Factors in International Location and Type of Corporate R&D:
Testimony to the House Subcommittee on Technology and Innovation[1]

Jerry Thursby
Professor & Ernest Scheller, Jr. Chair of
Innovation, Entrepreneurship & Commercialization
College of Management
Georgia Institute of Technology

Marie Thursby
Professor & Hal and John Smith Chair of Entrepreneurship
College of Management
Georgia Institute of Technology

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I. Introduction

The idea that the United States dominates cutting edge science and technology is increasingly challenged as the US share of patents and scientific awards declines and the media reports increasing corporate reliance on offshore research and development (R&D).[2] R&D globalization is also center stage in policy circles as questions are raised as to how the US and Western Europe can provide environments conducive to innovation.[3] Over a concern that policy discussions be informed by data, rather than case studies or anecdote, the Government University Industry Research Roundtable (GUIRR) of the National Academies asked the authors to undertake a study of the factors behind R&D site location with particular attention paid to the decision to locate in the home country *versus* other countries.[4] A survey was conducted in the summer and fall of 2005 and results can be found in Thursby and Thursby (2006a, 2006b).[5] The target firms were R&D intensive firms and large enough to feasibly have R&D facilities in multiple locations. The majority are firms whose home country is either the US or a country in Western Europe. For most of what follows we aggregate the responses of the US with those from Europe given that there are few differences based on the home country of the firm. Additional background on the survey is found in the appendices.

In this testimony we review and expand upon the findings of the earlier studies to address a series of questions posed to us by the Subcommittee on Technology and Innovation of the U.S. House of Representatives. We were provided with a list of questions. All of the questions pertain to the factors that influence R&D location, the types of R&D conducted in the US versus lower cost emerging countries, and the potential for government policies to attract and retain R&D in the US. Our survey evidence provides direct evidence on the relative importance of various factors, including policies, in both R&D location and the types of R&D conducted. Our results point to important differences in the factors that influence the decision to conduct R&D in developed economies *versus* emerging economies. Section II identifies trends in the distribution of R&D employment worldwide. Section III describes the factors considered in the survey and their relative importance for companies responding to the survey. Section IV addresses the types of R&D conducted in various locations and shows not only that there are clear differences in the types of R&D conducted in developed and emerging country sites, but the factors that are most important for the type of R&D conducted are somewhat different than those that influence site selection. The combined evidence is striking. As discussed in the conclusions in Section V, while cost is a factor it takes a back seat behind market and other input supply factors such as quality of personnel. Perhaps the most striking result is the importance of expertise in universities and an environment that facilitates collaboration with universities in both site location and type of R&D

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[2] A search of the archives of the *Wall Street Journal* and the *New York Times* over the period 2002-2005 showed 61 articles focused on the offshoring of R&D. Thirty-eight of these articles mentioned costs as a factor in offshoring decisions while 29 noted the quality of R&D personnel as a factor. Other factors were mentioned as well, though none as prominently as costs and quality of R&D personnel. Ten noted the role of output markets while 4 mentioned intellectual property regimes and 3 discussed the role of universities in the process.

[3] See, for example, the Council on Competitiveness, 2004, *Innovate America: Thriving in a World of Challenges and Change,* and the Committee on Science, Engineering, and Public Policy 2006, *Rising Above the Gathering Storm: Energizing and Employing American for a Brighter Economic Future.*

[4] Note that this study is a peer reviewed report *to* the National Academies rather than a report *by* the National Academies.

[5] Jerry Thursby & Marie Thursby, "Here or There? A Survey on the Factors in Multinational R&D Location," National Academies Press, 2006a. Jerry Thursby & Marie Thursby, "Where is the New Science in Corporate R&D?," *Science*, Vol. 314, December 2006b.

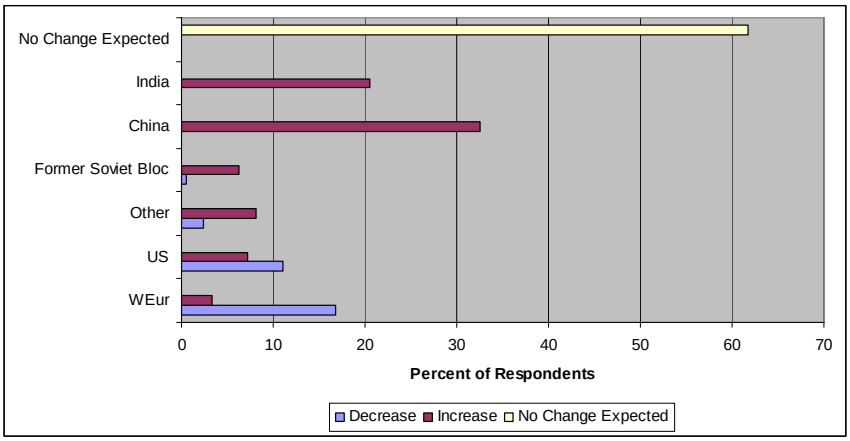
II. Current and Expected Future Distribution of R&D Employment

The firms who responded to the survey are generally multinational in their R&D efforts. Only about 15% of the 248 respondents currently have all R&D personnel in the home country whereas about 1 in 5 have more than half of R&D employees outside the home country.

