stimulate domestic talent.

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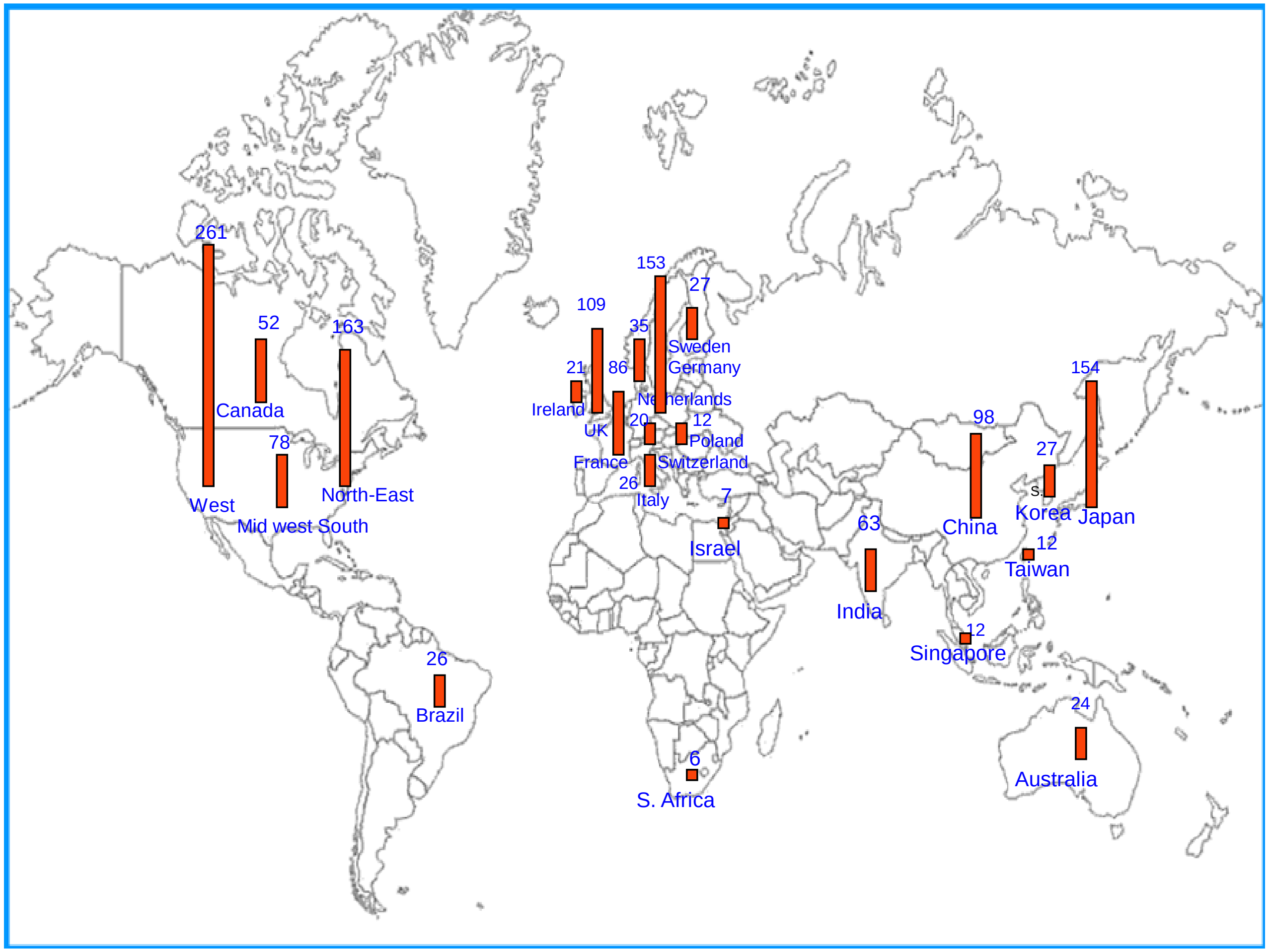
Distribution of Global R&D Facilities



Note: U.S. 'West' in the above map includes Texas.

Countries Benefiting from Multinational R&D Offshoring

		R&D Facilities Outbound	R&D Facilities Inbound	R&D Offshoring Net Benefit
1.	China	7	73	66
2.	India	0	57	57
3.	Brazil	0	23	23
4.	UK	51	72	21
5.	Ireland	0	19	19
6.	Australia	0	18	18
7.	Italy	5	16	11
8.	Poland	0	11	11
9.	Canada	30	37	7
10.	Israel	0	7	7
11.	Singapore	5	11	6
12.	South Africa	0	6	6
13.	Taiwan	4	6	2
14.	Sweden	25	16	-9
15.	Germany	82	72	-10
16.	S. Korea	24	10	-14
17.	USA	249	227	-22
18.	Netherlands	43	16	-27
19.	Switzerland	38	9	-29
20.	France	103	34	-69
21.	Japan	116	42	-74

Supporting Online Material on Method

In this study, we examine the R&D locations of the 500 largest multinationals globally as compiled by *Fortune* magazine in its *Fortune Global 500* listing. The sample covers a wide range of industries, including pharmaceuticals, chemicals, electronics, engineering, and equipment manufacturing. The study was conducted in three stages: sampling, data collection, and analysis.

