



# DOES EXCELLENCE IN ACADEMIC RESEARCH ATTRACT FOREIGN R&D?

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## INTRODUCTION

### Motivation:

- Internationalization of corporate R&D has risen over past decades (UNCTAD, 2005; OECD, 2007)
- Broad literature on the country and firm drivers of foreign R&D, but little empirical evidence on role of countries' academic research strengths
  - Surveys show that university research ranks high among factors driving locations' attractiveness perceived by multinational firms (Thursby & Thursby, 2006)
- Policy implications: strengthening academic research can increase private R&D

### Research Questions:

- Does the strength of countries' academic research attract foreign R&D?
- Do firms differ in the value they attach to academic research?
  - Are firms with a more outspoken science orientation in research more responsive to countries' academic research activities?



## PREVIOUS RESEARCH I

**Two main motivations to internationalize R&D activities** (Hakanson & Nobel, 1993; Kuemmerle, 1997; Florida, 1997)

- *Home-base exploiting R&D*: Adapt technologies to local markets and local manufacturing conditions
- *Home-base augmenting R&D*: Create new technologies abroad (for world markets), through technology sourcing, access to local knowledge sources (including universities)

**Home base augmenting motivation gains importance** (OECD, 2007; Von Zedtwitz & Gassmann, 2002; Ambos, 2005; Shimizutani & Todo, 2007)

- And may improve parent R&D performance (Iwasa & Odagiri, 2004; Griffith, Harrison & Van Reenen, 2006; Penner-Hahn & Shaver, 2005; Todo & Shimizutani, 2008)
- Is the role of universities in attracting foreign R&D increasing as well?<sup>3</sup>



## PREVIOUS RESEARCH II

- **Host country characteristics observed to affect inward R&D:**
  - Size of MNEs' local manufacturing and sales operations (+)  
(Kenny and Florida, 1994; Odagiri & Yasuda, 1996; Belderbos, 2001)
  - Large and sophisticated local markets (+)  
(Zejan, 1990; Kumar, 2001; Kuemmerle, 1999)
  - Technological strength (+)  
(Le Bas & Sierra, 2002; Patel & Vega, 1999; Belderbos et al, 2009; Todo & Shimizutani, 05)
  - Wage costs (-) and/or availability (+) of scientists and engineers  
(Thursby & Thursby, 2006; Kumar, 2001; Cantwell & Piscitello, 2005)
  - Strength of intellectual property rights regime (+)  
(Branstetter, 2006; Belderbos et al, 2008)



## PREVIOUS RESEARCH III

### **Universities impact on firm innovation activities:**

- Collaboration partners, consultants, supply scientists & engineers, (informal) knowledge transfers (Branstetter & Kwon, 2004)
- Proximity to/collaboration with universities increases performance (Jaffe, 1989; Cockburn & Henderson, 1998; Zucker et al, 2002; Belderbos et al, 2004; Leten et al, 2007)
- Academic research has positive effect on industrial R&D facilities at regional level (Jaffe, 1989; Anselin et al., 1997; Bania et al., 1992; Zucker et al, 1998, 2001)
- Different benefits of academic linkage across firms: ‘scientific absorptive capacity’ (Gambardella, 1992; Cockburn and Henderson, 1998; Liebeskind et al, 1996)



## PREVIOUS RESEARCH III

### **But limited evidence on university research and foreign R&D decisions by multinational firms**

- Analyses at the aggregate country/regional level (Cantwell & Piscitello, 2005; Hegde & Hicks, 2008) of relationship foreign firms' presence and public research
- Rough proxies for academic research such as public R&D employment or Nobel prize winners (Kuemmerle, 2001; Cantwell & Piscitello, 2005)



# Contribution of the paper

- Firm-level analysis of global R&D location decisions for a large sample of leading multinational firms
- Publication data as a measure of academic research strength, by relevance to technology fields
- Considers heterogeneity between firms
- Control for a broad set of country- and firm-level drivers of R&D:
  - Reduce risk of omitted variable bias in estimating the impact of academic research strength
  - + Additional robustness checks



## DATA

### **Data and Dependent variable:**

- 176 top R&D spending US, EU, and Japanese firms
- Five industries: Chemicals, Pharmaceuticals & Biotech, IT Hardware, Electronics & Electrical Machinery, Non-Electrical Machinery
- EPO patent application data for at the consolidated firm level
- R&D locations via patent inventor addresses (Deyle and Grupp, 2005)
- 30 technology fields (5 main technology classes), 40 host countries
- Two 4-year periods (1995-1998; 1999-2002)
  - Examine changes in drivers; explanatory variables not available on a yearly basis





## DATA AND EMPIRICAL MODEL

- Dependent variable: binary variable, taking 1 if firm has patent applications in host country, technology, and period
  - Binary variable: we identify presence of local R&D activities during the period
  - Little variation among positive patent counts (88% < 10, 61% ≤ 2)
  - 87089 (1995-1998) and 100326 (1999-2002) observations
  - 4.2%, 5.0% value 1
- Logit model with error terms clustered at the firm level

### **% of patents originating in foreign locations**

Firms:	European	US	Japanese
1995-1998	39	23	7,0
1999-2002	39	25	8,3

## R&D by country and region (# patents) 1995-2002

Firms:	Europe	%	US	%	Japan	%
Home Country	50027	61,0	33867	76,0	56431	92,3
Europe	19462	23,7	8'092	18,2	2356	3,9
Belgium	1520		338		68	
France	1729		1452		209	
Germany	6029		1866		1054	
Italy	2419		308		29	
Sweden	1418		114		68	
Switzerland	1009		319		22	
United Kingdom	1690		2628		760	
USA	10115	12,3			2082	3,4
Japan	752	0,9	1036	2,3		
Rest of Asia	612	0,7	398	0,9	135	0,2
China	131		35		15	
India	65		70		6	
Republic of Korea	61		39		30	
Russia	59		20		3	
Singapore	195		127		62	
Taiwan	20		68		4	
South America	65	0,1	62	0,1	2	0,0
Brazil	58		57		1	
Rest of World	1007		1122		123	
Israel	53		410		6	
Total	82040		44577		61129	



## VARIABLES

- **Explanatory variable of interest: Host countries' academic research strength**
  - Publications in Web of Science database (WOS: article, letter, note and review) in the years preceding each period
  - By country (author/institution addresses) and scientific disciplines: Mapped into 5 main technology classes
    - Most science fields are linked to one technology main class
  - Web of science: International peer reviewed journal list
    - Indicator of quality of academic research (peer review, minimum impact requirement) as well as volume

## ISI Publications per country/region and broad technology fields 1995-2002

	ALL	Electrical Eng.		Instruments		Chem/Pharma		Process Eng.		Mechanic Eng.	
France	571.599	55.379	10%	64.937	11%	328.816	58%	122.014	21%	75.805	13%
Germany	764.573	72.280	9%	99.564	13%	450.707	59%	164.150	21%	93.100	12%
Italy	382.816	41.362	11%	51.717	14%	230.766	60%	65.497	17%	47.099	12%
United Kingdom	828.697	64.090	8%	63.995	8%	530.036	64%	133.028	16%	98.354	12%
<b>Europe</b>	4.088.560	364.245	9%	438.804	11%	2.495.952	61%	785.385	19%	477.865	12%
<b>USA</b>	3.038.709	265.442	9%	238.367	8%	1.953.637	64%	434.239	14%	352.973	12%
<b>Japan</b>	949.969	110.139	12%	104.762	11%	510.902	54%	204.875	22%	101.236	11%
<b>other Aia</b>	1.310.200	199.514	15%	205.098	16%	565.946	43%	378.901	29%	233.873	18%
China	278.655	40.794	15%	44.368	16%	103.714	37%	93.848	34%	52.204	19%
India	201.290	21.583	11%	22.017	11%	103.212	51%	53.966	27%	29.183	14%
Israel	109.794	12.900	12%	12.150	11%	64.941	59%	19.502	18%	12.814	12%
Korea	141.129	28.782	20%	21.146	15%	61.539	44%	43.474	31%	24.831	18%
Russia	300.083	50.510	17%	77.445	26%	93.581	31%	106.404	35%	73.450	24%
Singapore	39.503	10.039	25%	4.892	12%	12.625	32%	10.448	26%	7.728	20%
Taiwan	116.533	23.875	20%	13.622	12%	49.480	42%	28.259	24%	20.531	18%
<b>South America</b>	198.243	17.165	9%	21.645	11%	116.966	59%	46.025	23%	25.585	13%
Brazil	113.751	11.189	10%	14.129	12%	66.993	59%	26.557	23%	14.106	12%
<b>Rest of World</b>	767.090	55.817	7%	51.144	7%	461.525	60%	125.651	16%	94.317	12%
Australia	247.052	17.615	7%	15.055	6%	154.325	62%	40.030	16%	30.165	12%
Canada	424.985	30.813	7%	26.327	6%	254.589	60%	63.407	15%	49.849	12%
<b>Total</b>	<b>10.352.771</b>	<b>1012322</b>	<b>10%</b>	<b>1059820</b>	<b>10%</b>	<b>6104928</b>	<b>59%</b>	<b>1975076</b>	<b>19%</b>	<b>1285849</b>	<b>12%</b>



