Globalization of Healthcare Research:
What Kind of Science is Conducted in New R&D Sites?

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February 2008

Prepared for the NBER Conference on Location of Biopharmaceutical Activity
March 7-8, 2008

The popular press abounds with reports of globalization, not only of manufacturing, information technology, and business services, but also research and development. These anecdotal reports paint a simple picture of multinationals increasingly locating R&D facilities in emerging countries to take advantage of low costs and increasing skill levels of the labor force in these countries.[1] Our recent survey of 250 multinational firms across 15 industries shows this picture is "off the mark" in two ways. (Thursby and Thursby 2006a and b). First, R&D location decisions are quite complex and influenced by a variety of factors. We investigated 13 factors, including output and input market factors, and policies, such as taxes, regulatory restrictions, intellectual property protection, as well as the potential for collaboration among firms and universities. The factors most important for location decisions were output market potential, quality of R&D personnel, university collaboration, and intellectual property protection. How these factors influenced decisions, however, varied depending on whether sites were in developed or emerging economies. Second, while many of the facilities identified in the survey were located in emerging economies, a substantial portion of new and planned facilities were in developed economies, most notably the United States and Western Europe.

The survey also we also asked firms to characterize the type and purpose of the science conducted at those recently established facilities. By type of science we mean whether the science is "new" or "familiar" and for the purpose of the science we mean whether it is for a "new" market for the firm or one that is "familiar" to the firm (where these terms are defined below). Finally, the "type" of R&D conducted at various sites is quite different. Roughly 50% of the R&D in developed economy sites involved cutting edge science as compared with only 22% of the R&D in emerging economy sites.

In this paper, we examine the extent to which these results vary across industries. In particular, we examine the location and type of science of respondents in the healthcare industry as compared to all other respondents. Not surprisingly there are some striking differences. First, in terms of overall location strategies, healthcare firms found locating close to high quality R&D personnel and universities to be more important than did other firms. While other firms reported that locating close to customers was moderately important, healthcare firms found it relatively unimportant. Second, on average healthcare firms reported a higher percentage of effort devoted to cutting edge science than did other firms. However, when asked if the purpose of the R&D was to develop entirely new products or processes, there was no significant difference between healthcare and other.

To identify factors behind the type of science at sites, we use logistic regressions for grouped data to relate the ratio of new to familiar science in the facilities identified by respondents to their views on a variety of country-specific characteristics. After controlling for various factors we replicate the result in the raw data that healthcare firms conduct more new science. Universities are substantially more important in conducting new science in healthcare firms than in non-healthcare firms.

We then repeat that exercise to examine the factors behind whether the R&D is conducted for new or familiar markets. It is quite striking that in addition to conducting more new science than other firms, healthcare firms are more likely than others to conduct R&D for new markets. The likelihood of healthcare firms conducting R&D for new markets is positively related to ease of collaboration with universities and faculty with specialized expertise. The effects for non-healthcare firms are mixed.

I. Related Literature

International trade theory provides a number of useful frameworks for thinking about multinational location decisions (Markusen 2006). Consider, for example, theories of foreign direct investment (FDI) which explain FDI in terms of multinational firms exploiting firm-specific assets across global markets. One of the hypotheses to emerge from this approach is the "proximity-concentration hypothesis"

[1] 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 the decisions to offshore R&D while 29 noted the quality of R&D personnel as a factor. No other factors were mentioned as prominently as costs and the quality of R&D personnel.

for multinational location decisions (Brainard 1997).[2] In the context of R&D location, a multinational firm faces a trade-off between achieving proximity to local users or foreign knowledge-generating institutions and concentrating R&D to take advantage of scale economies or avoid the costs of maintaining sites in multiple locations.

Vernon's (1974) product-life cycle hypothesis is an early example of this trade off. With new product R&D, one would expect centralization of R&D near firm headquarters and early sales within the same country because of the need for close communication and coordination between R&D, marketing, and production. As a product ages, foreign sales are possible, in which case R&D to support product localization may dictate foreign R&D locations. Indeed, Mansfield *et al*.'s (1979) study of 55 US-based manufacturing firms found a positive relationship between the percentage of foreign sales and the percentage of firm R&D conducted outside the US. They also found that the bulk of R&D in foreign subsidiaries was not for new products or processes, but for product and process improvement. Interestingly, they found that, holding constant the percentage of foreign sales (as well as sales), the percentage of R&D expenditure outside the country was higher for firms in the pharmaceutical industry.

Studies of Japanese overseas R&D investment have found similar results. Odagiri and Yasuda (1996) examined industry and firm level data on Japanese R&D subsidiaries in the US, Europe, and Asia in the late 1980s. Generally, they found that firms or industries more dependent on overseas production were more likely to establish overseas R&D facilities. They also found support for the hypothesis that Japanese investments in the US and Europe were motivated to access advanced technology. Miriani (2002) examined the European investments of 799 Japanese manufacturing firms in the late 1980s. She found that proximity to production was important throughout the sample, but it appeared to be less important in sectors which she classified as science intensive (such as pharmaceuticals). She also a significant positive relationship between the probability a firm would establish a subsidiary specializing in R&D (as opposed to both R&D and production or simply specializing in production) and the number of institutions of higher education nearby.

When proximity to production drives location, it is common to think of the investment as market driven or home-base exploiting (Kuemmerle 1997 and 1999). A natural framework for modeling location choice in that case is a model of market potential such as Krugman (1980) or Head and Mayer (2004). Indeed Koenig and MacGarvie (2008) estimate a variant of Head and Mayer's model in order to evaluate the role of domestic policies on biopharmaceutical location in 27 European countries. They find a significant positive effect of market potential on location.

To the extent that location is motivated by access to advanced technology or university knowledge, the investment can be called home-base augmenting (Kuemmerle 1997, 1999). The latter, of course, is a natural extension of comparative advantage theories where international activity is viewed as a function of differences in resources across countries.

A number of studies have examined the relationship of pharmaceutical productivity in R&D to home-base augmenting investments, particularly those that allow access to locally generated spillovers across the globe.[3] Chacar and Lieberman (2003) examine the R&D productivity of 21 US-based pharmaceuticals as a function of a measure of distance between labs as well as the number of US and foreign labs. They find a positive relationship between the number of foreign labs and productivity, as measured by both the number of new chemical entities invented (NCE) and drug patents. Within the US, however, they find a negative relationship between the number of labs and productivity for firms with more than two labs. Finally, they find limited support for increased productivity from proximity to multiple firm labs, but no benefit from proximity to other firms' labs.[4] For a sample of Japanese pharmaceuticals, Pen-

[2] The international trade literature has tended to focus on production location along with its implications for trade in goods and services rather than R&D location (see, for example, Helpman *et al*. 2004).

[3] For other work on the importance of locally generated spillovers in the biopharmaceutical industry see MacGarvie and Furman (2006) and Feldman (2003).

