

# Entrepreneurial Research Networks: Measuring and Interpreting

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**Yongsuk Jang, Ph.D.**  
**Senior Research Scientist**  
**Center for International Science and Technology Policy**  
**The George Washington University**

**Email: [jang@gwu.edu](mailto:jang@gwu.edu)**



# Why Cooperate for Research and Development?

## • Horizontal Collaboration

- 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
  
- **Market Failure**

## • Vertical Collaboration

- Cooperation with Firms in Different Industries
- Technology options view
- Supplier/Customer Relationship
- Complementary research resources
- Exploit research synergy
- Appropriate at early fluid evolutionary stage : emerging industries
- Technology Fusion
  
- **System Failure**

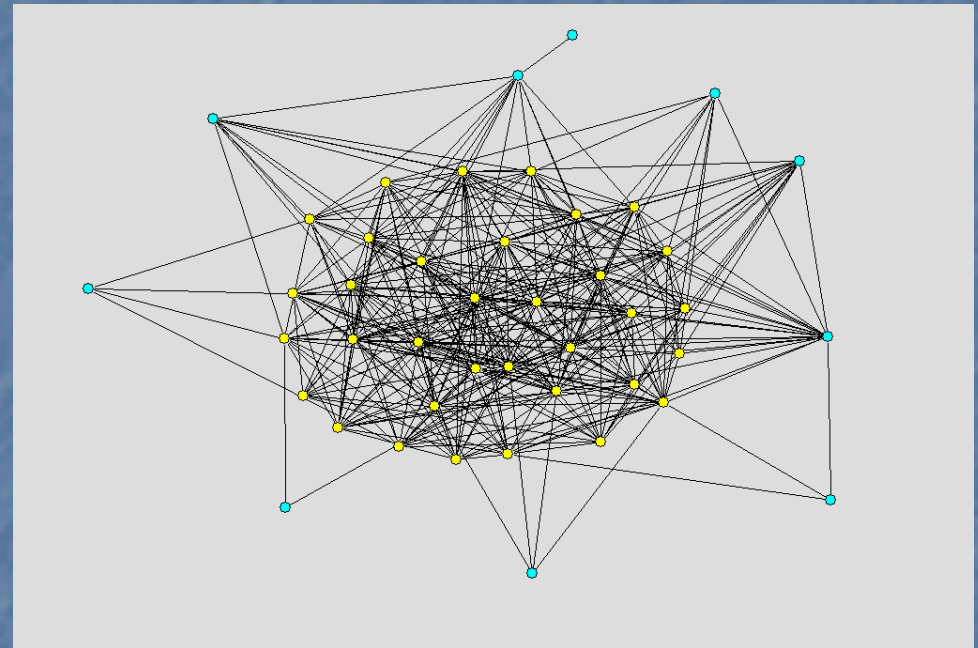
# Research Networks

Collaboration for R&D



Research Networks

- View from Various Characteristics of Collaborators
  - Individual Researchers
  - Affiliates
  - Disciplines
  - Technological Merits
  - Knowledge Components
  - Industries (Primary & Secondary)
  - Etc.



Which Networks are Good or Bad?

# ‘Entrepreneurial’ Research Networks

- “A person who organizes, operates, and assumes the risk for a business venture.” (American Heritage Dictionary)
- “Person who takes on the risks of starting a new business.” (Barron’s)

## **Key Characteristics**

- **Risk-taking**
- **New Trials**

**Research Collaborations that try Experimental (New) Forms even at Higher Risks**

# Methodology: Theoretical Ground

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

## *Survivor Principle*

“Economic competition eliminates relatively inefficient organizational forms over time.”

- Applied to the research network analysis, the survivor principle assumes that related characteristics (e.g., technologies) will be more frequently combined through research networks.
- In other words, for instance, if a certain pair of technologies is frequently observed throughout each database, it can be assumed that these two technologies are highly related.
- Conversely, technologies rarely or never combined are unrelated.”

