Research Consortia as Knowledge Brokers: Insights from Sematech

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Importance of External Ideas on Firm Innovation

Collaborations with university scientists (Cockburn and Henderson 1996; Zucker, Darby and Armstrong 2002; Fabrizio 2005)

Alliance partners (Mowery, Oxley and Silverman 1996)

New employees (Almeida and Kogut 1999; Rosenkopf and Almeida 2003; Song, Almeida, and Wu 2003)

Impact of Institutions on Dissemination of Ideas

Biological Resource Centers (Furman and Stern 2004)

Patent Pools (Lerner, Strojwas and Tirole 2003, Joshi and Nerkar 2011)

Standards-Setting Boards (Simcoe and Rysman 2005)

Research Consortia (Cassiman, Veugeler, Arts 2012; Branstetter and Sakikabara 1998, 2002)

What is a Research Consortium?

Association of two or more companies or non-profit organizations

Members combine efforts and resources towards a common goal

Often partially supported by government funding

Research is often "pre-competitive"

Contrast to patent pools:

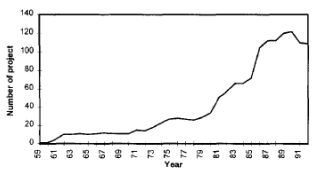
- **Patent pools combine prior outcomes for benefit of members (patents)**
- **Research consortia combine inputs for benefit of members (R&D)**

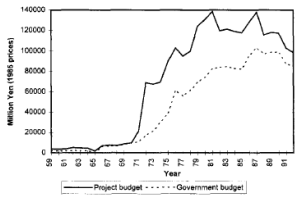
Effects of Research Consortia: Evidence from Japan

Lee Branstetter and Mariko Sakikabara

Studied 237 government-sponsored R&D consortia in Japan between 1959 and 1992

Consortia were sponsored by MITI and ministries of Transportation, Agriculture, Forestry and Fisheries, Post and Telecommunications, and Health and Welfare





Source: Sakikabara 1998

Effects of Research Consortia: Evidence from Japan

Survey Evidence (Sakikabara 1997, 1998)

Sharing of complementary knowledge and skills most important motivation to participate in consortia

Respondents believe that consortia enlarge the scale and quicken the pace of R&D

R&D conducted within the consortium is seen to complement firms' internal R&D

Benefits appear to be modest to large firms, more significant to small firms

Econometric Evidence (Branstetter & Sakakibara 2002)

Consortia associated with increased patenting by both members and non-members

But greater increase in patenting experienced by members

Greater impact for consortia that focus on basic rather than applied R&D

What is Sematech?

Established in 1987 by US Government and semiconductor firms

Response to concerns by defense establishment that the US was losing ground to Japan in critical semiconductor technologies

14 founding members

Large scale fabrication facility located in Austin, Texas

Original intent was for firms to conduct collaborative research in semiconductor process technology

Later focused on strengthening capabilities of semiconductor equipment suppliers

SEMATECH

Set Standards
Establish Roadmaps

Fund R&D
(~$2.5B, 1987-2004)

Perform in Texas; members send employees

Sponsor projects at universities, labs

Partner with suppliers

Consortia as Performers and Sponsors ("Brokers") of R&D: A Stylized View






Why Sematech?

Unique identification of 101 patents based on research performed and sponsored by the consortium (1987-1999)

- ~ 60% = assigned to Sematech, one or member firms ("performed")
- ~ 40% = assigned to a university or government ("brokered")

Can track follow-on inventions to research results (using patent citations) over long time horizon

Important institution and industry

Sematech Members (Founding)

	Participating Years	Nation
Advanced Micro Devices	1987 - present	US
Hewlett-Packard (Agilent)	1987 - present	US
IBM	1987 - present	US
Intel	1987 - present	US
Motorola (Freescale)	1987 - present	US
Texas Instruments	1987 - present	US
AT&T (Lucent/Agere)	1987 – 2003	US
Rockwell (Conexant Systems)	1987 – 2003	US
Digital Equipment Corp. (Compaq)	1987 – 2000	US
National Semiconductor	1987 - 1998	US
Harris Corporation	1987 – 1992	US
LSI Logic	1987 – 1992	US
Micron Technology	1987 – 1992	US
NCR	1987 – 1991	US