While the primary focus of the survey was factors behind the respondents' recent R&D location decisions, some questions addressed whether the distribution of R&D employment is changing or is expected to change. Two hundred and nine respondents answered a question on whether they "anticipate the worldwide distribution of technical staff will change substantially" over the next 3 years. Thirty-eight percent indicated a substantial change was anticipated.

The firms expecting a change were asked for the region(s) where employment was expected to grow and for the region(s) in which it was expected to decline. Respondents were given five choices (they could choose multiple locations): *United States, Western Europe, Former Soviet bloc countries, China, India, Other.* Results are in Figure 1.

Figure 1. Anticipated Changes in R&D Employment



China and India are the regions where most growth is expected. The "other" category consists largely of targets in Asia. Net decreases are expected for the US and Western Europe. For the US, 23 respondents anticipate a decrease while 15 anticipate an increase. Fifteen of those anticipating a decrease are US firms and 2 of the 13 anticipating an increase are US firms. Thus 11% of the 209 firms expect to decrease employment in the US while 7.2% expect to increase technical employment in the US; the net change is 3.8%. A larger net change is expected for Western European countries. Seven firms (3.3%) anticipate an increase in technical employment in Western Europe and 35 (16.7%) anticipate a decrease.

III. Factors in Location Decisions

III.1 New or Planned R&D Sites

Unlike a number of prior surveys on factors behind R&D site locations, this survey did not ask respondents for their general perceptions about issues in globalization.[6] Rather, the survey linked factors to specific locations. Respondents were asked whether or not their firm had recently established, or was planning to establish, a facility outside of the home country. If the answer was "no" the respondent was not asked further about R&D site locations outside the home country. This strategy was used in order to minimize noise in the data. Focusing on an actual site decision should, in principle, minimize responses driven by what respondents think the factors *ought to be*. In a real sense, the survey solicited responses from those who had "done their homework" or were "doing their homework" about site locations outside the home country. The specific survey statement and question was:

> *Think about some of the more recent R&D facilities established by your firm. This can include facilities you are in the process of building or staffing or which are only in the planning phase. Choose one of these that is OUTSIDE the home country and that is both considered to be central to your firm's current R&D strategy and about which you are familiar.*
>
> *Does such a facility come to mind?*

If the answer was "yes" the respondent was asked a series of questions about the identified facility. This exercise was repeated substituting "INSIDE the home country" for "OUTSIDE the home country." Respondents could answer for a) an outside facility, b) an inside facility, c) both an inside and an outside facility, or d) they would not answer questions about location decisions.

[6] See, for example, the Economist Intelligence Unit 2004, *Scattering the Seeds of Innovation: the Globalization of R&D* and the Council on Competitiveness 2005, *National Innovation Survey*.

For identified facilities, respondents were asked for the destination country, the year the facility was established (or expected to be established) and number (or expected number) of technical employees. Ninety-two facilities were identified in the home country and 143 outside the home country. Table 1 gives the locations (both inside and outside the home country) identified. Facilities are broken down by the country location of the facility (the leftmost column) and home country of the respondent.

Given the attention that has been drawn to the establishment of R&D facilities in China and India, it is interesting to note that a substantial number of respondents were able to identify sites in developed economies. There are more sites identified in the US and Western Europe (128) than in China and India combined (73). Recall, however, that these responses are not for all recent or planned sites. Our question was about sites that are both considered central to overall R&D strategy and about which the respondent is familiar.

Table 1. Site Locations of Recent or Planned Facilities

	Respondent's Home Country			
Site Location	**US**	**Western Europe**	**Other**	**Total Sites**
US	34	14	0	48
Western Europe	19	61	0	80
China	30	23	2	55
India	9	9	0	18
Other	13	12	9	34
Total Sites	105	119	11	235

III.2 Size and Age of Selected Sites

As a measure of the importance of the site, respondents were asked both for the number of technical employees employed or expected to be employed in the facility and for the number of technical employees worldwide. Employment by facility and worldwide employment are highly skewed so both the means and medians are reported in Table 2.

Table 2. Number of Technical Employees

	Median Number of Technical Employees	**Mean Number of Technical Employees**
Outside/Emerging	50	205
Outside/Developed	44.5	127
Inside	90	219
Worldwide employment	700	3788

For each R&D site, the survey asked for the year it was established or, if it was a planned facility, the length of time before it would be operational. More than 80% of the facilities were established after 2000 or are planned facilities.