[4] See Belderbos et al (2004 and 2007) regarding the implications of local spillovers for firm strategy.

ner-Hahn and Shaver (2005) find a positive relationship patent productivity and global expansion of R&D, but this effect is significant only for firms with prior complementary research capability. [5]

Furman *et al*. (2008) also examine the productivity effects of locally generated knowledge, but they take a more direct approach. They determine the specific therapeutic classes being researched at firm labs and then obtain a count of the number of articles within those therapeutic classes published by authors who live near the lab. They further separate this measure of firm exposure to locally generated knowledge into two measures: one for articles published by authors employed in the non-profit sector and one for authors employed by private firms. Publicly generated publications have a positive effect on patent productivity while privately generated publications have a negative effect.

The literature on government policies and multinational location decisions is too extensive to review, but a few studies should be mentioned. With the strengthening of trade related intellectual property (IP) rights in the World Trade Organization in the 1990s, it is natural to ask the extent to which strengthened IP has been a factor in increased globalization of R&D. The bulk of work in this area has examined a related issue, i.e. the impact of patent policies on innovation, with mixed results. Lerner (2002)'s analysis of patent reforms in 60 countries over 150 years finds little positive impact, although he does show a positive impact on patenting by foreigners. Branstetter et al. (2006) more directly address the issue by examining firm level data for foreign affiliates of US multinationals in response to IP reforms from 1982-1999. They find at least a 30 percent increase in royalty payments for technology transferred to these affiliates as well as an increase in foreign affiliate expenditure on R&D. Zhao's (2006) study of 1567 subsidiaries of US multinationals, some of which are in weak IP countries and other in strong IP locations, suggests that different management practices may explain the lack of a strong relation of IP and innovation. Her evidence suggests that firms with strong internal controls invest in locations with weak IP and that they develop technologies in those locations which are used internally.

There are of course, a myriad of tax policies that can either induce or impede the location of R&D in particular countries (Hines 1995). The use of tax incentives to attract multinational investment, as well as investment requirements for market access, is well documented, particularly in emerging economies. In the case of pharmaceuticals, regulatory policies, both in terms of restrictions on lines of research (such as stem cells) and the process of clinical trials are relevant. Kyle (2007) and Lanjouw (2005) show that drug launches are delayed in countries with price controls, and Koenig and MacGarvie (2008) show that investments are negatively related to price regulation.

Thus there are many factors that can influence multinational R&D location decisions. Thursby and Thursby (2006a) present survey evidence that allows a comparison of the relative importance of these factors. Respondents to the survey came from 250 R&D intensive multinationals across 15 industries. The survey investigated 13 factors, including output and input market factors, and policies, such as taxes, regulatory restrictions, intellectual property protection, as well as the potential for collaboration among firms and universities. Of these factors, the four most important for location were output market potential, quality of R&D personnel, university collaboration, and intellectual property protection. How these factors influenced decisions, however, varied depending on whether sites were in developed or emerging countries. For companies locating in emerging economies, the most important attraction was the growth potential in the market followed by the quality of R&D personnel. Tied for the third most important reason were costs (net of tax breaks), the expertise of university faculty, and the ease of collaborating with universities. For these economies, the quality of intellectual property protection was a detractor. When companies located R&D facilities either at home or in another developed economy, the most important factors were the quality of R&D personnel and the quality of intellectual property protection. Next in importance were the expertise of university faculty and the ease of collaborating with universities. Also important were market factors such as growth potential and the need to support sales of the company. Thus output and input market factors, as well as the intellectual property infrastructure were all important.

This survey also provided information on the type of R&D conducted at various sites. The type of R&D was defined with respect to whether it was for markets that were new or familiar to the firm and

[5] See Griffith et al. (2004) for a study of the ability of UK manufacturing firms to benefit from R&D in the US.

whether the science was "new" (cutting-edge) science or familiar science. Not surprisingly, sites in developed countries tended to spend more effort on new science than did those in emerging economies. Thursby and Thursby (2006b) then related the type of science conducted to the importance of various factors in choosing the location. The results are quite striking and reinforce other work on the importance of spillovers from universities. That is 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.

II. Survey Background

II.1. Respondent Pool:

The development of the survey included consultation with representatives of the Government University Industry Research Roundtable of the National Academies, the Industrial Research Institute (IRI), the European Industrial Research Management Association (EIRMA), the American Chemical Society and R&D managers from eleven US and European companies. These discussions were designed to uncover the potential array of factors that are related to R&D strategy with particular reference to location strategies. In addition, mechanisms for protecting and capitalizing on intellectual property were explored as was the type and general purpose of the R&D.

Potential respondent firms are research intensive, and it is appropriate to have multiple respondents from a single firm. If decisions on R&D site locations are made independently by multiple firm decision making units - for example, different business units - then each unit is an appropriate respondent. Contacts were made with 418 firms and responses were received from 203 firms were received for a response rate of 48.6%. The high response rate stems in part from the fact we had multiple potential contacts for many firms. From the 203 firms there are 250 responses. Seventy-six respondents (30.4%) were from business units and 174 (69.9%) were responding for a corporate R&D unit. Ninety-two percent gave either the US or a country in Western Europe as the home country of their firm. The firms are generally multinational in their R&D efforts. About 15% of the respondents currently have all R&D personnel in the home country whereas about 1 in 5 has more than half of R&D employees outside the home country.

II.2. Industry of Respondents

Each respondent was asked for their industry affiliation based on 14 classifications given in Table 1; in the third column is the number of respondents indicating each industry. A number of respondents (not surprisingly) noted more than one industry affiliation. Our interest in this paper lies primarily in a comparison of those whose industry affiliation is healthcare (industry 8). Those few firms that noted both healthcare and some other industry were coded in this paper's analysis as healthcare. One healthcare firm and 16 firms in other industries have home countries other than the US or Western Europe.

II.3. R&D Effort Defined

R&D effort was defined in terms of employment for two reasons. 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 in its effects on R&D output as the same amount spent in China). Second, it is clear from interviews with R&D managers that they were more likely to have a more accurate idea of the level of employment in a location than they would expenditures at that location.

To minimize errors associated with potential cross industry definitions of R&D and technical staff we provided the following

> *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.

II. 4. Primary Focus of Survey

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. 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?*

Those responding positively were asked a series of questions about that facility. This exercise was then repeated substituting "INSIDE the home country" for "OUTSIDE the home country."

In following a strategy of focusing on recent or planned facilities rather than on respondent's general perceptions of different locations we sacrifice observations since not all firms will have established recent facilities and in cases where they had established such facilities our respondent might not be familiar with the decision on site location. However, a benefit of 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. Note that, depending on their experience, respondents might not answer for any facility or they could answer for an outside facility, for an inside facility or for both.

Two hundred and forty-five new facilities were identified by respondents and 92 of these are in the home country of the respondent.[7] Thirty-eight of the sites are facilities of healthcare firms. Thirteen are in the US, 17 are in Western Europe and 6 are in emerging economies. The firm's home country is the US or Western Europe for all of the healthcare sites; 18 are US and 20 are Western European home countries.

III. Overall Strategies for Location of R&D

While the main focus was on an actual site selection sites, we did ask all respondents about the importance of various R&D location drivers to overall corporate or business unit strategy. Specifically we asked

> *Strategically, how important are each of the following drivers for the geographical location of your firm's R&D? Use a scale of 1 to 5 where 5 is very important and 1 is not important at all.*

The following statements were presented. In parentheses is the shorthand notation we use.