## VARIABLES II

- **Host country control variables:**
  - Market size and market sophistication:
    - Sector level market size: Host country production + imports - exports
    - GDP/capita
  - Technological strength:
    - Technological strength own field: Host country patents in field
    - Technological strength related fields: Host country patents fields some tech class
  - IPR protection level:
    - Index from Global Competiveness Report (ranges 0-10)
    - MNE opinions on strength patents, trademarks, copyright protection etc.
  - Cost R&D personnel: Yearly gross income of engineers (UBS)
  - Language similarity between host and home country: Dummy
  - Geographic distance between host and home country
  - European host country dummy
    - Propensity to patent with EPO likely higher for inventions in Europe 13



## VARIABLES III

- **Firm Scientific Orientation:**
  - Measured by average number of non-patent references to scientific literature in prior firm patent portfolio (t-1 – t-4)
  - Indicator of firm's 'usage' of science
    - Majority of patent inventors is aware of specific scientific papers cited on patents (Fleming & Sorenson, 2004)
    - Non-patent references parsed to retrieve only citations to WOS journals (57% of references on average)
- **Firm control variables:**
  - Technological strength in field: firm patents in technology field,
  - Overall size of R&D activities: total number firm patents
  - Sales/Manufacturing subsidiary in a host country: Dummy
  - Age of firm
  - International R&D experience
  - Country of origin
- **Explanatory variables**
  - One-year lagged values (1994 for period 1; 1998 for period 2)
  - All continuous variables are log transformed



	1995 - 1998		1999 - 2002	
	Model 1	Model 2	Model 1	Model 2
<b>Host Country Variables</b>				
Academic Research	0.2382*** (0.0783)	0.1887** (0.0851)	0.2155*** (0.0774)	0.1328* (0.0803)
Academic Research * Firm's Science Orientation		0.3160** (0.1557)		0.5350*** (0.1984)
Technological Strength	0.4008*** (0.0417)	0.4010*** (0.0419)	0.4264*** (0.0379)	0.4231*** (0.0375)
Technological Strength in Related Fields	0.1073* (0.0622)	0.1053* (0.0622)	0.1184** (0.0517)	0.1143** (0.0516)
IPR Protection	0.8911*** (0.2365)	0.8895*** (0.2371)	1.1968*** (0.2758)	1.1906*** (0.2784)
GDP per Capita	0.3558** (0.1742)	0.3509** (0.1729)	0.0337 (0.1732)	0.0438 (0.1743)
Market Size	0.1328*** (0.0459)	0.1285*** (0.0474)	0.1071* (0.0547)	0.1353** (0.0548)
Engineering Wage	-0.3530** (0.1552)	-0.3480** (0.1545)	-0.4490*** (0.1322)	-0.4542*** (0.1323)
European Host Country	0.0553 (0.1056)	0.0524 (0.1070)	-0.0914 (0.1025)	-0.0852 (0.1028)
Language Similarity	0.5441*** (0.1221)	0.5428*** (0.1213)	0.6398*** (0.1020)	0.6391*** (0.1019)
Geographic Distance	-0.1569*** (0.0589)	-0.1533*** (0.0587)	-0.2178*** (0.0505)	-0.2180*** (0.0505)
<b>Firm Variables</b>				
Firm's Science Orientation		-1.5164* (0.8070)		-1.6709 (1.1109)
Firm's Technological Strength	0.8298*** (0.0260)	0.8298*** (0.0257)	0.8142*** (0.0239)	0.8131*** (0.0236)
Firm's Total Patents	-0.0144 (0.0415)	-0.0071 (0.0440)	0.0114 (0.0444)	0.0110 (0.0453)
International R&D Experience	0.3001** (0.1433)	0.3034** (0.1433)	0.1858 (0.1382)	0.1658 (0.1338)
Firm's Age	-0.1494 (0.1022)	-0.1547 (0.1062)	-0.0634 (0.1062)	-0.0524 (0.1074)
Manufacturing or Sales Subsidiary	0.7054*** (0.1056)	0.7060*** (0.1054)	0.5723*** (0.0945)	0.5771*** (0.0948)