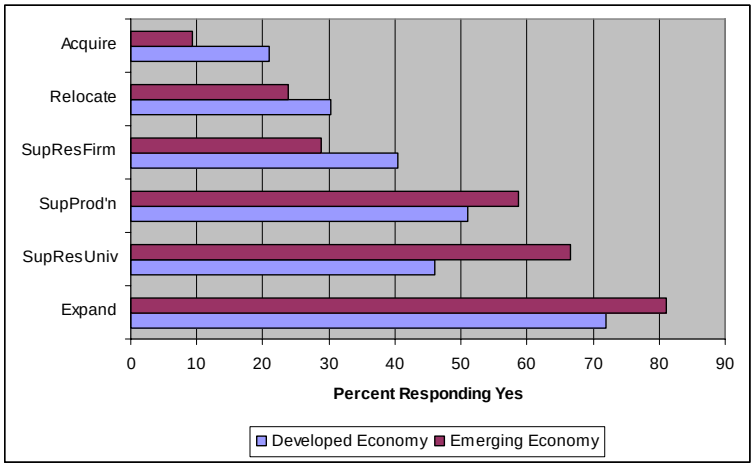
III.3 Site Background

We asked whether a series of statements were or were not correct about the site. The statements made were

1. This was part of an overall expansion of my firm's R&D effort
2. This was an acquisition of an existing R&D site.
3. This was to establish or support research relationships with other firms.
4. This was to establish or support research relationships with local universities or research institutes.
5. This was to support needs of existing production facilities.
6. This was a relocation of my firm's R&D effort.

The Yes/No responses to these statements were aggregated into responses for sites in a developed economy *versus* sites in emerging economies (responses for home *versus* other developed sites are not significantly different). The percent who indicated yes to each statement is in Figure 2. Developed *versus* emerging country responses are significantly different at a 10% level or smaller for all cases except supporting production and relocation. The most important feature of the sites is the fact that they are generally expansions of R&D effort. In contrast sites are less likely to be relocations of effort or the product of acquisitions. Emerging economy sites are more likely to be for the purpose of supporting university research relationships. While perhaps surprising it likely stems from firms having already established extensive research networks with universities in developed economies, whereas they may only now be in the process of establishing these networks in emerging economies.

Figure 2. Site Background



Observations: Emerging 86-90 Developed 142-147

III.4 Factors in the Selection of R&D Sites

This Section deals with the factors involved in the decision to locate. The approach was as follows. A list of potential factors involved in site selection was provided for each site that a respondent had identified as a recent or currently planned facility. Respondents were first asked whether they agreed or disagreed that the factor was correct about the location. They were then asked how important or central the factor was in the deliberations on whether to locate in the country. For sites outside the home country the statements were:

> *We want to know the factors that you considered in locating R&D in this country. First, we will ask if you agree or disagree with a statement about this location as it affects your firm. We use a 5 point scale where 5 indicates that you strongly agree and 1 indicates that you strongly disagree. 3 will indicate that you neither agree nor disagree. Second, we will ask how important or central the factor was in deliberations on whether to locate in this country. Use a scale of 1 to 5 where 5 is very important and 1 is not important at all.*

The following statements about factors were provided (shorthand used for each is in parentheses).

1. *There are highly qualified R&D personnel in this country. (QualR&D)*
2. *There are university faculty with special scientific or engineering expertise in this country.(UnivFac)*
3. *We were offered tax breaks and/or direct government assistance. (TaxBreaks)*
4. *In this country it is easy to negotiate ownership of intellectual property from research relationships. (Ownership)*
5. *Exclusive of tax breaks and direct government assistance, the costs of R&D are low in this country. (Costs)*
6. *The cultural and regulatory environment in this country is conducive to spinning off or spinning in new businesses. (Spin)*
7. *It is easy to collaborate with universities in this country. (CollabUniv)*
8. *There is good protection of intellectual property in this country. (IPProtect)*
9. *There are few regulatory and/or research restrictions in this country. (FewRestrict)*
10. *The R&D facility was established to support sales to foreign customers. (SupSales)*
11. *This country has high growth potential. (Growth)*
12. *The R&D facility was established to support production for export to other countries. (SupExport)*
13. *The establishment of an R&D facility was a regulatory or legal prerequisite for access to the local market. (LegalReq)*

Note that each statement was worded is such a way that agreement indicates that, from the standpoint of the firm, the factor is favorable for location at that site. If the level of agreement is a 4 or 5 then the factor is correct about the site and that factor is a potential attraction for the site. If a 1 or 2 is given then the respondent disagrees that the factor is correct and that factor is a potential push away from the site. It is then the level of importance that indicates whether the factor was actually an attraction or not.