1. *Sponsored research at universities or research institutes. (SponUniv)*
2. *Research collaborations with other firms. (CollabFirm)*
3. *Internet based searches for solutions to technical problems. (Internet)*
4. *Locating close to universities. (CloseUniv)*
5. *Locating close to highly qualified R&D personnel. (CloseR&D)*
6. *Locating close to competitors. (CloseComp)*

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[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.*

[7] In Thursby and Thursby (2006) we report on 235 identified sites. Due to a deadline in that work we began our earlier analysis before all respondents had answered the survey.

7. *Locating close to customers. (CloseCust)*

Each strategy was suggested in early interviews as being important and most are standard R&D location factors found in the management and economics literature. Some explanation is in order for the strategy involving internet based searches since this refers to a relatively new R&D approach. In interviews with industry R&D managers, several indicated the importance of internet companies that specialize in finding R&D solutions for firms. A number of these internet companies are, in fact, spin-offs and/or alliances formed by multinationals. Basically, the system works as follows. A firm seeking a solution to some problem sends the problem to one of these internet companies which then openly advertises the problem so that the available talent pool for solutions is worldwide. The internet company acts as a broker between firms seeking R&D solutions and R&D researchers. The use of such services would presumably reduce the reliance of firms on specific R&D sites.

In Figure 1 are average responses for the location strategies of healthcare firms *versus* all others. Healthcare responses are significantly different from other firm responses for all strategies except university sponsored research (*SponUniv)* and collaborating with other firms (*CollabFirm)*. Least important for both groups are internet based searches (*Internet*) and being close to competitors (*CloseComp)*. On the other hand, being close to customers (*CloseCust*) is significantly more important for industries other than healthcare. Locating close to quality R&D personnel (*CloseR&D*) and locating close to universities (*CloseUniv*) are both more important in healthcare.

IV. Factors in Site Location of Identified Sites

For those respondents who identified recently established or planned facilities (whether they were inside or outside the home country) we asked a series of questions regarding the factors behind the site location. 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 (either inside or outside the home country). Respondents were first asked whether they agreed or disagreed that the factor was correct about the location. This was followed by a question regarding how important or central the factor was in the deliberations on whether to locate in the country. Specifically, and for sites outside the home country, the statement was

> *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 (in parentheses we provide out shorthand notation).

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. (LegalReg)*

This exercise was repeated for sites that were identified *within* the home country with the exception that the factors numbered 10-13 were not included as factors for home country sites. From prior interviews with R&D managers these factors did not appear as important for home facilities as for outside facilities so to keep the survey short these four factors were deleted from the home site questions.

Each statement is worded in 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.

In Thursby and Thursby (2006) we show that there is substantial variation across responses depending on whether the site is in a developed or an emerging economy site. When the site is in a developed economy there is very little variation depending on whether that site is in the home country or not. Since there are only 6 identified healthcare sites in our sample we will present results on site location factors only for sites in developed countries.

In Figure 2 the average level of agreement is presented disaggregated by industry (healthcare versus other industries). In Figure 3 the average levels of agreement are presented. The number of sites varies from 13 to 31 for the healthcare firms and from 43 to 119 for other firms.

V. Type of Research

A series of questions were asked regarding the type of research conducted at the identified 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:

We are interested in the types of R&D conducted OUTSIDE the home country as they relate to new technologies and markets defined as follows.

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

Improving FAMLIAR TECHNOLO125GY 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.

Note that 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:

Approximately what percent of the technical staff employed OUTSIDE home country are engaged in R&D for the purpose of

a. Improving familiar technologies for familiar markets
b. Improving familiar technologies for new markets
c. Creating new technologies for familiar markets
d. Creating new technologies for new markets.

This exercise was conducted both for R&D outside the home country and inside the home country. As is the case for the level of agreement and importance of factors, results vary substantially only according to whether the site is in a developed economy *versus* an emerging economy. We report on only those sites in developed economies are.[8] Results are in Figure 4. In Figures 5 are the aggregates for new science (NewFam and NewNew) and new markets (FamNew and NewNew). Healthcare firms are as likely to conduct research that is aimed at either new markets or familiar markets as are other firms. Where healthcare firms differ significantly from other firms is in their greater focus on new technologies or science. However, this focus is seen only when the R&D is for familiar markets.

VI. Econometric Analysis of Type of R&D

Above are presented average responses for question on the type of R&D conducted at the identified facility. In this section we consider an econometric analysis of what might influence both the type and purpose of the R&D at a site. We begin with a discussion of the econometric approach. We then define our regressors and estimate the relation between regressors and the amount of new *versus* familiar technology conducted at the facility. Finally, we estimate the relation between our regressors and the amount of effort devoted to new *versus* familiar markets.

VI. 1 Econometric Model and Variables

The econometric models we use to explain both the split of effort between new and familiar technologies and for the split of effort between new and familiar markets are based on the logistic distribution. Consider first the split between new and familiar technologies or science. We assume that each technical employee at an R&D facility is associated with either a new science project or a familiar science project, but not both. A standard logit model would be appropriate if we observed the conduct of science by technical employee. That is, we would use

(1) $$\text{P}_\text{i}(\text{Employee conducts new science}) \equiv \ P_i = \frac{1}{1-\exp(-x_i\beta)}.$$

x_i is a vector of explanatory variables for the i[th] observation and is specific to the site rather than the employee, and β is a vector of parameters to be estimated. This can be rewritten as

(2) $$\log\frac{P_i}{1-P_i} = x_i\beta\,.$$

However, respondents provided the *fraction* of effort by site that is devoted to new and familiar science. Thus we have the fraction of new science conducted by site which is an estimate, $\hat{P}_i$, of P_i. We can replace the ratio on the left hand side of equation (2) with the ratio of the fraction of effort devoted to new science to the fraction of effort devoted to familiar science. That is, we have an estimate of the logit and we can regress

(3) $$\log\frac{\hat{P}_i}{1-\hat{P}_i} = x_i\beta + \varepsilon_i$$

Where

[8] The primary difference between developed and emerging economy sites is that emerging country sites are more likely to be conducting R&D using familiar technologies.

(4) $$\varepsilon_i = \log\frac{\hat{P}_i}{1-\hat{P}_i} - \log\frac{P_i}{1-P_i}.$$

This is a heteroscedastic disturbance with

(5) $$\text{var}(\varepsilon_i) \cong 1/n_i P_i(1-P_i)$$

Where n_i is the number of technical employees at the new R&D location. This regression model is linear in the explanatory variables and it is one that explains the log of the odds ratio where the odds are calculated from the responses on fraction of effort. Since there are observations on fraction of effort that are 0 or 1 we follow Cox's (1970) suggestion and add to each fraction the small positive number $1/2n_i$. We use weighted least squares with the unobserved P_i in (5) estimated by $\hat{P}_i$. This is the minimum logit chi-square method.[9]

Our approach to modeling the split between new and familiar markets is the same except that $\hat{P}_i$ is the fraction of effort devoted to new markets.