## Main model full results

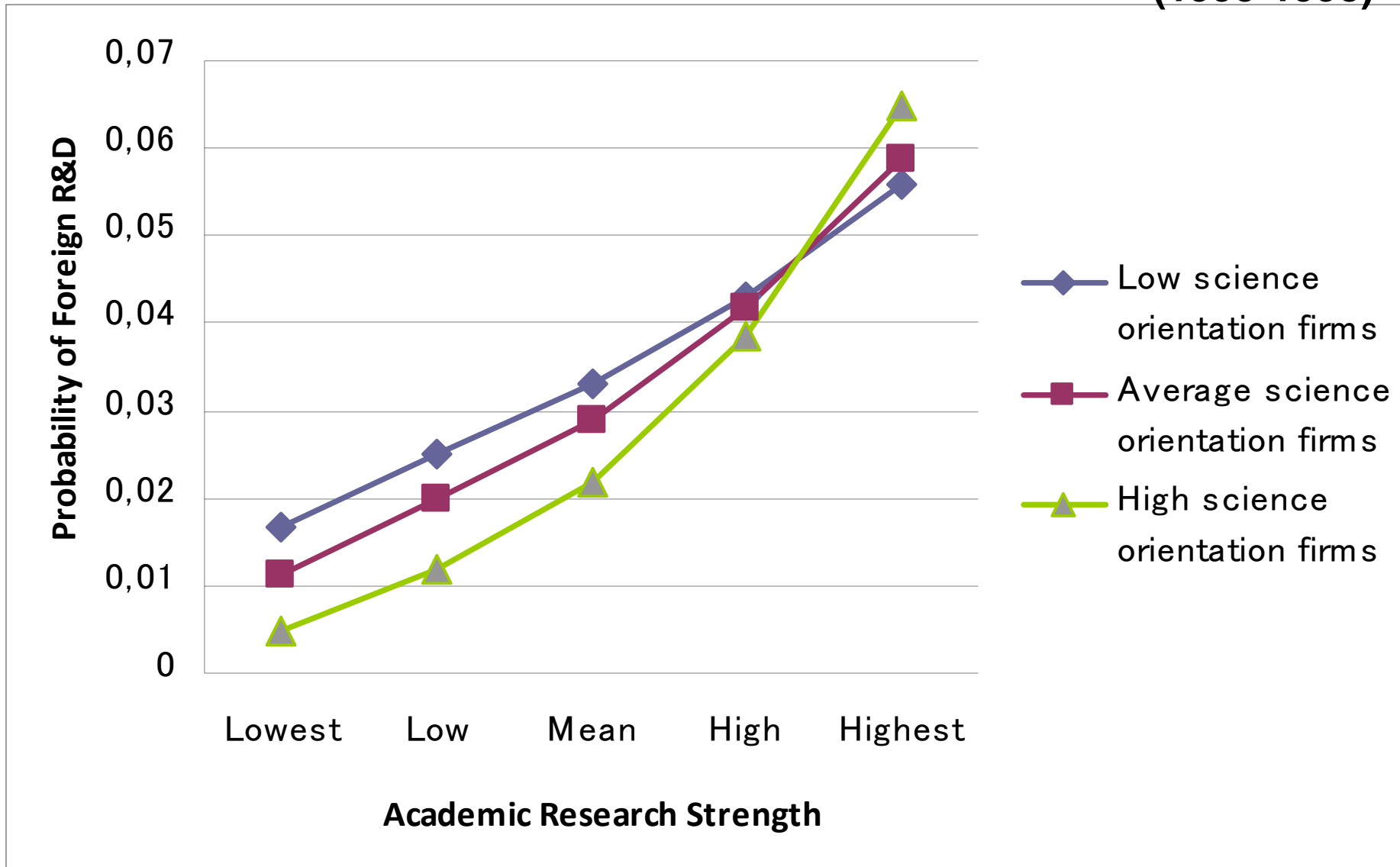


	1995 - 1998		1999 - 2002	
	Model 1	Model 2	Model 1	Model 2
<b>Home Country Dummies</b>				
Japan	-1.2975*** (0.1354)	-1.2980*** (0.1366)	-1.4035*** (0.1663)	-1.4539*** (0.1705)
Belgium	0.1380 (0.2525)	0.1564 (0.2551)	0.2396 (0.1759)	0.2821 (0.1900)
Switzerland	0.4237 (0.3745)	0.4011 (0.3628)	0.5545*** (0.2083)	0.6157*** (0.2067)
Germany	0.2233 (0.1526)	0.2198 (0.1543)	0.2487 (0.2014)	0.2783 (0.2020)
Denmark	0.3281 (0.7780)	0.3236 (0.7753)	0.3037 (0.3602)	0.3462 (0.3640)
Finland	0.3828* (0.2322)	0.3823* (0.2208)	0.6124** (0.2663)	0.6790** (0.2693)
France	-0.1004 (0.1551)	-0.0835 (0.1548)	0.0346 (0.1635)	0.0429 (0.1638)
Great Britain	0.1273 (0.2918)	0.1361 (0.2894)	0.0918 (0.1445)	0.1432 (0.1468)
Netherlands	0.1840 (0.2016)	0.2065 (0.1994)	-0.3852 (0.3992)	-0.3284 (0.4103)
Sweden	0.5635*** (0.1766)	0.5422*** (0.1746)	0.1972 (0.1565)	0.2445 (0.1669)
Technology Dummies (29)	Included	Included	Included	Included
Constant	-8.6726*** (0.6273)	-8.4455*** (0.6625)	-8.5579*** (0.6759)	-8.3230*** (0.6925)
Number of Observations	87089	87089	100326	100326
Log Likelihood	-9321	-9314	-11990	-11965
McFadden Pseudo R2	0.3851	0.3855	0.3990	0.4003
Correct Prediction for 1 (%) - Sensitivity	86.01	86.04	85.58	85.46
Correct Prediction for 0 (%) - Specificity	83.26	83.24	83.43	83.46
ROC	0.9211	0.9212	0.9225	0.9228
<b>Interaction Effect</b>				
% of positive values (significant)		90.0 (18.4)		98.5 (84.9)
% of negative values (significant)		10.0 (0.4)		1.5 (0.1)
<b>LR Tests</b>				
Chi-2 Model 2 versus Model 1		12.50***		48.82***



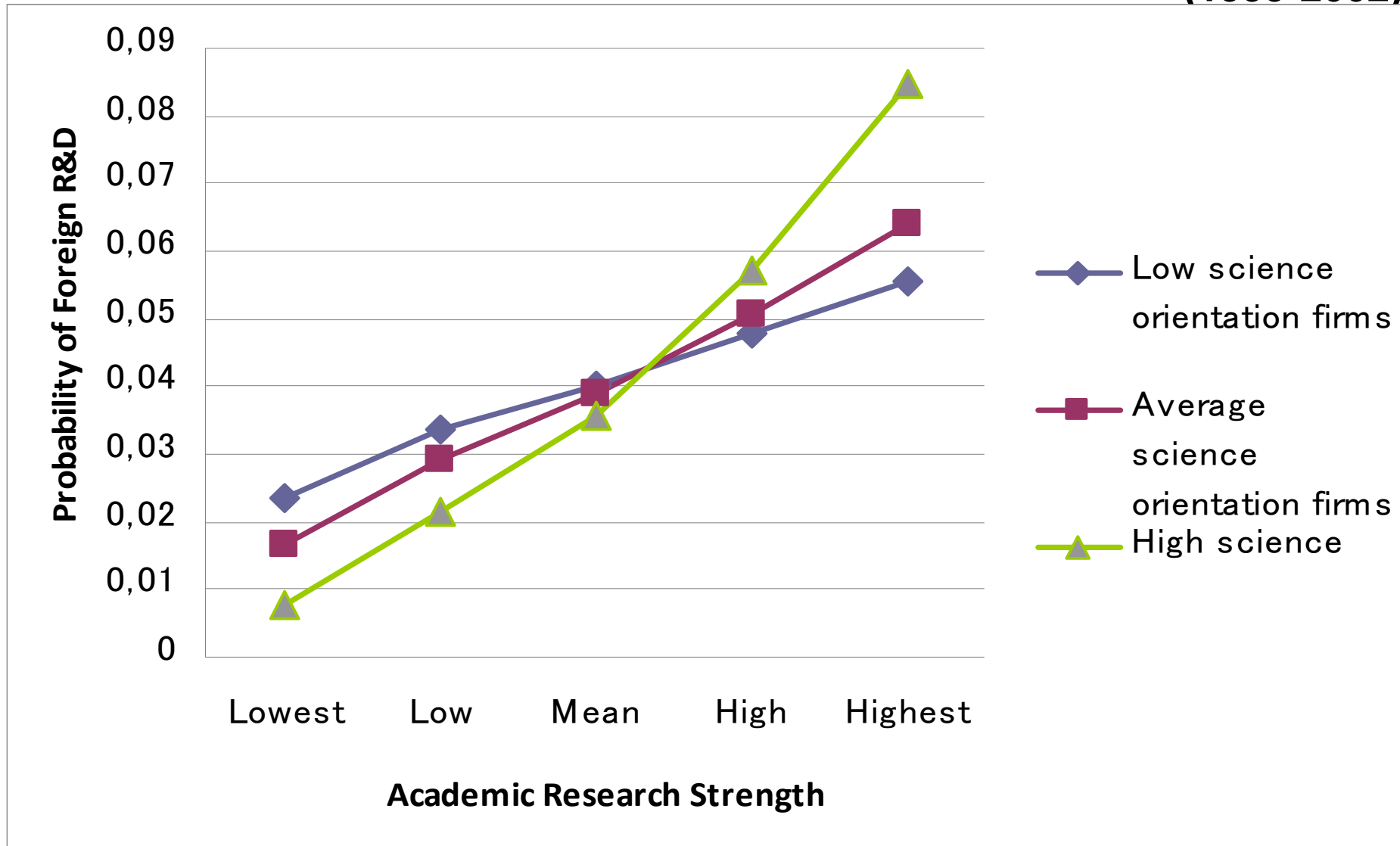


## Mean predicted values of the probability to conduct foreign R&D (1995-1998)





## Mean predicted values of the probability to conduct foreign R&D (1999-2002)





## Robustness Checks

1. Split sample test: firms with above or below median science orientation
2. Count model of the number of host country - originating patents
3. Including lagged dependent variable 'prior R&D' (prior host country originating patents of the firm in t-1)
  - Further control for unobserved heterogeneity; R&D decisions taken earlier
4. Examine firm heterogeneity related to technology leadership (Alcacer, 2007; Belderbos et al, 2008)
  - Split sample around median share of firm in total patents in the technology
  - Are leaders more attracted to public R&D than industrial R&D due to risk of local knowledge spillovers and appropriability?
5. Firm-level analysis aggregating over technologies
  - Reduces observations to 6486 and 6722, increases share of observations with value 1 to 18%