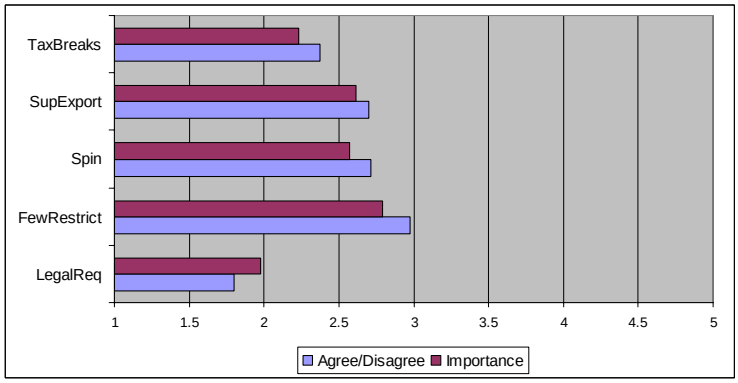
A similarly worded question was asked about facilities inside the home country. Results for sites in the home country are, with few exceptions, not significantly different from results for sites in other developed countries. For that reason we aggregate home and other developed country responses.

III.5 Unimportant Factors

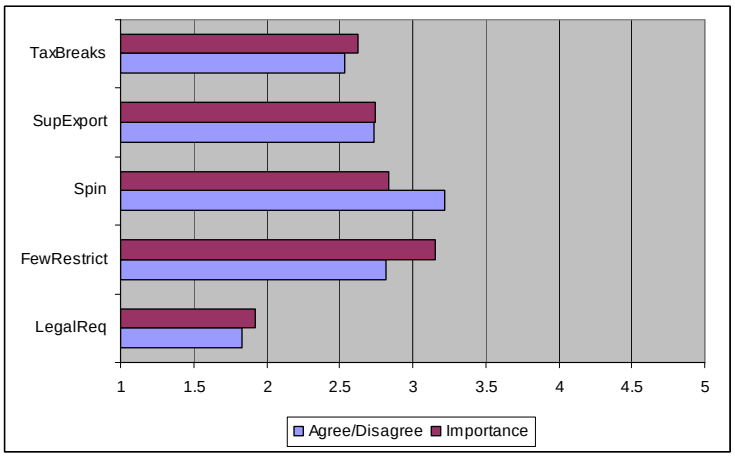
Five of the thirteen factors appear unimportant regardless of site location. These five factors have average or mean importance scores of less than 3 (that is, the average of the 1 to 5 scale on how important or central a factor was in deliberations on the site decision was less than 3) or only slightly greater than 3 no matter where the site is located. The factors are legal or regulatory requirement for market access, tax breaks and/or direct government assistance, spinning off or spinning in new businesses, supporting production for export to other countries and few research restrictions. Results for these factors are in the panels of Figure 3.

Figure 3. Unimportant Factors

a. Emerging Economies



b. Developed Economies



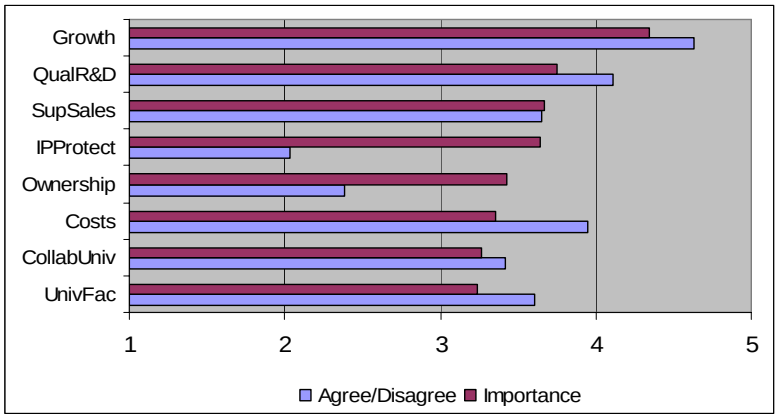
No of observations: Emerging 81 – 88 Developed 88-144

The result on tax breaks and/or other government assistance is perhaps surprising given their (apparent) popularity in attracting manufacturing. Mean values can mask whether tax breaks and/or direct government assistance were offered to some firms (but not others) and for those firms TaxBreaks could have been important. For emerging economy responses it is the case that only 3 of 80 respondents (3.8%) both agreed or strongly agreed (i.e., a score of 4 or 5) that they had been offered tax breaks and/or direct government assistance and had noted the importance of TaxBreaks as either a 4 or 5. In developed economies 26 of 140 respondents (18.6%) either agreed or strongly agreed and also noted that tax breaks were important (score of 4 or 5).

III.6 Important Factors: Emerging Economy Sites

Results for the remaining eight factors for sites in developing or emerging economies are in Figure 4; factors are ordered by level of importance. Eighty-one percent of these sites are in China or India.