Sampling

We first sought to identify the sample of countries and industries to study. For this purpose, we conducted interviews with managers and research officers based at multinational headquarters as well as subsidiaries in developed and emerging economies. Based on interviews with managers, we excluded financial services firms from our sample, because of the unique nature of financial services R&D. Discussions with decision makers and reviews of news reports led us to focus on 21 countries that currently seem to be major destinations for multinationals' R&D activity: USA, Canada, UK, Germany, France, Italy, Switzerland, Netherlands, Poland, Sweden, Ireland, Australia, Japan, China, Taiwan, India, South Korea, Singapore, South Africa, Israel, and Brazil.

Data Collection

The data collection was in four steps. First, we conducted an in-depth search of corporate and subsidiary websites across individual countries to objectively identify the location and number of R&D facilities across nations. Specifically, our search included R&D centers, labs, and offices. Second, we cross-checked and complemented these data with searches of the *Factiva* and *Corporate Affiliations* databases. *Factiva* provides news reports from global media, and includes reports of R&D activities. *Corporate Affiliations* is a repository of information of corporations' affiliates, subsidiaries, and divisions worldwide. Third, we further cross-checked a subset of these data by matching the locations of R&D centers with the addresses of inventors of patents assigned in the last three years to these firms. We used the Delphion database and the US Patent and Trade Office website for these patent searches. Fourth, whenever in doubt about the completeness of our dataset, we contacted managers of individual firms to cross-check the data. We collected all data on R&D location between January and September 2008.

Analysis: Drivers of Inbound R&D Location

In the third stage of the study, we analyzed the data collected. For this purpose, we clarify the independent and dependent variables.

Dependent variable: The main dependent variable is "Inbound R&D centers". It measures the number of R&D centers a country attracts from foreign multinationals (e.g., U.S. attracting R&D centers from non-U.S. multinationals).

Independent Variables: In addressing potential drivers of inbound R&D for a particular country, we account for a set of independent variables:

1. Size of national economy [Average GDP (1997-2007) corrected for Purchasing Power Parity]
2. Growth of national economy [Average GDP Growth (1997-2007) corrected for Purchasing Power Parity]
3. Intellectual Property Protection (Intellectual property protection score for each country from the World Economic Forum)

4. Availability of advanced scientific workforce (Total number of Science & Engineering PhDs awarded from the OECD Science and Technology Indicators)

We analyzed the impact of these variables on inbound R&D centers using a negative binomial regression model. Since inbound R&D centers are counts (i.e., they cannot be negative and they have to be integers), Ordinary Least Squares regression is inappropriate as an approach to model this data. The negative binomial regression is an appropriate model for such data, since this approach accounts for the unique nature of count data. Another approach to modeling such data is the Poisson regression; however, application of this approach to our data revealed significant over-dispersion in the model, indicating that the approach is inappropriate for these data.

Results of Analysis

Results from the negative binomial regression are in Table S2. Models 1-4 report univariate analyses of the effects of each independent variable on the number of foreign R&D centers in each country. The last column reports the results of the full model, which incorporates all the variables simultaneously. The results indicate that the Availability of Advanced Scientific Workforce has a significant and positive effect on the number of foreign R&D centers in each country. None of the other variables in the full model have a statistically significant effect on the number of foreign R&D centers.

Table S1. MNCs R&D Offshoring by Industries

Industry	Percentage (%) of R&D Centers Offshored
Network/Communications Equipment	74
Electronics	66
Petroleum Refining/Oil & Gas Equipment	58
Computers/Software	56
Pharmaceuticals	56
Motor vehicles and Parts	52
Chemicals	46
Industrial/Farm Equipment	45
Personal Products	39
Aerospace/Defense	32
Telecommunications	26

Table S2. Negative Binomial Regression Estimates for Drivers of Inbound R&D Location

Conceptual Variable	Independent Variables	Model 1	Model 2	Model 3	Model 4	Model 5
Size of Economy	GDP (PPP adjusted, 1997-2007)	3.2×10^{-4a}				-1.4×10^{-4}
Economic Growth	GDP Growth (PPP adjusted, 1997-2007)		1.4×10^{-4}			-1.3×10^{-4}
Intellectual Property Protection	Intellectual Property Protection Score			.02		.04
Availability of Advanced Scientific Workforce	Number of Science & Engineering PhD graduates				1.2×10^{-4a}	1.7×10^{-4a}
	Constant	2.63^{a}	3.45^{a}	3.38^{a}	2.49^{a}	2.23^{a}
		Pseudo R^2=.12 Log likelihood = -82.90	Pseudo R^2=.00 Log likelihood = -94.33	Pseudo R^2=.00 Log likelihood = -94.33	Pseudo R^2=.17 Log likelihood = -71.87	Pseudo R^2=.18 Log likelihood = -71.10

Note: $^{a}p < .01$, $^{b}p < .05$