VI. 2. New versus Familiar Science

The regressors for the split between new and familiar science include some of the factors that might have been behind the site location decision. It is likely that many of these site selection factors are also relevant in determining the type of R&D conducted at the site. The factors or country characteristics we consider as potentially important in decisions about the type of science conducted are highly qualified R&D personnel (*QualR&D*), low costs of R&D (*Costs*), growth potential (*Growth*), supporting sales to foreign customers (*SupSales*), ease of negotiating ownership of intellectual property from research relationships (*Ownership*), good protection of intellectual property (*IPProtect*), the presence of university faculty with special expertise (*UnivFac*) and the ease of collaboration with universities (*CollabUniv*). Each is important in the selection of a site for an R&D facility (Thursby & Thursby 2006), and the case can be made that each is potentially important in the split between new and familiar science. It is our prior belief that *Costs*, *Growth* and *SupSales* are more closely associated with familiar science. R&D to support sales and R&D to take advantage of expected growth are most likely to support product localization which we believe is primarily based on familiar science. Further, it is our prior that the two factors associated with universities (*UnivFac* and *CollabUniv*) are more closely associated with new science since most new science is the outgrowth of university research. We do not have strong priors on the other factors. Each could potentially affect new science more than familiar science and *visa versa.*

Information on the role of site selection factors comes from both the level of agreement and the importance of the factor in site selection. An algorithm is devised that combines both two scores into a single centrality scale ranging from 1 to 13. Low values indicate that the factor is a detractor to locating to the site and the factor was important in the selection of the site. High values indicate that the factor is an attractor to the site and the factor was important in selection of the site. Middle scores are for factors for which the respondent neither agrees nor disagrees is true about the site or else the factor was unimportant in site selection (regardless of the level of agreement). Algorithm details are in the appendix.

Earlier we noted that respondents were not asked questions about supporting sales or growth potential if the site was in the home country. However, we did ask whether each identified site was established to support the needs of production facilities. In order to include whether the site was in direct support of sales or production and to include the home sites in the econometric analysis we use the indicator variable for supporting production (*NeedProd* = 1 if the site was established at least in part to support the needs of production) rather than *SupSales*. In our earlier study, the growth potential of the country was shown to be important largely for emerging economies. In place of *Growth* we use an indicator variable of whether the country of the R&D facility is developed or not (*Develop* = 1 if the country is developed). We use the International Monetary Fund's list of emerging economies to categorize countries. *Develop*

[9] For more on this approach to dealing with fractional (grouped) data see, for example, Maddala (1983).

should capture any additional features of emerging and developed economies that affect the type of R&D but which are not captured by our centrality measures (such as infrastructure).

Each factor is entered as the log of the centrality measure. We also include two interaction variables. We include the product of *UnivFac* and *CollabUniv* (*Fac_Collab*) to capture the likely case that the importance of faculty will be directly affected by the ease of collaboration with universities and *visa versa*. For example, if faculty expertise is central then it also follows that their importance in the conduct of science should be affected by the ease of collaboration. Similarly, we include the interaction of *Ownership* and *IPProtect* (*IP_Own*). Each should directly affect the other.

The regressors also include an indicator variable of whether the firm is in the healthcare industry (*Health*=1 if the firm is in the healthcare industry), a measure of the firm's R&D size and an indicator of whether the site is in the home country (*Home* = 1 if the site is in the respondent firm's home country). Our measure of each firm's R&D size is the number of the firm's worldwide technical employees as reported by our respondents (*FirmSize*).

Summary statistics are found in Table 2. Healthcare observations are in the first panel and non-healthcare observations are in the second panel.

We also include the location factors interacted with the indicator variable *Health*:

- *H_IPProtect*
- *H_Costs*
- *H_CollabUniv*
- *H_UnivFac*
- *H_Ownership*
- *H_NeedProd*
- *H_Develop*
- *H_QualR&D*.

Health is also interacted with *FirmSize* and with *Home*. We do not have a prior for whether there is an industry difference for *FirmSize*, it is included more for the sake of completeness. The importance of *Home* is expected to be different between healthcare and other firms since a large fraction of the technical employees for European healthcare firms are located in the US. This does not hold for US healthcare firms nor is there a substantial difference for other industries.[10]

Including the indicator variable *Health* and *Health* interacted with all other variables allows for the coefficients for the healthcare industry to differ from those for other industries. These interactions allow for an examination of differences between firms in the healthcare industry and firms in other industries since statistical significance of an interaction term implies that that variable has a coefficient that differs between healthcare and other industries.

With the exception of the indicator variables all variables are converted to logarithms thus the coefficients in our regressions are to be interpreted as the elasticities of the odds ratio ($P_i/(1-P_i)$), that is, the elasticities of the logit, with respect to the right hand side regressors.

The results for new *versus* familiar science with all independent variables are in the first panel of results in Table 1. The dependent variable is $\log(\hat{P}_i/(1-\hat{P}_i))$ where the fraction of effort devoted to new science is $\hat{P}_i$ and the fraction of effort devoted to familiar science is $1-\hat{P}_i$. After accounting for missing observations there are 24 healthcare observations and 155 other industry observations. In this first regression there are few significant coefficients which is not surprising given the number of regressors and only 179 observations.

[10] This result is from a question in our survey regarding the fraction of worldwide technical employees employed in various countries. US healthcare firms reported about 19% of their technical employees to be in Western Europe. The comparable figure for other firms is only 9%. Western European healthcare firms have about 31.5% of their employees in the US. The comparable figure for other Western European firms is 12.8%.

In our second regression *Costs* and *H_Costs* are dropped from the regression since neither has a t-statistic greater than 0.17 in absolute value and the p-value in a joint test of their significance is 0.979. We also drop *IPProtect* and *H_IPProtect* since both t-statistics are small and the p-value in a test of their joint significance is only 0.862. In addition we drop the interaction term *H_FirmSize* since it is has a very small t-statistic (-.04) and because our prior is that there is not a difference between healthcare firms and other firms in the effect of the number of technical employees in a firm. Results are in Panel 2 of Table 1.

None of the variables associated with ease of ownership (*Ownership, H_Ownership* or *IP_Own*) are significantly different from zero nor are they jointly different from zero. These variables are dropped from the third regression. We also drop *Develop*. Of the remaining variables interacted with *Health* the ones associated with faculty having special expertise (*H_UnivFac*) and supporting the needs of production (*H_NeedProd*) are not significantly different from zero. We drop *H_UnivFac* from the regression, but we retain *H_NeedProd* since it was significant in the first panel.

The results of this final regression are in Panel 3 of Table 3. We concentrate our analysis on this final regression. In Table 4 are the odds ratios for the results in Panel 3. The tests reported in Table 4 are test of whether the odds ratios are different from one. Note that a number of the effects are measured across several coefficients.