Figure 4. Important Factors Emerging Economy Sites



Number of Observations 81-87. Statistical Tests of Importance (5% level):
UnivFac=CollabUniv=Costs=Ownership
Costs=Ownership=IPProtect=SupSales
Ownership=IPProtect=Supsales=QualR&D

All factors with the exception of growth are similar in their levels of importance. Only the growth potential of the country is significantly different from all other factors. The decision to locate in an emerging economy is a complex one in which only growth potential of the output market stands out as significantly more important than all others.

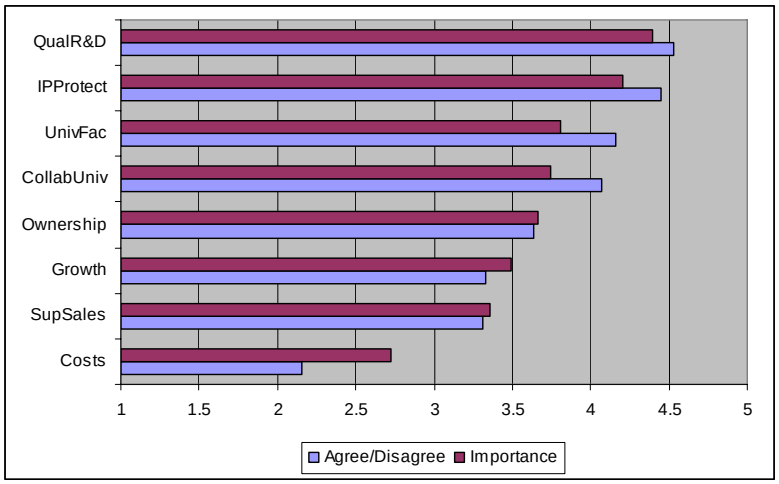
The results on costs are noteworthy as they conflict with more anecdotal reports (see footnote 2). Respondents agree that costs (net of tax breaks and direct government assistance) are low, but they attach significantly less importance to them in deliberations on selection of sites (1% level of significance). Costs are lower in emerging economies, but they do not stand out as being particularly important or central in location decisions as compared to other factors. In particular, five factors are higher in importance – and two of the five are significantly higher.

For the two intellectual property factors (ease of ownership of intellectual property from research relationships and good protection of intellectual property), there is disagreement with the factor statements. Nonetheless, both factors were important or central in the location deliberations. That is, the IP environment is not good for sites in emerging economies, the companies consider this in their deliberations, but they nonetheless establish sites there. Clearly, the positive factors in these economies outweigh the negative IP factors, an issue addressed later in more detail.

III.7 Important Factors: Developed Economics

Figure 5 gives the results for factors in developed economies; factors are ordered by the level of importance. While costs are not important, they are included in this Figure for comparison with emerging economies.

Figure 5. Important Factors in Developed Economies



Number of Observations 52-144. Statistical Tests of Importance (5% level):
SupSales=Ownership=Growth=CollabUniv
Ownership=Growth=CollabUniv=UnivFac
IPProtect=QualR&D

The most important factors in the deliberations to place a site in a developed economy are intellectual property protection and the quality of R&D personnel (which are not significantly different). This contrasts sharply with emerging economy sites in which growth potential is the most important factor (followed by the quality of R&D personnel). The next 5 factors ("university faculty with special expertise" to "supporting sales") are all important with each having a mean importance score greater than 3, but they are not statistically significantly different from each other in importance.

III.8 Summary of the Importance of Factors in Site Selection

The importance of factors in selecting R&D sites varies according to whether the facility is in a developed or in an emerging economy. To summarize, we categorize factors by whether they can be viewed as attractions to a site or whether they detract from the site. An "attractor" is defined as a factor with a mean agree/disagree score greater than 3 and a mean importance score greater than 3. All statements about factors are made in such a way that, if true, the statement would be positive from the standpoint of the firm. A "detractor" is defined as a factor receiving a mean agree/disagree score of less than 3 and a mean importance score greater than 3.

Table 3. Attractor and Detractor Definitions

	Agree/Disagree Score	Importance Score
Attractor	> 3	> 3
Detractor	< 3	> 3

Results on attractors and detractors are in Table 4. The factors are presented separately for sites in developed *versus* emerging economies. They are rank ordered by importance; the first factors in a list are the most important. An "equal" sign signifies no significant difference in the factors. For example, the quality of R&D personnel and IP protection are equal in importance for locating in a developed economy and they are the most important factors in that decision; this is followed by university factors, etc.