Sematech Members (New Since 1995)

	Participating Years	Nation
Infineon Technologies	1995 - present	Germany
Philips	1995 - present	Netherlands
Taiwan Semiconductor	1995 - present	Taiwan
Hyundai Electronics (Hynix)	1995 – 2002	South Korea
ST Microelectronics	1995 – 2002	Europe
LG Semicon	1995 – 1997	South Korea
Samsung Electronics	1995-1997, 2005	South Korea
Spansion (AMD/Fujitsu)	2004 – present	US/Japan
Matsushita (Panasonic)	2005	Japan

Research Questions

1. **What is the overall impact of Sematech research on follow-on inventive activity?**
2. **Do members make more rapid or extensive use of Sematech research than do non-member firms?**
3. **Does the relative "advantage" of membership differ for brokered R&D project vs. research performed by the consortium?**

Our Approach

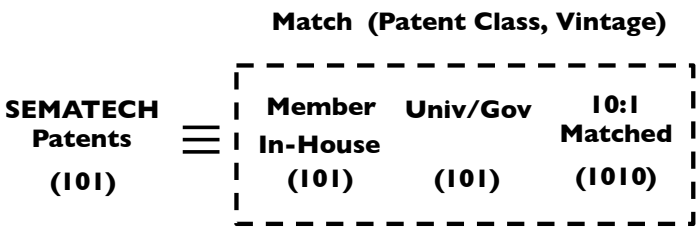
Trace citations to 101 Sematech patents made in follow-on inventions
- Overall
- Brokered vs. Performed

Examine patterns of diffusion (levels and timing):
- Overall
- To Member vs. Non-Member Semiconductor Firms

Establish baseline estimates using citations to three sets of control group patents

In multivariate regressions, control for differences in the underlying inventions ("basicness," "generality," "scope," age)

Construction of Control Groups



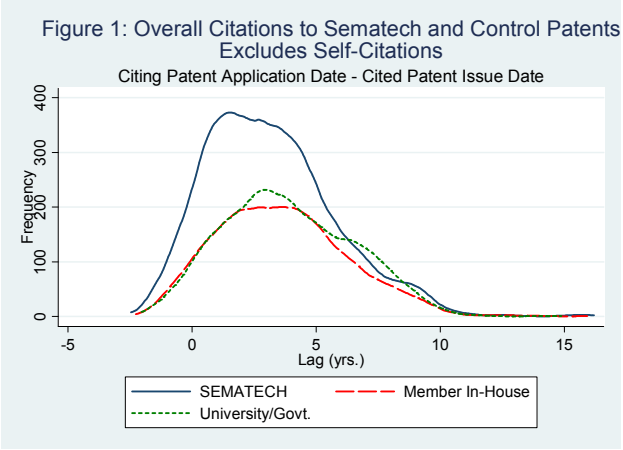
Who's Citing (Members/Non-Members)
How Often (# Cites, 1987 – 2004)
How Quickly

Descriptive Statistics: Sematech vs. Control Groups

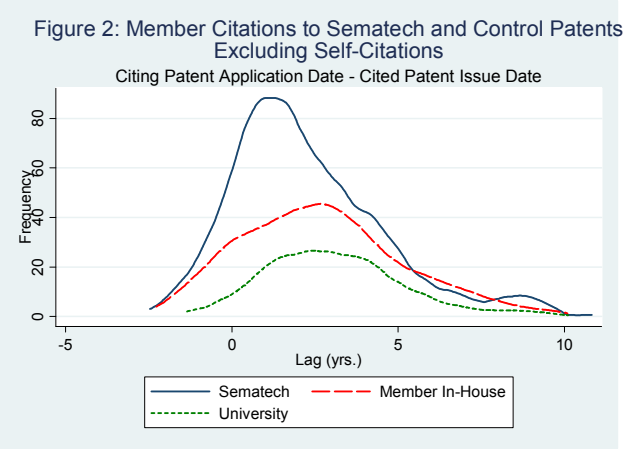
Variables	Pooled Sample	Sematech Patents	Control Groups	
			Member In-House Patents	University Patents
Citations received per patent, excluding self-citations	17.62	23.73	13.87***	15.26***
Lag to first citation, excluding self-citations (years)	0.20	0.03	0.41**	0.14
Mean citation lag, excluding self-citations (years)	3.34	3.30	3.41	3.30
Generality	0.81	0.84	0.76**	0.82
Scope	16.10	16.32	14.04**	17.93
Basicness	0.61	0.69	0.55***	0.60**
Application Year	1993	1993	1993	1993
Number of Observations	303	101	101	101