Our first results are whether the total effect on the log of the logit is different for healthcare firms versus non-healthcare firms. We take the difference between the predicted value of the log of the logit for healthcare firms (*Health* = 1) and the predicted log of the logit for non-healthcare firms (*Health* = 0). Predictions are made at the mean values of the continuous variables, and we only include coefficients that are significantly different from zero. Further, we compute these differences for healthcare sites in emerging economies, in developed economies that are not in the home country and for sites in the home country. We then compute the odds ratio for these differences. For emerging economies the odds ratio is 0.725 which is not significantly different from 1. Thus, there is no significant difference between healthcare and non-healthcare firms for sites in emerging economies. However, when the site is in a developed economy outside the home country, the odds ratio is 3.937 (significantly different from 1 at a 1% level) for the difference between healthcare and non-healthcare firms. For sites in the home country the comparable odds ratio is 1.464 (significantly different from 1 at a 5% level). Thus, healthcare firms are more likely to conduct new science than are non-health care firms – a result we found in the raw data (see Figure 5). However, there is more of a bias in healthcare toward new science in developed sites outside the home country.

Turning to the partial effects in Table 4 we again see that there is a bias in healthcare toward conducting new science in developed economies which is not found for other firms. We find the opposite for sites in the home country. For home sites non-healthcare firms have a bias for new science while there is not such bias for healthcare firms.[11] There is not a significant difference between the industries in the effects of supporting the needs of production (*NeedProd*). For both types of firms new science is less likely to support the needs of production. The relationship between the log of the odds ratio and the quality of R&D personnel is reversed for non-healthcare and healthcare firms. The effect is negative for the former but positive for the latter. These differences are significant at a 5% level.

Finally, the two university effects (*CollabUniv* and *UnivFac*) have positive effects on new science in the healthcare industry but only *UnivFac* has an effect in other industries. This latter variable has the same effect in both industries. In a less extensive analysis where industry controls were not employed we found that the most important factor for the conduct of new science was *CollabUniv* (Thursby and Thursby 2006b). The results here suggest that the reason for the importance of this variable is largely

[11] The coefficient of the interaction between *Home* and *Health* (*H_Home*) is positive and significantly different from zero. It is also close in absolute size to the coefficient of *Home*. In a test of whether the coefficients of *Home* and *H_Home* sum to zero, the p-value is 0.779. Thus whether the healthcare site is in the home country or not does not change the amount of new *versus* familiar science.

driven by the healthcare industry.[12] In addition, that earlier study found that the second most important factor was *UnivFac* which we also find to be ranked second in importance among the factors.

VI. 3. New versus Familiar Markets

In examining the split of effort at identified R&D sites between new *versus* familiar markets we begin with the same regressors used for studying new *versus* familiar science. Similarly, the dependent variable is $\log(\hat{P}_i/(1-\hat{P}_i))$ but where $\hat{P}_i$ is now the fraction of R&D effort at the site that is devoted to new markets and $1-\hat{P}_i$ is the fraction of effort devoted to familiar markets.

The results are in Panel 1 of Table 5. Very few of the interaction terms are significantly different from zero. Neither *IPProtect* nor *H_IPProtect* is significantly different from zero and both t statistics are very small (-0.15 and -0.31, respectively). In a test of their joint significance the p-value is 0.945. For this reason we drop these two variables. In addition, *H_UnivFac* has a t-statistic of only -.004 (p-value of 0.996) providing strong evidence of no difference between healthcare and non-healthcare firms in the importance of faculty expertise. *H_UnivFac* is dropped from the regression.

The results after dropping these variables are in Panel 2 of the table. The t-statistics for *H_Develop, H_Costs* and *NeedProd* are each substantially less than one. They are dropped from the regression and the results are in Panel 3. In this final regression all coefficients are significantly different from zero at least at a 10% level with the exceptions of *H_Home* and *UnivFac*. These latter regressors are not dropped since their t-statistics are close to being significant at the 10% level.[13]

As before, we compute the odds ratio for each variable. These are presented in Table 6. We also compute the difference in the odds ratio for healthcare firms versus other firms for sites in developed countries outside the home country and for sites in the home country. The odds ratio for the difference across industries for developed sites outside the home country is 2.593 (significant at 1%) and for inside the home country is 1.583 (significant at 5%). Thus healthcare firms are more likely to be conducting research aimed at new markets than are other firms. Note that in the raw data we did not find that difference (see Figure 5)

Healthcare firms differ from other firms in the importance of highly qualified personnel, collaborating with universities and the ease of negotiating ownership of intellectual property from research relationships. Highly qualified personnel are less important in R&D for new markets in healthcare. For non-healthcare firms *CollabUniv* and *Ownership* are more closely associated with familiar markets, while for healthcare they are more closely associated with new markets. The magnitude of the effect of *CollabUniv* is noteworthy and likely a function of the fact that new drug discovery draws quite heavily on basic science (Cockburn 2008).

Location in the home country is more closely associated with new markets across industries, which is consistent with Vernon's product life cycle hypothesis (Vernon 1974). Notice that this is not a developed country phenomenon since developed country location is more closely associated with familiar markets.

Healthcare and non-healthcare also differ in whether the site was established to support the needs of production. *NeedsProd* has no effect on the odds ratio for non-healthcare firms. For healthcare, if the site was established, at least in part, to support the needs of production then the R&D conducted at the site is more likely to be for familiar markets. This result is consistent with earlier results on product localization and foreign R&D (see for example Mansfield et al. (1979) and Miriani (2002)).

Finally, across all industries large firms are more likely to be conducting R&D for familiar markets, and university faculty are more likely to be associated with new markets.

VII. Concluding Remarks

[12] It is, of course, the case that *CollabUniv* might be important in other industries and this importance might be masked by their inclusion with other industries where *CollabUniv* is not important.

[13] If these variables are dropped results are qualitatively the same for the remaining variables.

In this paper we have analyzed responses to our recent survey of 250 multinational firm decisions on location of recently established or planned R&D facilities and the type and purpose of the R&D conducted at those facilities. Of particular interest is not only on the importance of factors behind these decisions, but also on how the relative importance within the healthcare industry is different from that in other industries. We find some striking differences. First, in terms of overall location strategies, healthcare firms found locating close to high quality R&D personnel and universities to be more important than did other firms. While other firms reported that locating close to customers was moderately important, healthcare firms found it relatively unimportant. Second, on average healthcare firms reported a higher percentage of effort devoted to cutting edge science than did other firms. However, when asked if the purpose of the R&D was to develop entirely new products or processes, there was no significant difference between healthcare and other.

To identify factors behind the type of science at sites, we use logistic regressions for grouped data to relate the ratio of new to familiar science in the facilities identified by respondents to their views on a variety of country-specific characteristics. After controlling for various factors we replicate the result in the raw data that healthcare firms conduct more new science. Universities are substantially more important in conducting new science in healthcare firms than in non-healthcare firms.

We then repeat that exercise to examine the factors behind whether the R&D is conducted for new or familiar markets. It is quite striking that in addition to conducting more new science than other firms, healthcare firms are more likely than others to conduct R&D for new markets. The likelihood of healthcare firms conducting R&D for new markets is positively related to ease of collaboration with universities and faculty with specialized expertise. The effects for non-healthcare firms are mixed.