Table 4. Attractors and Detractors

	Attractors	Detractors
Developed Economies	Quality of R&D Personnel = IP Protection University Factors Output Markets	*No Detractors*
Emerging	Output Markets Quality of R&D Personnel Costs = University Factors	IP Factors

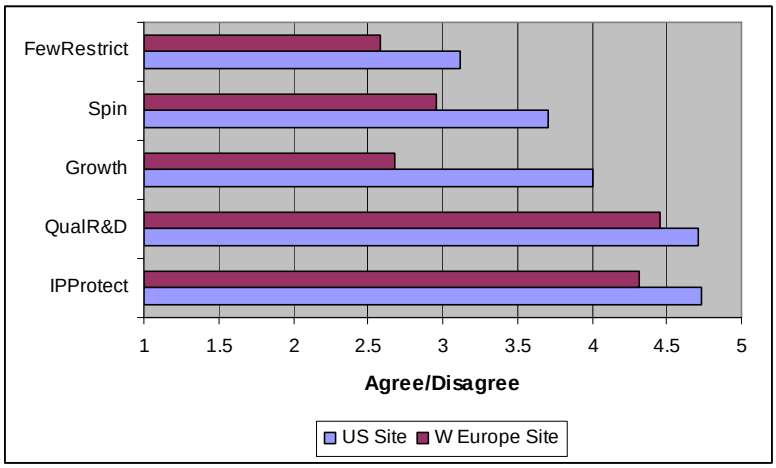
Output Markets are Growth & SupSales
University Factors are CollabUniv and UnivFac
IP Factors are IPProtect and Ownership

III.9 US versus Western Europe

Figure 6 gives the levels of agreement only for those factors where there is a significantly different (5% level) response for sites in the US *versus* Western Europe.[7] Their level of importance is given in Figure 7.

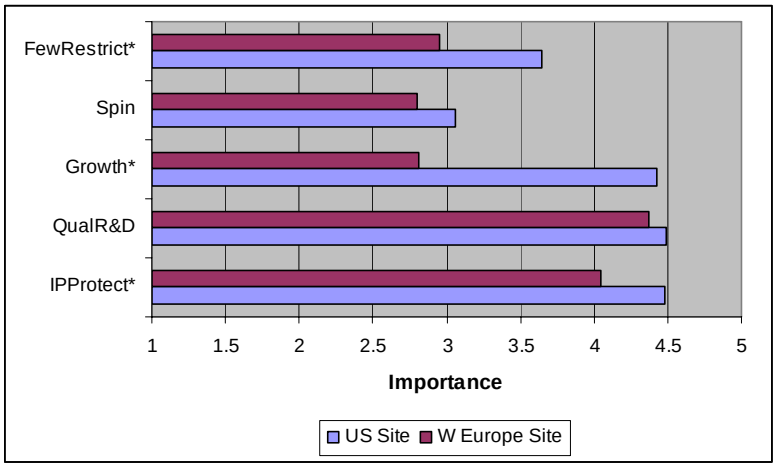
[7] There are significantly different levels of agreement for SupExport but we do not include it in the figure. Western European sites are significantly more likely to support exports. However, this is almost certainly due to the fact that many European respondents are based in small countries that tend to be more exported oriented.

Figure 6. Agree/Disagree Levels for US *versus* Western European Sites



No. Observations: US 47-49 (except Growth at 15) WEur 75-79 (Except Growth at 28)

Figure 7. Importance Levels for US *versus* Western European Sites



**Indicates that the difference is significant at the 5% level*

While the quality of R&D personnel and IP protection are significantly higher in the US the differences do not appear to be qualitatively large and the importance of the quality of R&D personnel is not significantly different. On the other hand, the differences in the levels of agreement for growth potential, the ability to spin companies in or out, and few restrictions are not only statistically significant, but the differences are qualitatively large. Additionally, the importance in the location decision of growth potential and few restrictions are significantly different.

IV. Types of Research Conducted in Developed versus Emerging Countries

A series of questions were asked regarding the type of research conducted at various sites. Rather than use the standard categories of development, applied research and basic research, the survey focused on whether the purpose of the R&D is to create products and services that are new to the firm and whether the R&D involves a novel application of science. The following definitions were used:

A NEW TECHNOLOGY is a novel application of science as an output of the R&D. It may be patentable or not.

Improving FAMLIAR TECHNOLOGY refers to an application of science currently used by you and/or your competitors.

R&D for NEW MARKETS is designed to create products or services that are new to your firm.

R&D for FAMLIAR MARKETS refers to improvement of products or services that you already offer your customers or where you have a good understanding of the end use.