## Split sample test



	1995 - 1998		1999 - 2002	
	Science Orientation		Science Orientation	
	Low	High	Low	High
<b>Host Country Variables</b>				
Academic Research	0.0585 (0.1039)	0.4402*** (0.0923)	0.0755 (0.0864)	0.4128*** (0.1095)
Technological Strength	0.3526*** (0.0705)	0.4196*** (0.0523)	0.4956*** (0.0494)	0.3247*** (0.0555)
Technological Strength in Related Fields	0.2394** (0.1035)	-0.0310 (0.0682)	0.1701** (0.0697)	0.0464 (0.0728)
IPR Protection	0.4272 (0.4109)	1.2096*** (0.2956)	1.0100** (0.4003)	1.3635*** (0.3556)
GDP per Capita	0.3993 (0.2746)	0.3109 (0.2054)	-0.1277 (0.2505)	0.2089 (0.1862)
Market Size	0.1265 (0.0788)	0.1614*** (0.0540)	0.0613 (0.0783)	0.2024*** (0.0676)
Engineering Wage	-0.2895 (0.2518)	-0.3031* (0.1703)	-0.4530** (0.1842)	-0.4129** (0.1618)
European Host Country	0.3282** (0.1545)	-0.0964 (0.1421)	0.1296 (0.1477)	-0.1786 (0.1407)
Language Similarity	0.7683*** (0.1876)	0.3378** (0.1655)	0.6767*** (0.1431)	0.6378*** (0.1391)
Geographic Distance	-0.0755 (0.0744)	-0.1949** (0.0949)	-0.1278** (0.0644)	-0.2517*** (0.0858)
<b>Firm Variables</b>				
Firm's Technological Strength	0.8101*** (0.0406)	0.8474*** (0.0395)	0.8164*** (0.0326)	0.8226*** (0.0371)
Firm's Total Patents	0.1012* (0.0597)	-0.1499** (0.0663)	0.0737 (0.0595)	-0.0058 (0.0815)
International R&D Experience	0.2755 (0.2004)	0.3330 (0.2105)	0.1433 (0.1653)	0.2897 (0.2463)
Firm's Age	-0.4100** (0.1609)	0.0414 (0.1303)	-0.2609* (0.1501)	0.0440 (0.1278)
Manufacturing or Sales Subsidiary	0.9871*** (0.1623)	0.5377*** (0.1383)	0.6236*** (0.1348)	0.5700*** (0.1374)

## Split sample test



	1995 - 1998		1999 - 2002	
	Science Orientation		Science Orientation	
	Low	High	Low	High
<b>Home Country Dummies</b>				
Japan	-1.3718*** (0.2414)	-1.3682*** (0.1670)	-1.3499*** (0.3747)	-1.5212*** (0.2015)
Belgium	-0.3631* (0.2011)	0.0512 (0.3368)	0.6268*** (0.2151)	-0.0846 (0.2405)
Switzerland	0.5355* (0.3193)		0.7610*** (0.2585)	
Germany	0.2400 (0.1839)	0.2960 (0.2118)	0.2856 (0.2971)	0.6715** (0.2738)
Denmark	0.5644 (0.8012)	-0.9769*** (0.2974)	0.4948 (0.3412)	0.1596 (0.3110)
Finland	0.5329*** (0.1779)		0.6509*** (0.2022)	
France	-0.0980 (0.2325)	-0.1255 (0.2225)	0.1727 (0.2555)	-0.1015 (0.2104)
Great Britain	0.2809 (0.3374)	-0.4040 (0.5213)	0.1541 (0.1929)	0.1444 (0.4170)
Netherlands	0.7310* (0.4316)	0.1547 (0.2048)	-0.4771 (0.3956)	1.0131*** (0.2391)
Sweden	0.8411*** (0.1955)		0.3372 (0.2160)	
Technology Dummies (29)	Included	Included	Included	Included
Constant	-7.9811*** (0.9326)	-9.3219*** (0.8408)	-7.5401*** (0.9908)	-10.0376*** (0.8551)
Number of Observations	40450	46537	48096	52192
Log Likelihood	-4467	-4740	-6656	-5219
McFadden Pseudo R2	0.3648	0.4162	0.3880	0.4191
Correct Prediction for 1 (%) - Sensitivity	85.36	87.23	84.54	86.46
Correct Prediction for 0 (%) - Specificity	82.05	84.53	82.51	84.88
ROC	0.9162	0.9293	0.9161	0.9311



	1995 - 1998	1999 - 2002
<b>Host Country Variables</b>		
Academic Research	0.2482*** (0.0911)	-0.0126 (0.0833)
Academic Research * Firm's Science Orientation	0.1590 (0.1732)	0.6585*** (0.1929)
Technological Strength	0.3756*** (0.0602)	0.4452*** (0.0517)
Technological Strength in Related Fields	0.1639** (0.0833)	0.2782*** (0.0675)
IPR Protection	0.9223*** (0.3113)	1.0045*** (0.3449)
GDP per Capita	0.5905*** (0.1949)	-0.0177 (0.1879)
Market Size	0.0803 (0.0729)	0.0907 (0.0590)
Engineering Wage	-0.3284* (0.1812)	-0.3428** (0.1557)
European Host Country	0.1256 (0.1546)	0.0473 (0.1412)
Language Similarity	0.3610** (0.1564)	0.6363*** (0.1308)
Geographic Distance	-0.3026*** (0.0825)	-0.1666** (0.0663)
<b>Firm Variables</b>		
Firm's Science Orientation	-1.1679 (0.9495)	-2.5779* (1.3797)
Firm's Technological Strength	1.0059*** (0.0368)	1.0081*** (0.0280)
Firm's Total Patents	-0.0141 (0.0618)	-0.0174 (0.0611)
International R&D Experience	-0.0263 (0.1800)	0.1028 (0.1892)
Firm's Age	-0.1050 (0.1215)	-0.2133 (0.1407)
Manufacturing or Sales Subsidiary	0.9796*** (0.1337)	0.8449*** (0.1219)



	1995 - 1998	1999 - 2002
<b>Home Country Dummies</b>		
Japan	-1.5079*** (0.1685)	-1.5784*** (0.2082)
Belgium	-0.1650 (0.2640)	0.4958** (0.2165)
Switzerland	0.5592 (0.4179)	0.8438*** (0.2438)
Germany	0.1607 (0.2305)	0.3675 (0.2320)
Denmark	1.0323 (0.7519)	0.9654* (0.5172)
Finland	0.1161 (0.2544)	0.6229*** (0.2391)
France	-0.1009 (0.2850)	0.3259 (0.2388)
Great Britain	0.0931 (0.2555)	0.2806 (0.2692)
Netherlands	-0.1374 (0.2172)	-0.1118 (0.3414)
Sweden	0.6929** (0.2968)	0.3009 (0.2296)
Technology Dummies (29)	Included	Included
Constant	-8.1242*** (0.7383)	-7.5929*** (0.7512)
In alpha	1.9686*** (0.0829)	1.8580*** (0.0756)
Number of Observations	87089	100326
Log Likelihood	-17507	-23896
Wald Chi2	7478	10326
McFadden's Adj. R2	0.254	0.258
<b>Interaction Effect</b>		
% of positive values (significant)	27.9 (0)	99.4 (82.6)
% of negative values (significant)	72.1 (0,1)	0.6 (0.1)