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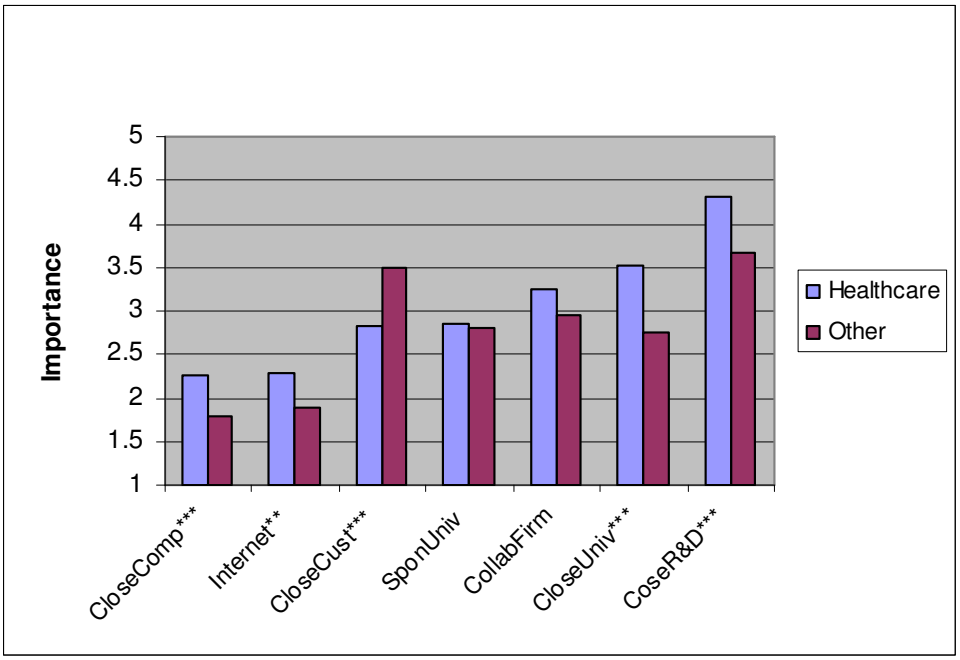
Table 1. Industry of Respondents

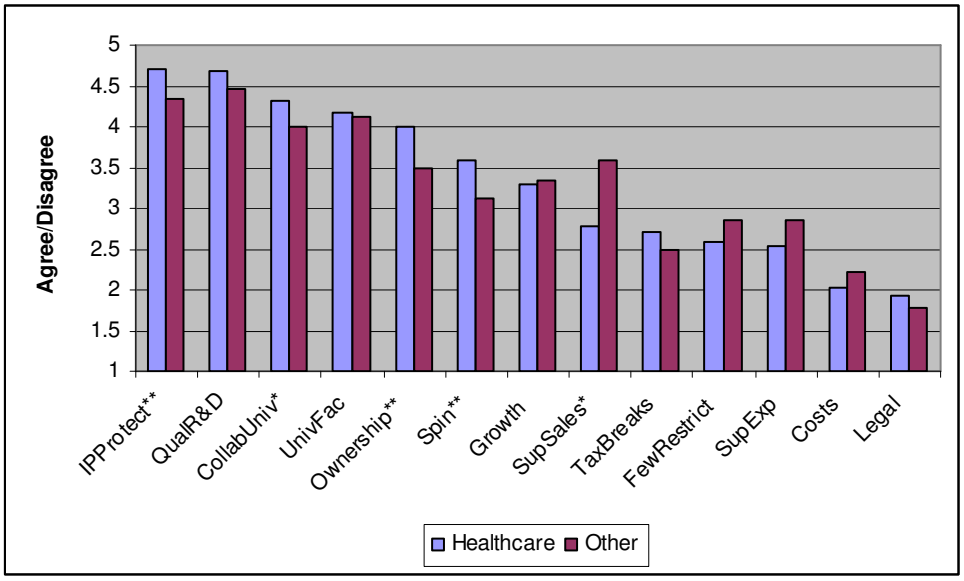
	Industry	Number of Firms
1	Aerospace; transportation & public utilities	15
2	Chemicals & advanced materials	64
3	Communications; telecommunications networks/systems; computer/computer related products; electronics	20
4	Personal care; consumer products not listed elsewhere	19
5	Fabricated metal products; primary metal products	5
6	Food, tobacco & related products	22
7	Genetic engineering/molecular biology	5
8	Healthcare, including medical products and pharmaceuticals	43
9	Industrial machinery & equipment	16
10	Industrial products not listed elsewhere	24
11	Paper & allied products	5
12	Petroleum & related products	10
13	Professional & related products	2
14	R&D services	30

Figure 1. Overall Location Strategies



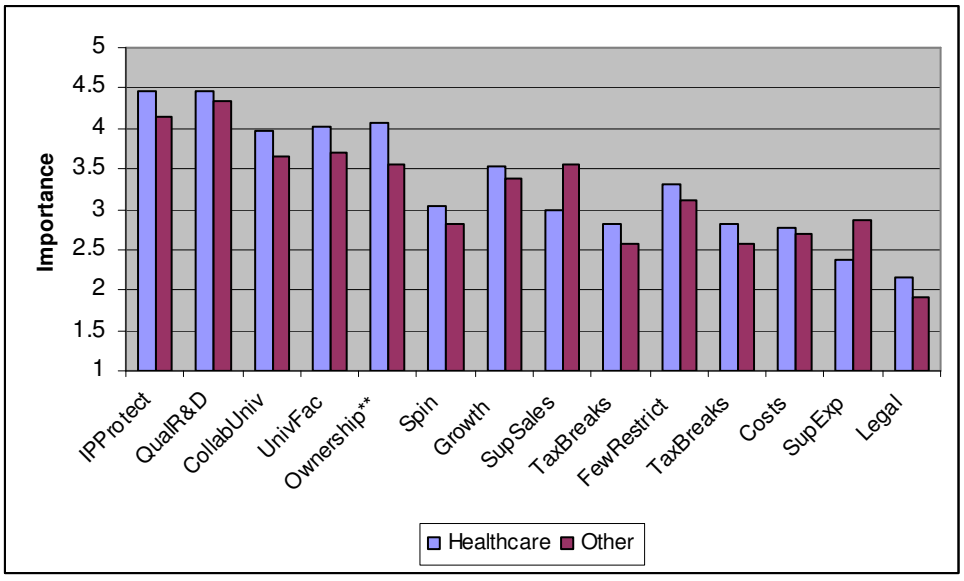
*** Significant at 1% ** Significant at 5%
Number of observations: Healthcare 42-43. Other 205-211.