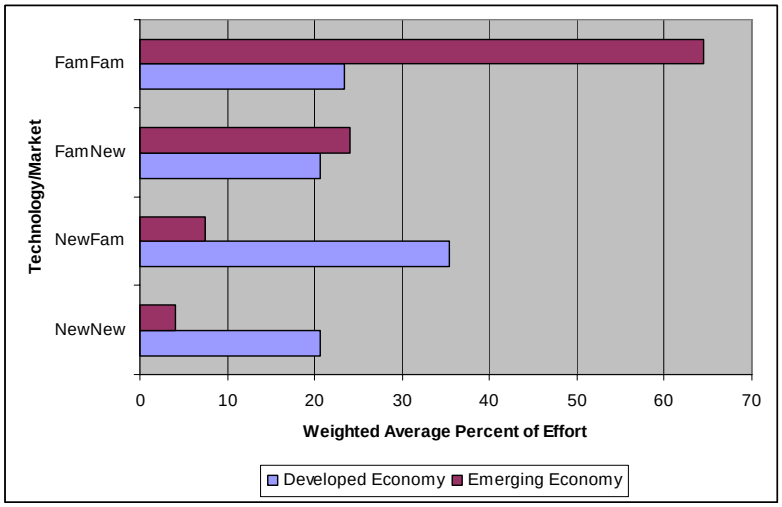
This gives four possible types of R&D:
1) Improving familiar technologies for familiar markets

2) Improving familiar technologies for new markets
3) Creating new technologies for familiar markets
4) Creating new technologies for new markets.

The survey's use of "New" *versus* "Familiar" markets does not refer to geographical markets; the question is whether the firm is currently selling such a product or service. Respondents were then asked for the percent of the technical staff employed in each of the above four activities.

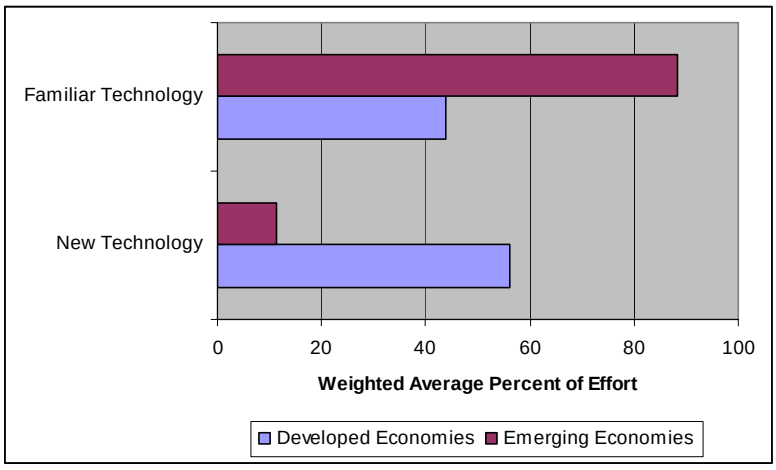
Results do not vary significantly between responses for the home country and other developed economies hence the results are aggregated. In addition, we have used weighted averages where the weights are the number of technical employees at a facility; thus, facilities are treated differently according to their size. Results are in Figure 8. Results for new science *versus* familiar science are aggregated in Figure 9.

Figure 8. Types of Research Conducted



Number of Observations: Developed Economy 133 Emerging Economy 85

Figure 9. New *versus* Familiar Technology



When comparing types of R&D across sites, work at emerging economy sites is always significantly different from effort at other sites.

It is striking that very little new science is conducted in emerging economies. Thus, while companies are conducting R&D in economies despite weak IP protection (as shown in Table 4), their cutting edge science tends not to be done in those locations.

In Thursby and Thursby (2006b) we related the responses on agreement and importance of the various factors affecting site location to the percentage of effort devoted to new science in the sites. The primary results are given In Table

5. The first column lists each factor considered important in site selection and the second column gives the importance rank attached to the amount of new science conducted. Note that the importance of factors for the type of science conducted is different from the importance of factors in site selection. Of particular note is the fact that university characteristics are the most important factors in determining where new or cutting edge science is conducted.

Table 5. Relative Factor Importance in Determining where New Science is Conducted

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

Rank is from most important (rank=1) to factors not important in type of science.

V. Conclusion

Our survey evidence directly addresses several of the Subcommittee questions. First, we explored the role of a variety of factors in R&D site location. We included thirteen factors, including demand factors such as market growth potential, resource supply factors such as cost or quality of technical personnel, as well as a number of policies such as taxes, IP protection, and regulatory environments.

Several results are striking. First, as shown in Table 4, the relative importance of factors for sites located in emerging economies is quite different than those in developed economies. Quality of R&D personnel and IP protection are the most important attractions for companies locating in developed countries, while output market potential is the most important attraction of emerging economies. Second, university expertise and the ease of collaborating with universities is the 3rd most important factor in developed countries and they are tied with cost as the 3rd most important factor in emerging countries. Third, as shown in Figures 5 and 6, when sites in the United States and Western Europe are compared, the United States appears to be more conducive to location when the growth potential of the market is considered important.

