

An Approach to Measure Industrial Cooperation for R&D

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Firms Cooperate for R&D

◆ Horizontal Cooperation

- Cooperation with Firms in Same Industry
- Conventional view
- Share Costs
- Reduce Risks
- Avoid Duplications
- Technical Standards
- Popular at later intermediate or early mature evolutionary stages

◆ Vertical Cooperation

- Cooperation with Firms in Different Industries
- Technology option view
- Supplier/Customer Relationship
- Complementary research resources
- Exploit research synergy
- Appropriate at early fluid evolutionary stage : emerging industries
- **Technology fusion**
- **Research Diversification**

Business Diversification vs. Research Diversification

◆ Business Diversification

- **Firms diversify into other business lines by producing other goods/services**
- **A Firm with diversified business lines**
- **Each business line**

◆ Research Diversification

- **Firms diversify into other technical areas by cooperating with firms in other industries for R&D**
- **A Research project within which firms in different industries are cooperating for R&D**
- **Each primary industry of participating firms**

Research Questions

◆ Who cooperates with whom?

- Which industries cooperates with which industries for R&D?
- Are these research diversification related?
- To what extent?

◆ Strategic cooperation?

- Are these research diversification non-random strategic behavior?

◆ Coherent cooperation?

- Are these research diversification consistent?

Methodology

Survivor Principle @ David Teece, Richard Rumelt, Giovanni Dosi, Sidney Winter (1994),
“Understanding corporate coherence: Theory and evidence”

◆ Research Relatedness

- **No. of Research Projects in both industries**

$$J_{ij} = \sum_k C_{ik} C_{jk}$$

- **Expected Value**

$$P_r[X_{ij} = x] = \frac{\binom{n_i}{x} \binom{K - n_i}{n_j - x}}{\binom{K}{n_j}}$$

- **Mean and Variance**

$$\mu_{ij} = E(X_{ij}) = \frac{n_i n_j}{K} \quad \sigma_{ij}^2 = \mu_{ij} \left(1 - \frac{n_i}{K}\right) \left(\frac{K}{K-1}\right)$$

- **Measure of Research Relatedness**

$$t_{ij} = \frac{J_{ij} - \mu_{ij}}{\sigma_{ij}}$$

◆ Research Coherence

- **Weighted Average Relatedness to all neighbors (WAR)**

$$WAR_i = \frac{\sum_{j \neq i} t_{ij} p_j}{\sum_{j \neq i} p_j}$$

- **Weighted Average Relatedness to the closest Neighbor (WARN)**

$$WARN_i = \frac{\sum_{j \neq i} t_{ij} p_j \lambda_{ij}}{\sum_{j \neq i} p_j \lambda_{ij}}$$