Figure 2. Average Levels of Agreement/Disagreement



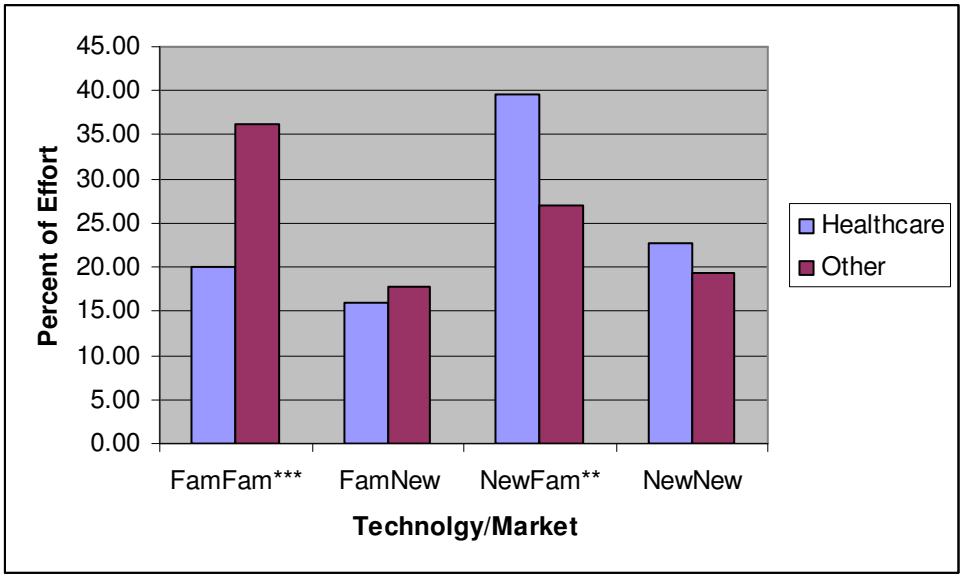
*** Significantly different at a 1% level
** Significantly different at a 5% level
* Significantly different at a 10% level

Figure 3. Average Levels of Importance



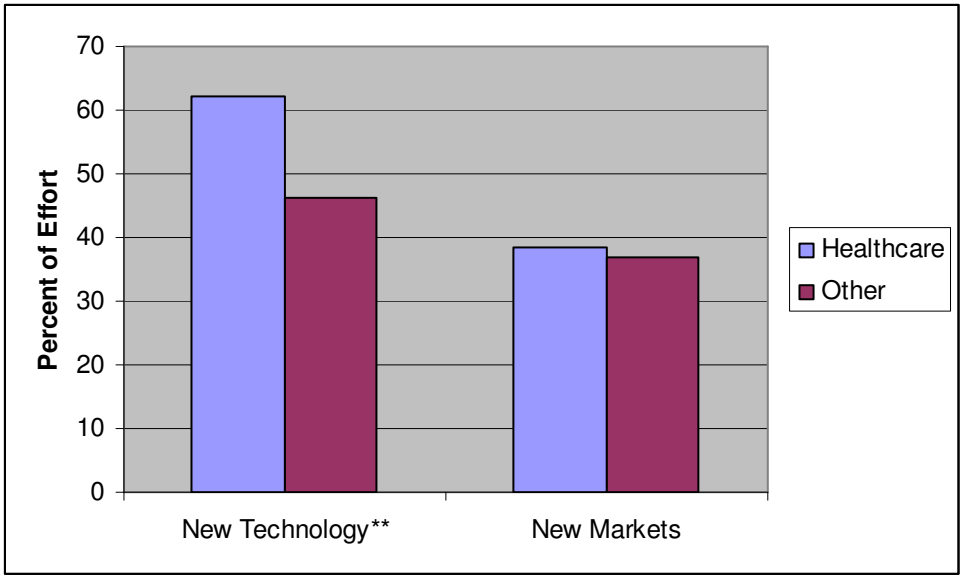
*** Significantly different at a 1% level
** Significantly different at a 5% level
* Significantly different at a 10% level

Figure 4. Type of Science and Purpose: Developed Country Sites Only



*** Significantly different at a 1% level
** Significantly different at a 5% level
* Significantly different at a 10% level

Figure 5. Type of Science: Developed Country Sites Only



*** Significantly different at a 1% level
** Significantly different at a 5% level
* Significantly different at a 10% level

Table 2. Summary Statistics

Panel 1: Healthcare Respondents

	Number of Observations	Mean	Standard Deviation	Min	Max
Percent New Science	30	55.17	33.49	0	100
Percent New Markets	30	36.83	28.21	0	100
CollabUniv	27	10.00	1.98	6	13
Costs	28	6.32	2.58	2	13
Develop	30	0.83	0.38	0	1
FirmSize	30	3526.07	3366.23	10	12000
Home	30	0.47	0.51	0	1
IPProtect	30	10.83	2.83	4	13
NeedProd	30	0.33	0.48	0	1
Ownership	29	9.79	2.72	3	13
QualR&D	30	11.60	2.01	7	13
UnivFac	29	10.17	2.36	5	13

Panel 2: Non-Healthcare Respondents

	Number of Observations	Mean	Standard Deviation	Min	Max
Percent New Science	183	36.10	31.51	0	100
Percent New Markets	183	35.11	27.35	0	100
CollabUniv	173	9.08	2.23	3	13
Costs	174	7.90	3.00	2	13
Develop	183	0.57	0.50	0	1
FirmSize	176	5274.06	16118.88	7	130000
Home	183	0.38	0.49	0	1
IPProtect	179	8.16	3.97	1	13
NeedProd	176	0.57	0.50	0	1
Ownership	177	7.49	2.96	1	13
QualR&D	182	10.85	2.09	4	13
UnivFac	179	9.57	2.29	5	13

Table 3. Logit Regression Results for New *versus* Familiar Science

Panel 1	**Coef.**	**t-Stat**			**Coef.**	**t-Stat**	
Health	-6.052	-0.98					
Develop	0.281	0.95		*H_Develop*	2.480	1.97	*
FirmSize	0.072	1.71	*	*H_FirmSize*	-0.006	-0.04	
Home	0.871	3.56	***	*H_Home*	-1.149	-2.23	**
Costs	0.032	0.17		*H_Costs*	-0.113	-0.16	
QualR&D	-0.794	-2.12	**	*H_QualR&D*	0.439	0.20	
NeedProd	-0.395	-2.45	**	*H_NeedProd*	-1.016	-2.48	**
CollabUniv	6.165	1.89	*	*H_CollabUniv*	0.483	0.30	
UnivFac	7.467	2.37	**	*H_UnivFac*	0.455	0.21	
IPProtect	0.183	0.49		*H_IPProtect*	-0.364	-0.26	
Ownership	0.680	1.58		*H_Ownership*	1.446	1.01	
Fac_Collab	-2.806	-1.97	**				
IP_Own	-0.313	-1.46					
No. Obs.	179			R-Square	0.543		

Panel 2	**Coef.**	**t-Stat**			**Coef.**	**t-Stat**	
Health	-7.209	-3.47	***				
Develop	0.273	0.98		*H_Develop*	1.690	3.36	***
FirmSize	0.103	3.24	***	*H_FirmSize*			
Home	0.848	3.72	***	*H_Home*	-0.840	-2.42	**
Costs				*H_Costs*			
QualR&D	-0.740	-2.25	**	*H_QualR&D*	1.329	2.71	***
NeedProd	-0.486	-3.15	***	*H_NeedProd*	-0.364	-1.38	
CollabUniv	7.991	2.59	***	*H_CollabUniv*	3.021	2.74	***
UnivFac	9.261	3.09	***	*H_UnivFac*	-0.698	-1.01	
IPProtect				*H_IPProtect*			
Ownership	0.480	1.22		*H_Ownership*	-0.777	-1.34	
Fac_Collab	-3.630	-2.69	***				
IP_Own	-0.182	-1.20					
No. Obs.	182			R-Square	0.552		