	1995 - 1998	1999 - 2002
<b>Host Country Variables</b>		
Prior R&D Activities	2.4448*** (0.1361)	2.3832*** (0.0995)
Academic Research	0.1722** (0.0836)	0.1134 (0.0771)
Academic Research * Firm's Science Orientation	0.2053 (0.1432)	0.4287** (0.1998)
Technological Strength	0.3638*** (0.0430)	0.3804*** (0.0380)
Technological Strength in Related Fields	0.0997 (0.0612)	0.1145** (0.0546)
IPR Protection	0.7812*** (0.2257)	0.9728*** (0.2673)
GDP per Capita	0.2997* (0.1590)	0.0110 (0.1638)
Market Size	0.1177*** (0.0455)	0.1216** (0.0531)
Engineering Wage	-0.2964** (0.1431)	-0.3865*** (0.1248)
European Host Country	0.0685 (0.1069)	-0.0841 (0.0985)
Language Similarity	0.4877*** (0.1121)	0.6106*** (0.0991)
Geographic Distance	-0.1112** (0.0529)	-0.2052*** (0.0461)
<b>Firm Variables</b>		
Firm's Science Orientation	-1.0100 (0.7218)	-1.1039 (1.0958)
Firm's Technological Strength	0.7204*** (0.0293)	0.6945*** (0.0243)
Firm's Total Patents	0.0004 (0.0431)	0.0209 (0.0442)
International R&D Experience	0.2721* (0.1453)	0.0877 (0.1282)
Firm's Age	-0.1784* (0.1080)	-0.0312 (0.1108)
Manufacturing or Sales Subsidiary	0.6943*** (0.1017)	0.5217*** (0.0884)





	1995 - 1998	1999 - 2002
<b>Home Country Dummies</b>		
Japan	-1.1971*** (0.1307)	-1.3640*** (0.1646)
Belgium	0.1597 (0.2997)	0.1659 (0.1733)
Switzerland	0.4170 (0.3530)	0.5885*** (0.1804)
Germany	0.2924** (0.1490)	0.3088 (0.1972)
Denmark	0.3219 (0.7442)	0.3546 (0.3118)
Finland	0.4316* (0.2300)	0.7141** (0.2931)
France	-0.1478 (0.1604)	0.0116 (0.1636)
Great Britain	0.1788 (0.3120)	0.1015 (0.1454)
Netherlands	0.2787 (0.1983)	-0.3099 (0.3785)
Sweden	0.6325*** (0.1668)	0.1720 (0.1625)
Technology Dummies (29)	Included	Included
Constant	-8.0006*** (0.6494)	-7.6277*** (0.6737)
Number of Observations	87089	100326
Log Likelihood	-8811	-11254
McFadden Pseudo R2	0.4187	0.4359
Correct Prediction for 1 (%) - Sensitivity	86.09	84.90
Correct Prediction for 0 (%) - Specificity	84.18	84.65
ROC	0.9265	0.9288
<b>Interaction Effect</b>		
% of positive values (significant)	93.3 (0)	99.6 (85.3)
% of negative values (significant)	6.7 (0)	0.4 (0)



	1995 - 1998		1999 - 2002	
	Laggards	Leaders	Laggards	Leaders
<b>Host Country Variables</b>				
Academic Research	0.2121 (0.1748)	0.1580** (0.0777)	0.0441 (0.1361)	0.1507** (0.0723)
Academic Research * Firm's Science Orientation	0.1106 (0.2624)	0.4116** (0.1625)	0.5704* (0.2989)	0.5271** (0.2214)
Technological Strength	0.4420*** (0.0984)	0.3922*** (0.0531)	0.4162*** (0.0864)	0.4232*** (0.0420)
Technological Strength in Related Fields	0.1287 (0.1241)	0.0940 (0.0629)	0.1425 (0.1099)	0.1053** (0.0510)
IPR Protection	0.9131* (0.5384)	0.9247*** (0.2476)	0.7520* (0.4285)	1.2575*** (0.3002)
GDP per Capita	1.0039*** (0.3484)	0.2323 (0.1690)	0.9076** (0.4301)	-0.0878 (0.1601)
Market Size	0.0366 (0.0798)	0.2000*** (0.0488)	0.1129 (0.0771)	0.1702*** (0.0574)
Engineering Wage	-0.7467** (0.2970)	-0.2681* (0.1468)	-0.7337*** (0.2476)	-0.3865*** (0.1282)
European Host Country	0.1817 (0.1793)	0.0194 (0.1147)	0.2645* (0.1440)	-0.1875* (0.1137)
Language Similarity	0.6780*** (0.1567)	0.4595*** (0.1331)	0.6596*** (0.1429)	0.6221*** (0.1011)
Geographic Distance	-0.1277* (0.0739)	-0.1800*** (0.0645)	-0.1264* (0.0655)	-0.2582*** (0.0538)
<b>Firm Variables</b>				
Firm's Science Orientation	-0.6869 (1.2762)	-2.1014** (0.8547)	-1.6201 (1.9190)	-2.0223* (1.0529)
Firm's Technological Strength	0.6683*** (0.1213)	0.8337*** (0.0350)	0.6724*** (0.0867)	0.7733*** (0.0396)
Firm's Total Patents	0.0081 (0.0538)	0.0138 (0.0521)	0.0129 (0.0487)	0.0489 (0.0569)
International R&D Experience	0.1451 (0.1161)	0.6226*** (0.1866)	-0.0115 (0.1518)	0.3628** (0.1578)
Firm's Age	-0.0955 (0.1174)	-0.2257* (0.1214)	-0.0657 (0.1183)	-0.0642 (0.1089)
Manufacturing or Sales Subsidiary	0.5708*** (0.1729)	0.7393*** (0.1072)	0.6971*** (0.1608)	0.5343*** (0.0967)



	1995 - 1998		1999 - 2002	
	Laggards	Leaders	Laggards	Leaders
<b>Home Country Dummies</b>				
Japan	-1.2391*** (0.1902)	-1.3139*** (0.1475)	-1.3800*** (0.2037)	-1.4788*** (0.1740)
Belgium	0.2432 (0.3684)	-0.0436 (0.1948)	0.5644* (0.3026)	0.0928 (0.2119)
Switzerland	0.3151 (0.4027)	0.4312 (0.3493)	0.7665*** (0.2033)	0.5566** (0.2466)
Germany	0.2137 (0.2673)	0.1074 (0.1581)	0.4816* (0.2529)	0.1291 (0.2238)
Denmark	0.9084* (0.4981)	-0.5979 (0.9438)	0.4498 (0.3508)	0.5136 (0.3575)
Finland	0.0329 (0.2714)	0.6030** (0.2360)	0.5570** (0.2616)	0.6711** (0.2698)
France	-0.2858 (0.2667)	-0.0461 (0.1448)	-0.0056 (0.2816)	0.0208 (0.1733)
Great Britain	0.4574* (0.2484)	-0.2241 (0.2916)	0.5641*** (0.2026)	-0.1631 (0.1456)
Netherlands	0.3528 (0.3561)	0.0480 (0.1676)	0.2416 (0.2739)	-0.7428* (0.4013)
Sweden	0.4308 (0.3996)	0.6177*** (0.1850)	0.1622 (0.2499)	0.2670 (0.1779)
Technology Dummies (29)	Included	Included	Included	Included
Constant	-8.8818*** (0.9951)	-8.9600*** (0.7908)	-8.7945*** (0.9583)	-8.6859*** (0.7104)
Number of Observations	48774	38315	55554	44772
Log Likelihood	-3126	-6109	-3861	-8016
McFadden Pseudo R2	0.2793	0.3886	0.2844	0.3979
Correct Prediction for 1 (%) - Sensitivity	86.44	85.23	84.79	84.76
Correct Prediction for 0 (%) - Specificity	80.86	82.72	80.60	82.45
ROC	0.9004	0.9137	0.9002	0.9135
<b>Interaction Effect</b>				
% of positive values (significant)	74.7 (0)	88.9 (28,5)	99.6 (52.6)	96.5 (69.6)
% of negative values (significant)	25.3 (0)	11.1 (0,6)	0.4 (0)	3.5 (0.1)