Data

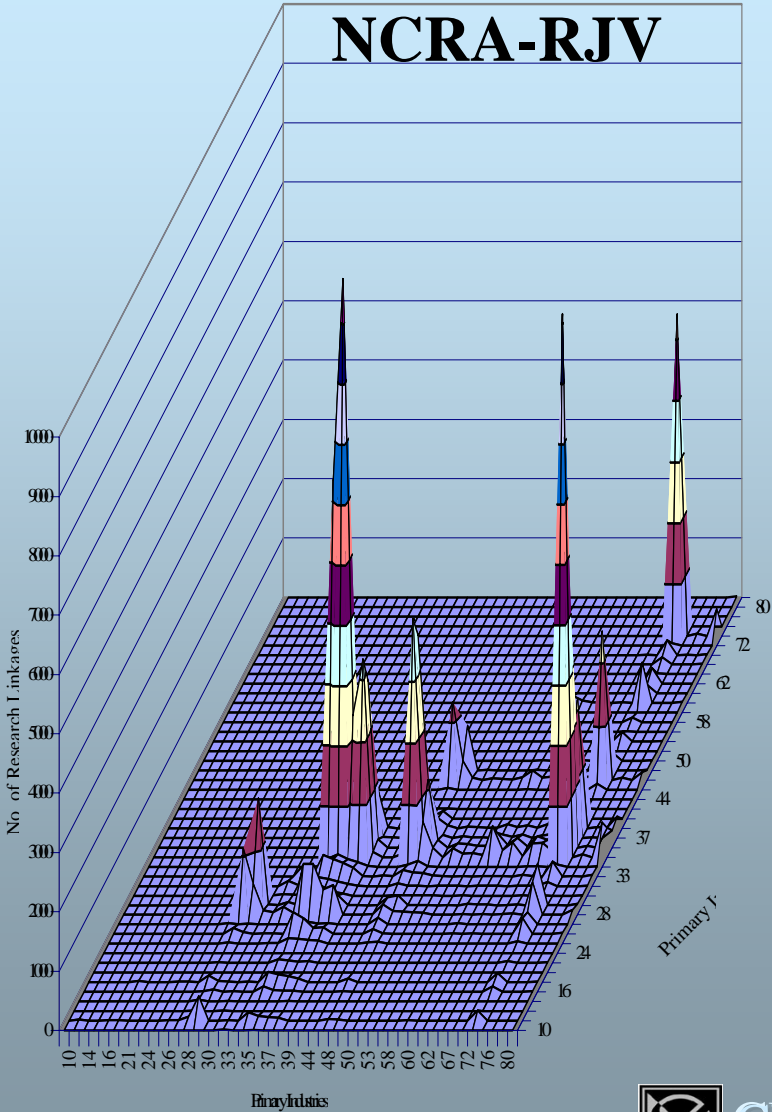
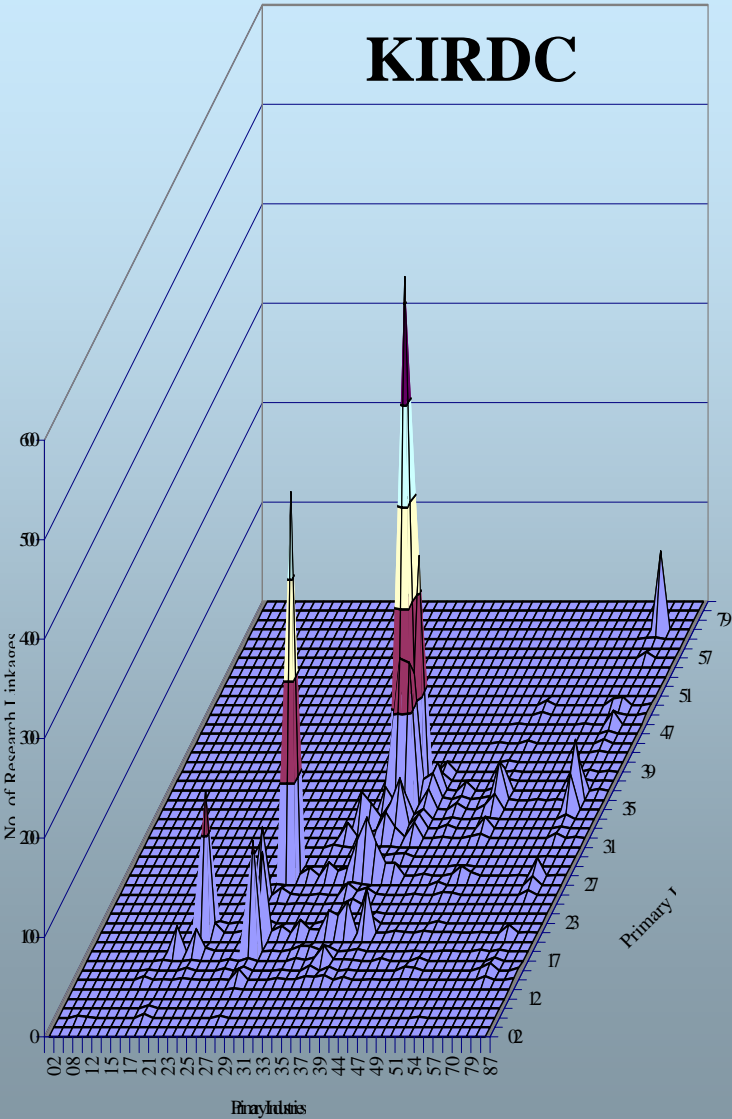
◆KIRDC