Panel 3	**Coef.**	**t-Stat**			**Coef.**	**t-Stat**	
Health	-9.019	-4.77	***				
Develop				*H_Develop*	1.691	4.87	***
FirmSize	0.085	2.92	***	*H_FirmSize*			
Home	0.866	5.78	***	*H_Home*	-0.989	-3.36	***
Costs				*H_Costs*			
QualR&D	-0.587	-1.85	*	*H_QualR&D*	1.383	2.91	***
NeedProd	-0.481	-3.22	***	*H_NeedProd*	-0.250	-1.00	
CollabUniv	11.116	3.97	***	*H_CollabUniv*	2.337	2.70	***
UnivFac	11.612	4.09	***	*H_UnivFac*			
IPProtect				*H_IPProtect*			
Ownership				*H_Ownership*			
Fac_Collab	-4.920	-3.95	***				
IP_Own							
No. Obs.	186			R-Square	0.530		

Table 4. New Science vs. Familiar Science Odds Ratios

	Non-Healthcare		Healthcare	
Develop	1.000		5.427	***
Home	2.378	***	0.884	
FirmSize	1.089	***	1.089	***
QualR&D	0.556	*	2.217	**
NeedProd	0.618	***	0.482	***
CollabUniv	1.116		11.551	***
UnivFac	2.343	***	2.343	***

Tests are for difference between the odds ratio and the value 1.
*** Significantly different at a 1% level
** Significantly different at a 5% level
* Significantly different at a 10% level

Table 5. Logit Regression Results for New *versus* Familiar Markets

Panel 1	**Coef.**	**t-Stat**			**Coef.**	**t-Stat**	
Health	-8.044	-1.02					
Develop	-0.600	-2.39	**	*H_Develop*	0.310	0.28	
FirmSize	-0.056	-1.52		*H_FirmSize*	-0.111	-0.43	
Home	0.948	4.15	***	*H_Home*	-0.624	-1.43	
Costs	0.466	2.68	***	*H_Costs*	0.410	0.35	
QualR&D	-0.677	-2.17	**	*H_QualR&D*	-1.913	-0.57	
NeedProd	0.027	0.21		*H_NeedProd*	-1.323	-1.43	
CollabUniv	-5.885	-2.26	**	*H_CollabUniv*	5.287	1.73	*
UnivFac	-4.336	-1.60		*H_UnivFac*	-0.012	0.00	
IPProtect	-0.054	-0.15		*H_IPProtect*	-0.444	-0.31	
Ownership	-1.161	-2.99	***	*H_Ownership*	1.152	2.00	**
Fac_Collab	2.392	2.03	**				
IP_Own	0.270	1.34					
No. Obs.	179			R-Square	0.573		

Panel 2	**Coef.**	**t-Stat**			**Coef.**	**t-Stat**	
Health	-7.960	-1.66	*				
Develop	-0.605	-2.51	**	*H_Develop*	0.150	0.30	
FirmSize	-0.058	-1.77	*	*H_FirmSize*	-0.150	-2.34	**
Home	0.956	4.33	***	*H_Home*	-0.582	-1.49	
Costs	0.475	2.97	***	*H_Costs*	0.392	0.65	
QualR&D	-0.695	-2.47	**	*H_QualR&D*	-2.486	-2.72	***
NeedProd	0.033	0.27		*H_NeedProd*	-1.458	-4.35	***
CollabUniv	-5.891	-2.28	**	*H_CollabUniv*	5.494	3.16	***
UnivFac	-4.356	-1.63		*H_UnivFac*			
IPProtect				*H_IPProtect*			
Ownership	-1.115	-3.58	**	*H_Ownership*	1.249	2.62	**
Fac_Collab	2.402	2.06	**				
IP_Own	0.240	2.29	**				
No. Obs.	179			R-Square	0.573		

Panel 3	**Coef.**	**t-Stat**			**Coef.**	**t-Stat**	
Health	-5.364	-2.18	**				
Develop	-0.581	-2.73	***	*H_Develop*			
FirmSize	-0.059	-1.94	*	*H_FirmSize*	-0.153	-2.45	**
Home	0.966	4.81	***	*H_Home*	-0.494	-1.62	
Costs	0.494	3.22	***	*H_Costs*			
QualR&D	-0.705	-2.55	**	*H_QualR&D*	-2.697	-3.19	***
NeedProd				*H_NeedProd*	-1.448	-5.06	***
CollabUniv	-5.252	-2.29	**	*H_CollabUniv*	4.690	4.47	***
UnivFac	-3.733	-1.55		*H_UnivFac*			
IPProtect				*H_IPProtect*			
Ownership	-1.138	-3.74	***	*H_Ownership*	1.478	4.46	***
Fac_Collab	2.123	2.04	**				
IP_Own	0.240	2.33	**				
No. Obs.	179			R-Square	0.571		

Table 6. New Markets vs. Familiar Markets Odds Ratios

	Non-Healthcare		Healthcare	
Develop	0.559	***	0.559	***
Home	2.627	***	1.604	*
FirmSize	0.942	*	0.809	***
Costs	1.638	***	1.638	***
QualR&D	0.494	**	0.033	***
NeedProd	1.000		0.235	***
CollabUniv	0.605	*	65.791	***
UnivFac	2.483	***	2.483	***
Ownership	0.514	***	2.254	***

Tests are for difference between the odds ratio and the value 1.

*** Significantly different at a 1% level

** Significantly different at a 5% level

* Significantly different at a 10% level

Appendix: Algorithm to Combine Agreement/Disagreement and Importance of Factor Scores.

We begin by subtracting 3 from the agreement score. Recall that the statements about the factors are made in such a way that agreement with the statement implies that the factor is a potential attraction to the site and disagreement is a possible detractor. Since the scores go from 1 (strongly disagree) to 5 (strongly agree) subtracting 3 gives provides a metric where negative values measure disagreement and positive values measure agreement. Zero implies that the respondent neither agrees nor disagrees. The importance score also goes from 1 (not important at all) to 5 (extremely important). We subtract 1 from the importance score and then multiply the result times the revised agreement score. The reason for subtracting 1 from the importance scores is that this provides for a product with a score of 0 when a factor is not important at all regardless of the level of agreement. The resulting product gives scores from the following set: {-8, -6, -4, -3, -2, -1, 0, 1, 2, 3, 4, 6, 8}. The lower scores represent factors that are both detractors and which were important in the site selection deliberations. The higher scores represent factors that are both attractors and which were important in the site selection deliberations. The middle scores represent factors that were either not important in deliberations (regardless of the level of agreement or disagreement) or for which the respondent neither agree nor disagreed. We then transform scores of -6 and 6 to scores of -5 and 5, respectively. Then we transform scores of -8 and 8 to scores of -6 and 6, respectively. These latter transformations are made so that the set of scores increases everywhere by single units. Finally, we add 7 to every score to transform the scores to positive values ranging from 1 to 13.