*** p>0.01, ** p>0.05, * p>0.1

Plot of Overall Citations



Plot of Citations by Members



Descriptive Statistics: Sematech Performed vs. Brokered

Variables	Pooled Sample	Sematech Performed	Sematech Brokered
Citations received per patent, excluding self-citations	23.73	20.67	27.70*
Lag to first citation, excluding self-citations (years)	0.03	0.13	-0.10
Overall citation lag, excluding self-citations (years)	3.30	2.98	3.70**
Generality	0.84	0.82	0.89*
Scope	16.32	15.42	17.47
Basicness	0.69	0.72	0.69
Application Year	1993	1993	1993
Number of Observations	101	101	101

*** p>0.01, ** p>0.05, * p>0.1

Citations to Sematech vs. University Patents

Variables	(1)	(2)	(3)	(4)	(5)
Sematech Patent		0.33*** (0.12)	0.38*** (0.14)	0.18 (0.12)	0.18 (0.12)
Sematech * Brokered			-0.13 (0.18)		
Sematech * Multiple Assignees				0.62*** (0.20)	
Sematech * Mult. Assignee Types					0.62*** (0.20)
Generality	2.78*** (0.25)	2.77*** (0.24)	2.77*** (0.24)	2.81*** (-0.004)	2.78*** (-0.01)
Basicness	0.03 (0.20)	-0.04 (0.20)	-0.05 (0.20)	-0.004 (0.120)	-0.02 (0.20)
Scope	0.014** (0.006)	0.013** (0.006)	0.013** (0.006)	0.012** (0.006)	0.01* (0.01)
Application Year	0.05* (0.03)	0.04* (0.03)	0.04 (0.027)	0.013 (0.027)	0.012 (0.027)
Constant	-98.36 (50.51)	-86.85 (50.52)	-75.17 (53.18)	-25.58 (53.31)	-23.64 (53.57)
Log-likelihood	-734.84	-730.99	-730.73	-730.78	-725.87
Number of observations	195	195	195	195	195

Citations to Sematech vs. Member In-House Patents

Variables	(1)	(2)	(3)	(4)	(5)
Sematech Patent		0.33*** (0.11)	0.37*** (0.14)	0.20 (0.12)	0.20 (0.13)
Sematech * Brokered			-0.12 (0.18)		
Sematech * Multiple Assignees				0.50** (0.22)	
Sematech * Mult. Assignee Types					0.51** (0.21)
Generality	2.38*** (0.23)	2.32*** (0.23)	2.32*** (0.23)	2.36*** (0.23)	2.34*** (-0.23)
Basicness	-0.17 (0.21)	-0.30 (0.21)	-0.31 (0.21)	-0.28 (0.21)	-0.29 (0.21)
Scope	0.04*** (0.01)	0.03*** (0.01)	0.03*** (0.01)	0.03*** (0.01)	0.03*** (0.01)
Application Year	0.06** (0.03)	0.05** (0.03)	0.05* (0.03)	0.03 (0.03)	0.03 (0.03)
Constant	-112.35 (51.95)	-107.10 (51.57)	-96.83 (53.98)	-59.14 (54.73)	-56.60 (54.94)
Log-likelihood	-741.04	-737.62	-737.40	-734.52	-734.38
Number of observations	201	201	201	201	201