We also explored the type of R&D conducted in different locations and in our *Science* publication. An important result from our combined studies is that the factors that are the most important in determining location are somewhat different that those that determine the type of R&D conducted. While universities, and an environment conducive to collaboration, are among the top three factors in attracting a facility, they are the most important factors in determining where the cutting edge science is conducted. IP protection is a significant detractor to locating in emerging economies (see Table 4), but notice in Table 5 that IP protection does not determine the type of science. Our interpretation, explored more fully in Thursby and Thursby (2006b) is that IP protection is important for conducting both cutting edge and routine R&D.

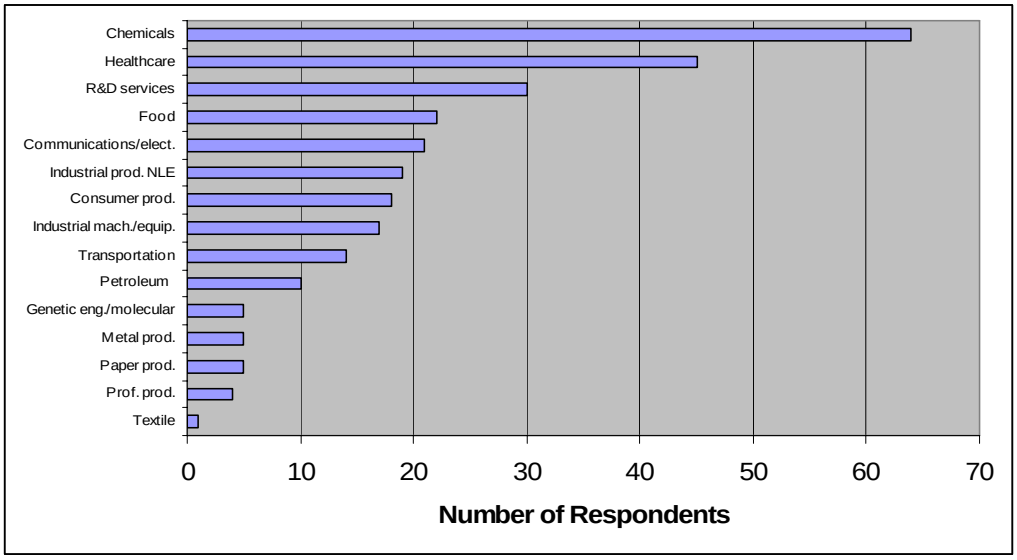
From a policy perspective, then, these results emphasize the importance of policies that support the conduct of R&D. These include policies to support the training of a highly qualified technical workforce as well as good IP protection which provides incentives not only to conduct R&D but facilitates the exchange of ideas emerging from research. According to the firms in our sample, both the quality of R&D personnel and IP protection are highest in the United States. The results on ease of university collaboration further emphasize the need for policies that facilitate the exchange of ideas. Finally, it should be noted that while on average tax breaks were not important, for companies locating in developed countries almost 19% said they were important.

Appendix A: Survey Design and Respondent Characteristics

The survey has benefited not only from the input of GUIRR but also from the input of the Industrial Research Institute, the European Industrial Research Management Association and the American Chemical Society's Committee on Corporate Associates. R&D managers from ten firms were interviewed about R&D site locations and the design of the survey. Based on those discussions the most relevant issues on R&D location strategies and factors in the location decision were identified. Discussions also covered mechanisms for capitalizing and protecting intellectual property. Survey responses were obtained over the period May 2005 to February 2006.

The industry of the respondent is given in Figure A1. Note that respondents were permitted to specify more than one industry. Two hundred and eighty industrial selections were made.

Figure A1. Respondent Industry



Appendix B: Definitions

R&D effort can be defined in a variety of ways. Here effort is defined in terms of employment. Questions regarding expenditures are subject to greater potential measurement error than are questions regarding employment. First, there are the usual problems with exchange rate conversions and issues of purchasing power across economies (e.g., is $1mil spent on R&D in the US comparable to the same amount spent in, say, China). Second, it is clear from interviews with R&D managers that they were more likely to have a clear notion of employment in various locations than they would expenditures. It is also noted that employment effects generally translate directly into policy issues of interest.

The survey began with a set of definitions:

> *For the purpose of this survey, we consider research and development, that is, R&D, to encompass the following: 1) R&D that entails new applications of science to develop new technologies, 2) R&D to improve technologies currently used by you, 3) R&D to create new products or services, and 4) R&D to improve existing products or services sold or licensed by you.*
>
> *Whenever we use the phrase "technical staff" we mean employees who conduct or support R&D. These include researchers, research assistants, lab technicians and engineers involved in any of these types of R&D.*
>
> *Whenever we use the word production we mean either manufacturing of a good or provision of a service.*
>
> *Product means either a good or provision of a service.*