## Aggregate firm level analysis



	1995 - 1998		1999 - 2002	
	Model 1	Model 2	Model 1	Model 2
<b>Host Country Variables</b>				
Academic Research	0.2466*** (0.0827)	0.1796** (0.0874)	0.1969** (0.0782)	0.0967 (0.0806)
Academic Research * Firm's Science Orientation		0.3936** (0.1768)		0.8048*** (0.2596)
Technological Strength	0.3711*** (0.0698)	0.3668*** (0.0703)	0.4477*** (0.0541)	0.4462*** (0.0538)
IPR Protection	0.5035* (0.2722)	0.5058* (0.2736)	0.8210** (0.3325)	0.8360** (0.3348)
GDP per Capita	0.2098 (0.1592)	0.2085 (0.1590)	-0.2656* (0.1513)	-0.2720* (0.1519)
Market Size	0.2312*** (0.0590)	0.2363*** (0.0594)	0.2046*** (0.0639)	0.2053*** (0.0636)
Engineering Wage	-0.1659 (0.1268)	-0.1615 (0.1267)	-0.1316 (0.1116)	-0.1305 (0.1125)
European Host Country	0.1544 (0.1310)	0.1533 (0.1314)	-0.0872 (0.1247)	-0.0972 (0.1261)
Language Similarity	0.6667*** (0.1320)	0.6624*** (0.1320)	0.6346*** (0.1292)	0.6307*** (0.1300)
Geographic Distance	-0.1558** (0.0607)	-0.1576*** (0.0606)	-0.3265*** (0.0561)	-0.3319*** (0.0562)
<b>Firm Variables</b>				
Firm's Science Orientation		-1.1472* (0.6097)		-2.0384** (0.8617)
Firm's Total Patents	0.8557*** (0.0785)	0.8762*** (0.0808)	0.9646*** (0.0732)	0.9833*** (0.0772)
International R&D Experience	0.2519* (0.1501)	0.2457* (0.1487)	0.0201 (0.1955)	0.0136 (0.1940)
Firm's Age	0.0126 (0.1248)	0.0155 (0.1300)	-0.0532 (0.1071)	-0.0565 (0.1085)
Manufacturing or Sales Subsidiary	0.8736*** (0.1116)	0.8727*** (0.1130)	0.7077*** (0.0994)	0.7231*** (0.0993)



	1995 - 1998		1999 - 2002	
	Model 1	Model 2	Model 1	Model 2
<b>Home Country Dummies</b>				
Japan	-1.2467*** (0.1720)	-1.2375*** (0.1769)	-1.5398*** (0.1773)	-1.5809*** (0.1831)
Belgium	-0.3703 (0.4558)	-0.3638 (0.4542)	0.0124 (0.2832)	0.0219 (0.2808)
Switzerland	0.1628 (0.3767)	0.1148 (0.3496)	0.2255 (0.2574)	0.1704 (0.2493)
Germany	0.2981 (0.2479)	0.2709 (0.2440)	0.1008 (0.2962)	0.0682 (0.2987)
Denmark	-0.2386 (0.6719)	-0.2407 (0.6679)	0.2491 (0.1556)	0.2306 (0.1544)
Finland	0.1309 (0.5131)	0.1242 (0.4894)	0.1809 (0.5237)	0.1417 (0.4917)
France	-0.3765 (0.2679)	-0.3633 (0.2689)	-0.4859* (0.2661)	-0.4857* (0.2616)
Great Britain	0.2271 (0.3905)	0.2118 (0.3881)	-0.2131 (0.2658)	-0.2365 (0.2679)
Netherlands	0.0754 (0.2348)	0.0911 (0.2295)	-0.2509 (0.4421)	-0.3160 (0.4446)
Sweden	0.8179** (0.3887)	0.7645** (0.3607)	0.2731 (0.3430)	0.1792 (0.3307)
Industry Dummies (4)	Included	Included	Included	Included
Constant	-6.4722*** (1.5873)	-6.3252*** (1.5727)	-0.4421 (1.2912)	-0.1050 (1.3190)
Number of Observations	6486	6486	6722	6722
Log Likelihood	-1711	-1709	-1986	-1980
McFadden Pseudo R2	0.3957	0.3966	0.4006	0.4023
Correct Prediction for 1 (%) - Sensitivity	83.24	83.63	81.88	81.73
Correct Prediction for 0 (%) - Specificity	81.34	81.26	80.77	80.92
ROC	0.9005	0.9008	0.8976	0.8981
<b>Interaction Effect</b>				
% of positive values (significant)		89.1 (31.6)		96 (77.3)
% of negative values (significant)		10.9 (0.8)		4 (0.5)
<b>LR Tests</b>				
Chi-2 Model 2 versus Model 1		5.02*		11.82***



## CONCLUSIONS

- **Significant impact of countries' relevant academic research strength on foreign R&D decisions of firms**
  - After controlling for a variety of other country-, technology-, and firm-specific factors affecting R&D internationalization decisions
  - Robust over specifications
  - Elasticity of probability of conducting foreign R&D with respect to academic research is 0.21-0.24, exceeding elasticity for market size and GDP per capita (second period)



## CONCLUSIONS II

- **Firm heterogeneity in responsiveness to academic research**
  - Firms with a greater science orientation in their research activities weigh countries' academic research strengths stronger in their location decisions
  - This pattern appears to gain in strength in the most recent period
  - Elasticity of foreign R&D with respect to academic research 0.4 for above-median science oriented firms
  - For countries with the highest academic research strengths, this greater responsiveness is large enough to overcome the tendency of science intensive firms to concentrate R&D activities at home
  - Technology leaders are also attracted to academic research, but leadership is not a necessary condition for the valuation of academic research in R&D location decisions



## **FURTHER RESEARCH**

- Examine patterns for most recent period: 2003-2006. Is trend continuing?
- Examine specific features of university research that are potentially most attractive to foreign investors: academic spinoff intensity, degree of collaboration with industry, basic or applied publications?
- Analyses at regional level (academic research spillovers are strongest at the local level): US States/MSAs, NUTS 2/3 regions in Europe
- EU bias in patent counts: 'triadic patents'. Or replicate with US patents
- Distinguish between home base augmenting 'research' and home base exploiting 'development' activities
  - E.g. taking into account (self)citation data in patents





# DETAILED TABLES

	<b>European Firms</b>	<b>US firms</b>	<b>Japanese firms</b>
<b>Firm's home country</b>	50027	33867	56431
%	61%	76%	92,3%
<b>Europe</b>	19462	8'092	2356
%	23,7%	18,2%	3,9%
Austria	1059	43	21
Belgium	1520	338	68
Denmark	403	140	11
Finland	615	28	0
France	1729	1452	209
Germany	6029	1866	1054
Greece	18	5	0
Hungary	94	8	3
Ireland	60	106	24
Italy	2419	308	29
Luxembourg	4	2	9
Netherlands	773	439	70
Norway	268	24	4
Poland	40	5	0
Portugal	12	1	0
Spain	302	266	4
Sweden	1418	114	68
Switzerland	1009	319	22
United Kingdom	1690	2628	760
<b>USA</b>	10115		2082
%	12,3%		3,4%
<b>Japan</b>	752	1036	
%	0,9%	2,3%	
<b>Rest of Asia</b>	649	798	140
%	0,8%	1,8%	0,2%
China	131	35	15
Hong Kong	25	8	0
India	65	70	6
Indonesia	10	0	3
Israel	53	410	6
Malaysia	23	10	7
Philippinnes	2	7	0
Republic of Korea	61	39	30
Russia	59	20	3
Singapore	195	127	62
Taiwan	20	68	4
Thailand	5	4	4
<b>South America</b>	63	61	2
%	0,1%	0,1%	0%
Argentina	3	2	1
Brazil	58	57	1
Colombia	2	2	0
<b>Rest of World</b>	954	712	117
%	1,2%	1,6%	0,2%
Australia	200	131	76
Canada	693	557	39
Mexico	25	18	2
South-Africa	36	6	0
<b>Total</b>	82012	44566	61128