Citations to Sematech vs. University by Group

	All Citers	Citations made by Members			Citations made by Non-Members		
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
Sematech Patent	0.33*** (0.12)	0.92*** (0.22)	1.03*** (0.24)	0.75*** (0.23)	0.13 (0.19)	0.24 (0.22)	-0.04 (0.21)
Sematech * Brokered			-0.31 (0.30)			-0.29 (0.30)	
Sematech * Multiple Assignee Types				0.67* (0.35)			0.66* (0.34)
Generality	2.77*** (0.24)	2.39*** (0.44)	2.41*** (0.44)	2.42*** (0.44)	3.66*** (0.62)	3.68*** (0.619)	3.63*** (0.607)
Basicness	-0.04 (0.20)	-0.42 (0.36)	-0.44 (0.36)	-0.38 (0.36)	0.05 (0.34)	0.03 (0.03)	0.10 (0.34)
Scope	0.01** (0.01)	-0.001 (0.01)	-0.001 (0.01)	-0.003 (0.01)	0.013 (0.01)	0.013 (0.01)	0.01 (0.01)
Application Year	0.04* (0.03)	0.15*** (0.05)	0.14*** (0.05)	0.11** (0.05)	0.06 (0.04)	0.05 (0.04)	0.03 (0.04)
Constant	-86.84 (50.52)	-302.15 (889.00)	-277.98 (92.61)	-227.26 (96.26)	-125.48 (75.97)	-99.59 (80.69)	-55.55 (82.93)
Log-likelihood	-730.99	-490.83	-490.32	-488.92	-415.83	-415.37	-413.85
Number of Obs.	195	195	195	195	195	195	195

Sematech vs. University by Group (Time to First Citation)

	All Citers	Citations made by Members			Citations made by Non-Members		
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
Sematech Patent	-0.07 (0.17)	-0.93*** (0.33)	-1.28*** (0.37)	-0.81** (0.35)	-0.19 (0.42)	-0.69 (0.48)	-0.001 (0.45)
Sematech * Brokered			0.93** (0.45)			1.21** (0.59)	
Sematech * Multiple Assignee Types				-0.52 (0.54)			-0.85 (0.71)
Generality	-0.73* (0.38)	1.44 (0.94)	1.41 (0.93)	1.40 (0.94)	-0.69 (1.55)	-0.91 (1.54)	-0.99 (1.57)
Basicness	0.07 (0.30)	0.21 (0.55)	0.28 (0.55)	0.16 (0.55)	-0.22 (0.70)	-0.17 (0.69)	-0.29 (0.70)
Scope	-0.02* (0.01)	-0.02 (0.02)	-0.02 (0.02)	-0.02 (0.02)	-0.01 (0.02)	-0.02 (0.02)	-0.01 (0.02)
Application Year	-0.13*** (0.04)	-0.26*** (0.07)	-0.22*** (0.07)	-0.24*** (0.07)	-0.16 (0.10)	-0.10 (0.10)	-0.12 (0.10)
Constant	252.7*** (78.2)	526.7*** (140.6)	440.0*** (145.2)	486.6*** (146.6)	321.2 (195.3)	194.9 (202.7)	239.2 (206.6)
Adj. R-squared	0.06	0.16	0.178	0.19	0.03	0.06	0.04
Number of Obs.	186	136	136	136	135	135	135

Regression Results

Technologies embedded in Sematech patents diffuse more extensively, quickly, and widely than control group patents

Members build on Sematech patents both more quickly and more extensively than they do control group patents

Members cite Sematech-performed patents almost 16 months earlier than control patents

- Difference drops to 4 months for patents based on brokered research
- Contrasting results for non-member firms

Summary

Sematech appears to facilitate the dissemination of new technologies within the semiconductor industry

Disproportionate effects on member firms

Consistent with Branstetter and Sakikabara findings on Japanese research consortia

Members retain greatest lead-time advantage in making use of Sematech-performed projects

Provides a new – but restricted – view of one institutional arrangement on the innovative behavior of firms

Ongoing Work

Exploit change in policy allowing foreign firms to join

Difference-in-Differences analysis of effects of membership before and after policy shift

Analyze effect on supplier firms

Identify citations made by suppliers