- All R&D Projects cooperatively conducted under major government R&D programs in Korea
- 1982 – 1996
- 4,220 Projects
- 12,599 Memberships

◆NCRA-RJV

- All Research Joint Ventures (RJVs) registered under NCRA and NCRPA
- 1985 – 1996
- 671 RJVs
- 9,965 Memberships

Research Contacts



Measure of Research Relatedness

Variables	<i>KIRDC</i>	<i>NCRA-RJV</i>
<i>K</i>	2,125	493
<i>I</i>	51	51
<i>I*</i>	1,275	1,275
<i>J_{ij}</i>	342	616
Sum <i>t_{ij}</i>	80.7339	1,361.7735
Ave <i>t_{ij}</i>	0.2361	2.2107
Min <i>t_{ij}</i>	-10.2659	-6.1058
Max <i>t_{ij}</i>	26.5707	13.3676
StDev <i>t_{ij}</i>	3.4955	2.3523
Var <i>t_{ij}</i>	12.2185	5.5334
Normality-Test	2.2610	38.1373
<i>CJ_{ij}</i>	210	
<i>R</i> ² (<i>CJ_{ij}</i>)	0.6618	
<i>R</i> ² (<i>Ct_{ij}</i>)	0.2260	

K : Projects/RJVs involved in two or more industrial activities

I : A set of unique industrial activities where *K* are active

*I** : All possible pairs of industrial activities = $I(I-1) / 2$

J_{ij} : All observed pairs of industrial activities

t_{ij} : Measure of industrial relatedness

Normality-Test: Z-test for Ave *t_{ij}* = 0; test function = $\Sigma t_{ij} / \text{Sqrt}(I^*)$

CJ_{ij} : *J_{ij}* commonly observed both in KIRDC and NCRA-RJV

*R*² (*CJ_{ij}* or *Ct_{ij}*) : *R*² of commonly observed *J_{ij}* or *t_{ij}*

Measure of Research Coherence

Variable	<i>KIRDC</i>		<i>NCRA-RJV</i>	
	WAR_i	$WARN_i$	WAR_i	$WARN_i$
K		2,125		493
I		51		51
Σm_k		4,776		1,782
Sum	-883.2007	1,027.4904	6,335.6482	7,624.7318
Ave	-0.1849	0.2151	3.5554	4.2787
Min	-10.2659	-10.2659	-6.1058	-6.1058
Max	26.5707	26.5707	12.6376	13.3676
StDev	4.4638	4.5456	2.9240	3.0370
Var	19.9254	20.6623	8.5500	9.2234
R^2	0.0026	0.0056	0.0563	0.0072
F	12.2345	12.0087	106.2480	12.9657
β_1	-0.2746	0.5162	-0.1547	-0.0576
t	-3.4978	3.4654	-10.3077	-3.6008
p -value	0.0005	0.0005	0.0000	0.0003

K : Projects/RJVs active in two or more industrial activities

I : A set of unique industrial activities where K are active¹

m_k : Number of observed industrial activities in K

WAR_i : Weighted Average Relatedness of industry i

$WARN_i$: Weighted Average Relatedness to Neighbors of industry i

R^2 , F , β_1 , t , p -value : Statistics for simple regressions of m_k on WAR_i or $WARN_i$

Interpretations

◆ Strategic (non-random) research diversification

- Vertical research cooperation is a non-random strategic behavior in both cases
- Vertical research cooperation in the US is more strategic than that in Korea
- Vertical research cooperation in the US is more experimental than that in Korea
- Patterns of vertical research cooperation are significantly different between two cases

◆ Coherent research diversification - NO

- Decreasing WAR but not stable WARN
- Korean research diversification intensifies its interests into more related industries (positive β_1 of WARN)
- US research diversification blends slightly less related industries (negative β_1 of WARN)
- US research diversification is more experimental than the Koreans



Future Developments

- ◆ **Broader international comparative analysis**
- ◆ **Analysis at lower levels of SIC (3 or 4 digits) code**
- ◆ **Analysis with secondary business lines**
- ◆ **Comparison of Business diversification and Research diversification with time lag**
- ◆ **Usefulness in Technology Road-mapping or Foresights**
- ◆ **Guidelines to planning of public research portfolio**