Company name	Industry	Country	R&D				
Bayer AG	Chemicals	Germany	2414	Allergan inc	Pharmaceuticals	United States	604
BASF	Chemicals	Germany	1105	Yamanouchi Pharmaceutical	Pharmaceuticals	Japan	495
EI du Pont de Nemours	Chemicals	United States	1069	Fujisawa Pharmaceutical	Pharmaceuticals	Japan	462
Mitsubishi Chemical	Chemicals	Japan	673	Eisai	Pharmaceuticals	Japan	442
Sumitomo Chemical	Chemicals	Japan	539	Altana AG	Pharmaceuticals	Germany	412
Solvay	Chemicals	Belgium	420	Daiichi Pharmaceutical	Pharmaceuticals	Japan	395
Asahi Kasei	Chemicals	Japan	365	Millennium Pharmaceuticals inc	Pharmaceuticals	United States	387
Mitsui Chemicals	Chemicals	Japan	275	Chiron	Pharmaceuticals	United States	310
Toray Industries	Chemicals	Japan	264	Genzyme corp	Pharmaceuticals	United States	266
PPG Industries	Chemicals	United States	230	Appera corp	Pharmaceuticals	United States	256
ICI (Imperial Chemical Industries)	Chemicals	United Kingdom	221	Lundbeck	Pharmaceuticals	Denmark	246
Teijin	Chemicals	Japan	221	Shionogi	Pharmaceuticals	Japan	231
Shin-Etsu Chemical	Chemicals	Japan	195	Kyowa Hakko Kogyo	Pharmaceuticals	Japan	229
Rohm & Haas	Chemicals	United States	189	Ono Pharmaceutical	Pharmaceuticals	Japan	225
Linde AG	Chemicals	Germany	179	Taisho Pharmaceutical	Pharmaceuticals	Japan	218
Eastman Chemical	Chemicals	United States	149	UCB (including Celltech)	Pharmaceuticals	Belgium	216
Showa Denko	Chemicals	Japan	126	Tanabe Seiyaku	Pharmaceuticals	Japan	182
SNPE	Chemicals	France	115	Sepracor	Pharmaceuticals	United States	175
JSR	Chemicals	Japan	112	Pliva d.d.	Pharmaceuticals	Croatia	86
Kaneka	Chemicals	Japan	103	Siemens	Electronics & electrical	Germany	5511
Nitto Denko	Chemicals	Japan	102	Matsushita Electric	Electronics & electrical	Japan	4285
Air Products and Chemicals	Chemicals	United States	96	Sony	Electronics & electrical	Japan	3278
L'air Liquide	Chemicals	France	94	Koninklijke Philips Electronics	Electronics & electrical	Netherlands	2617
Johnson Matthey plc	Chemicals	United Kingdom	77	Canon	Electronics & electrical	Japan	1917
Lubrizol	Chemicals	United States	74	Sharp	Electronics & electrical	Japan	1125
Engelhard	Chemicals	United States	74	Sanyo Electric	Electronics & electrical	Japan	894
FMC	Chemicals	United States	69	Ricoh	Electronics & electrical	Japan	684
Praxair	Chemicals	United States	59	Schneider Electric S A	Electronics & electrical	France	494
Avery Dennison	Chemicals	United States	59	ABB (Asea Brown Boveri)	Electronics & electrical	Switzerland	486
BOC group plc	Chemicals	United Kingdom	57	ALSTOM	Electronics & electrical	France	473
Kemira OYJ	Chemicals	Finland	48	Pioneer	Electronics & electrical	Japan	381
Borealis as	Chemicals	Denmark	43	Sumitomo Electric	Electronics & electrical	Japan	360
Süd-Chemie AG	Chemicals	Germany	29	Omron	Electronics & electrical	Japan	298
Pfizer	Pharmaceuticals	United States	5653	Thomson	Electronics & electrical	France	295
Johnson&Johnson	Pharmaceuticals	United States	3714	Alps Electric	Electronics & electrical	Japan	280
Novartis AG	Pharmaceuticals	Switzerland	2978	Olympus Optical	Electronics & electrical	Japan	257
AstraZeneca	Pharmaceuticals	United Kingdom	2736	TDK	Electronics & electrical	Japan	236
Merck & Co inc	Pharmaceuticals	United States	2520	Fuji Electric	Electronics & electrical	Japan	198
Eli Lilly and Company	Pharmaceuticals	United States	1863	Yokogawa Electric	Electronics & electrical	Japan	187
Bristol-Myers-Squibb Co	Pharmaceuticals	United States	1807	Furukawa Electric	Electronics & electrical	Japan	184
Wyeth	Pharmaceuticals	United States	1660	Eaton Corp	Electronics & electrical	United States	177
Sanofi-Synthelabo	Pharmaceuticals	France	1316	Pitney Bowes Inc	Electronics & electrical	United States	117
Amgen inc	Pharmaceuticals	United States	1312	Harman International industries inc	Electronics & electrical	United States	113
Schering Plough Corp	Pharmaceuticals	United States	1165	Molex inc	Electronics & electrical	United States	93
Schering AG	Pharmaceuticals	Germany	947	Symbol Technologies	Electronics & electrical	United States	86
Takeda Chemical	Pharmaceuticals	Japan	919	SPX Corporation	Electronics & electrical	United States	76
Sankyo	Pharmaceuticals	Japan	641	Spectris plc	Electronics & electrical	United Kingdom	48
Merck Kommanditgesellschaft	Pharmaceuticals	Germany	605	Vaisala OYI	Electronics & electrical	Finland	21
				Mitsubishi Heavy	Engineering	Japan	810
				Caterpillar	Engineering	United States	530
				Deere	Engineering	United States	458
				MAN	Engineering	Germany	407
				Komatsu	Engineering	Japan	315
				Scania AB	Engineering	Sweden	237

Sandvik AB	Engineering	Sweden	185	National Semiconductor	IT hardware	United States	345
Kubota	Engineering	Japan	172	LSI Logic Corp	IT hardware	United States	343
Danaher	Engineering	United States	164	ASML holding NV	IT hardware	Netherlands	287
IHI	Engineering	Japan	163	Rohm	IT hardware	Japan	235
Ingersoll-Rand	Engineering	United States	162	Murata Manufacturing	IT hardware	Japan	232
Cummins	Engineering	United States	159	Océ NV	IT hardware	Netherlands	208
Atlas Copco AB	Engineering	Sweden	128	Nikon	IT hardware	Japan	203
Kawasaki Heavy Industries	Engineering	Japan	115	Advantest	IT hardware	Japan	175
Ebara	Engineering	Japan	104	Casio Computer	IT hardware	Japan	104
American Standard Companies	Engineering	United States	101	Amitsu	IT hardware	Japan	98
SMC	Engineering	Japan	97	Spirent plc	IT hardware	United Kingdom	94
ITT Industries	Engineering	United States	96	ASM International NV	IT hardware	Netherlands	79
Schindler holding AG	Engineering	Switzerland	89	Bull	IT hardware	France	60
Kone oyi	Engineering	Finland	88	Filtronic plc	IT hardware	United Kingdom	40
Illinois Tool Works	Engineering	United States	85	GNS store Nord as	IT hardware	Denmark	40
Tomkins plc	Engineering	United Kingdom	83				
SKF AB	Engineering	Sweden	83				
Rieter holding AG	Engineering	Switzerland	83				
Dainippon Screen Mfg	Engineering	Japan	80				
Danfoss as	Engineering	Denmark	78				
Sunimoto Heavy Industries	Engineering	Japan	76				
Saurer AG	Engineering	Switzerland	75				
Stok NV	Engineering	Netherlands	74				
Parker Hannifin	Engineering	United States	74				
Wartsila OYJ ABP	Engineering	Finland	70				
Claas Kommanditgesellschaft	Engineering	Germany	67				
Hamamatsu Photonics	Engineering	Japan	65				
Mettler-Toledo International	Engineering	United States	62				
NSK	Engineering	Japan	61				
AGCO	Engineering	United States	57				
Nokia oyi	IT hardware	Finland	3978				
Intel	IT hardware	United States	3457				
Telefonab LM Ericsson	IT hardware	Sweden	3229				
Motorola	IT hardware	United States	2990				
Hewlett-Packard	IT hardware	United States	2895				
Hitachi	IT hardware	Japan	2751				
Toshiba	IT hardware	Japan	2491				
Fujitsu	IT hardware	Japan	2114				
NEC	IT hardware	Japan	1899				
Alcatel	IT hardware	France	1593				
Sun Microsystems	IT hardware	United States	1456				
Texas Instruments	IT hardware	United States	1386				
Lucent Technologies	IT hardware	United States	1180				
STMicroelectronics	IT hardware	France	921				
Applied Materials	IT hardware	United States	730				
Xerox	IT hardware	United States	688				
AMD	IT hardware	United States	676				
EMC	IT hardware	United States	660				
Micron technology inc	IT hardware	United States	520				
Broadcom Corp	IT hardware	United States	518				
Apple Computer	IT hardware	United States	373				
Tokyo Electron	IT hardware	Japan	371				
Analog Devices	IT hardware	United States	357				
Kyocera	IT hardware	Japan	350				