# Methodology: Technological Relatedness

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- No. of IRC in both technologies

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

- Expected Value

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

- with Mean &

$$\mu_{ij} = E(X_{ij}) = \frac{n_i n_j}{K}$$

- Variance

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

- Measure of Technological Relatedness

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

# Methodology: Technological Coherence

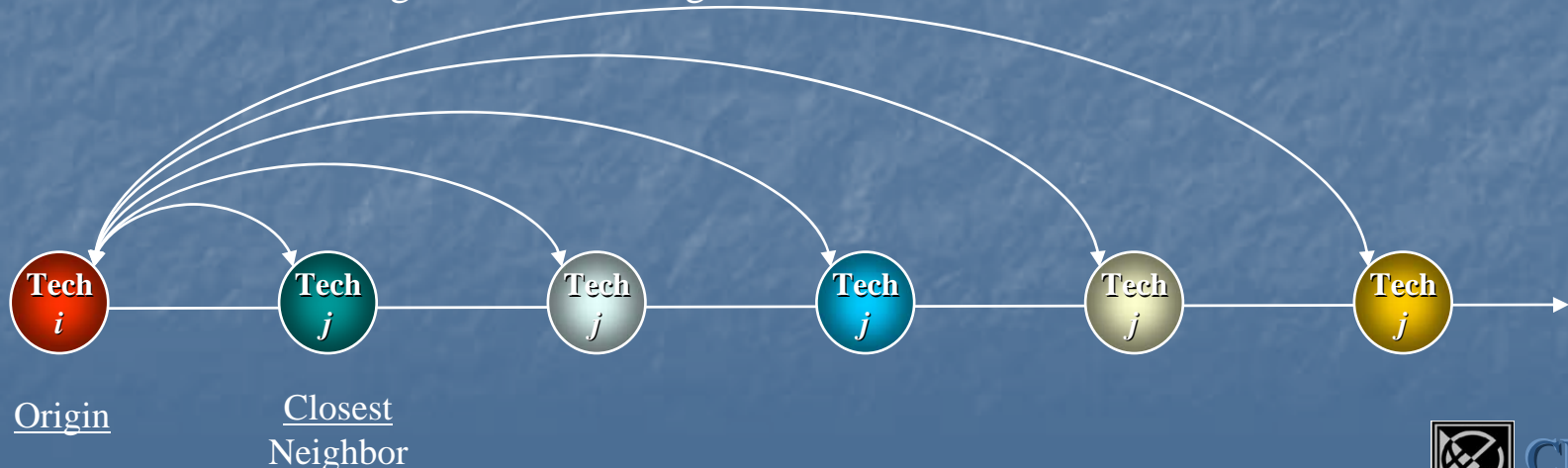
Weighted Average Relatedness to all neighbors (WAR)

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

Weighted Average Relatedness to the closest Neighbor (WARN)

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

“..... A useful analogy would be to a residential neighborhood, where  $WARN_i$  measures the inverse of the average distance from a house to its neighbors, and  $WAR_i$  measures the inverse of the average distance from a house to all other houses in the area. As the area covered is increased, the distance to nearest neighbors does not change, but the average distance to all other homes does rise. In the technological landscape, one sees that in a more diverse firm, just as in a larger neighborhood, the average distance to other technologies increase, but the average distance to neighbors does not.”



# Data

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## 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