	<b>Electrical Eng.</b>		<b>Instruments</b>		<b>Chem/Pharma</b>		<b>Process Eng.</b>		<b>Mechanic Eng.</b>		<b>Ex Science</b>
<b>Europe</b>	364.245	9%	438.804	11%	2.495.952	61%	785.385	19%	477.865	12%	4.088.560
Austria	6.997	8%	9.057	11%	53.828	65%	14.590	18%	7.895	10%	82.981
Belgium	11.152	9%	13.497	11%	77.469	64%	21.210	18%	10.926	9%	120.297
Denmark	6.135	7%	7.675	9%	59.008	66%	15.337	17%	9.799	11%	90.087
Finland	6.990	8%	7.530	9%	55.230	65%	14.926	18%	7.870	9%	84.722
France	55.379	10%	64.937	11%	328.816	58%	122.014	21%	75.805	13%	571.599
Germany	72.280	9%	99.564	13%	450.707	59%	164.150	21%	93.100	12%	764.573
Greece	7.951	14%	6.356	11%	29.219	51%	11.957	21%	8.469	15%	56.963
Hungary	4.304	9%	5.983	13%	27.176	58%	9.829	21%	4.253	9%	46.619
Ireland	2.498	8%	2.202	7%	19.406	65%	5.156	17%	2.975	10%	29.730
Italy	41.362	11%	51.717	14%	230.766	60%	65.497	17%	47.099	12%	382.816
Luxembourg	42	4%	57	5%	809	77%	112	11%	64	6%	1.049
Netherlands	17.233	8%	18.727	8%	151.444	66%	36.885	16%	23.677	10%	229.027
Norway	3.124	5%	3.650	6%	35.158	60%	10.883	19%	8.342	14%	58.473
Poland	13.277	12%	17.755	16%	50.151	46%	36.028	33%	15.668	14%	108.996
Portugal	3.603	10%	4.204	12%	16.903	48%	9.876	28%	4.415	13%	34.852
Spain	20.265	8%	21.984	9%	162.390	63%	53.761	21%	23.895	9%	257.532
Sweden	12.607	7%	15.346	9%	117.720	66%	32.061	18%	17.332	10%	178.445
Switzerland	14.956	9%	24.568	15%	99.716	62%	28.085	17%	17.927	11%	161.102
United Kingdom	64.090	8%	63.995	8%	530.036	64%	133.028	16%	98.354	12%	828.697
<b>USA</b>	265.442	9%	238.367	8%	1.953.637	64%	434.239	14%	352.973	12%	3.038.709
<b>Japan</b>	110.139	12%	104.762	11%	510.902	54%	204.875	22%	101.236	11%	949.969
<b>Rest of Asia</b>	195.197	16%	199.715	16%	523.392	42%	367.983	30%	227.313	18%	1.246.204
China	40.794	15%	44.368	16%	103.714	37%	93.848	34%	52.204	19%	278.655
Hong Kong	5.070	20%	2.680	10%	11.667	46%	5.253	21%	3.766	15%	25.564
India	21.583	11%	22.017	11%	103.212	51%	53.966	27%	29.183	14%	201.290
Indonesia	161	3%	240	5%	3.104	62%	963	19%	736	15%	4.980
Israel	12.900	12%	12.150	11%	64.941	59%	19.502	18%	12.814	12%	109.794
Malaysia	598	11%	577	11%	6.049	51%	2.757	27%	805	14%	10.029
Philippines	116	3%	140	3%	2.972	70%	895	21%	272	6%	4.254
Korea	28.782	20%	21.146	15%	61.539	44%	43.474	31%	24.831	18%	141.129
Russia	50.510	17%	77.445	26%	93.581	31%	106.404	35%	73.450	24%	300.083
Singapore	10.039	25%	4.892	12%	12.625	32%	10.448	26%	7.728	20%	39.503
Taiwan	23.875	20%	13.622	12%	49.480	42%	28.259	24%	20.531	18%	116.533
Thailand	769	5%	438	3%	10.508	73%	2.214	15%	993	7%	14.390
<b>South America</b>	15.204	9%	19.550	12%	99.871	60%	39.343	23%	20.868	12%	167.718
Argentina	3.521	7%	4.728	10%	28.942	61%	11.264	24%	6.002	13%	47.591
Brazil	11.189	10%	14.129	12%	66.993	59%	26.557	23%	14.106	12%	113.751
Colombia	494	8%	693	11%	3.936	62%	1.522	24%	760	12%	6.376
<b>Rest of World</b>	55.817	7%	51.144	7%	461.525	60%	125.651	16%	94.317	12%	767.090
Australia	17.615	7%	15.055	6%	154.325	62%	40.030	16%	30.165	12%	247.052
Canada	30.813	7%	26.327	6%	254.589	60%	63.407	15%	49.849	12%	424.985
Mexico	5.463	11%	7.235	14%	26.814	52%	13.958	27%	8.558	17%	51.532
South-Africa	1.926	4%	2.527	6%	25.797	59%	8.256	19%	5.745	13%	43.521
<b>Total</b>	999.766	10%	1.044.864	10%	5.985.630	59%	1.939.876	19%	1.263.295	12%	10.163.729

<b><i>Technology Class</i></b>	<b><i>Technology Main Class</i></b>
1 Electrical machinery and apparatus, electrical energy	Electrical engineering
2 Audio-visual technology	Electrical engineering
3 Telecommunications	Electrical engineering
4 Information technology	Electrical engineering
5 Semiconductors	Electrical engineering
6 Optics	Instruments
7 Analysis, measurement and control technology	Instruments
8 Medical technology	Instruments
9 Nuclear engineering	Instruments
10 Organic fine chemistry	Chemistry, Pharma
11 Macromolecular chemistry, polymers	Chemistry, Pharma
12 Pharmaceuticals, cosmetics	Chemistry, Pharma
13 Biotechnology	Chemistry, Pharma
14 Agriculture, food chemistry	Chemistry, Pharma
15 Chemical and petrol industry, basic materials chemistry	Chemistry, Pharma
16 Chemical engineering	Process engineering and special equipment
17 Surface technology, coating	Process engineering and special equipment
18 Materials, metallurgy	Process engineering and special equipment
19 Materials processing, textiles & paper	Process engineering and special equipment
20 Handling, printing	Process engineering and special equipment
21 Agricultural and food processing, machinery and apparatus	Process engineering and special equipment
22 Environmental technology	Process engineering and special equipment
23 Machine tools	Mechanical engineering and machinery
24 Engines, pumps and turbines	Mechanical engineering and machinery
25 Thermal processes and apparatus	Mechanical engineering and machinery
26 Mechanical elements	Mechanical engineering and machinery
27 Transport	Mechanical engineering and machinery
28 Space technology, weapons	Mechanical engineering and machinery
29 Consumer goods and equipment	Mechanical engineering and machinery
30 Civil engineering, building and mining	Mechanical engineering and machinery