# Questions

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- **What Type?**

- **Horizontal vs. Vertical Research Collaborations**

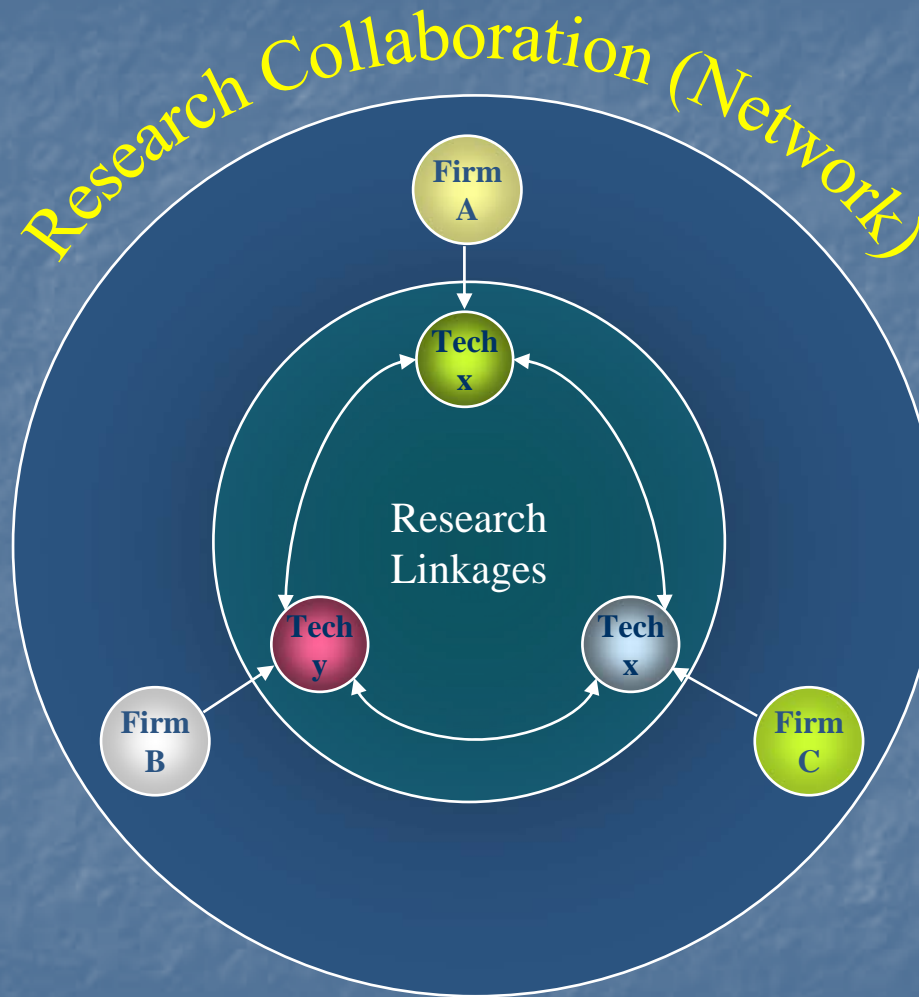
- **Strategic Behavior?**

- **Random vs. Strategic Behavior**

- **Entrepreneurial?**

- **Coherent vs. Incoherent Collaborations**

# Methodology: Research Linkage



## Research Linkages:

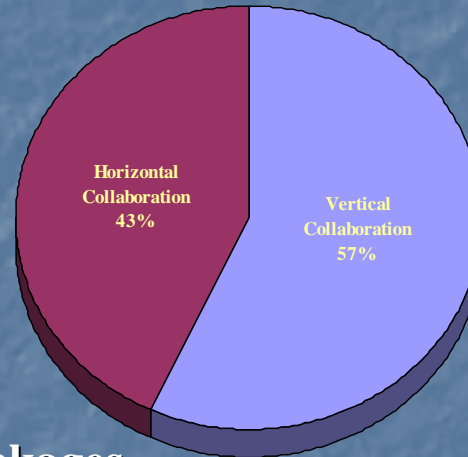
$$N(N-1)/2 = 3$$

- A-B (x-y)
- A-C (x-x)
- B-C (y-x)
  
- Horizontal: A-C
- Vertical: A-B & B-C

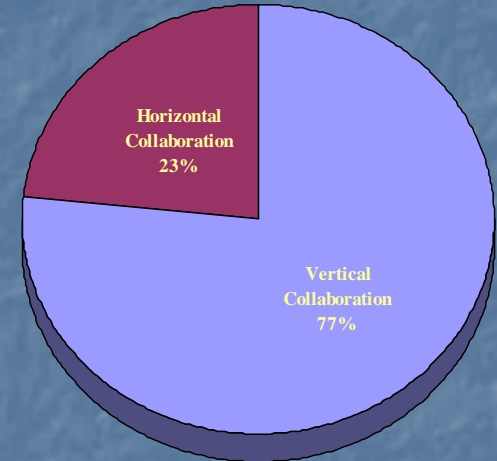
# Horizontal vs. Vertical

## Shapes of Research Collaboration

Korea

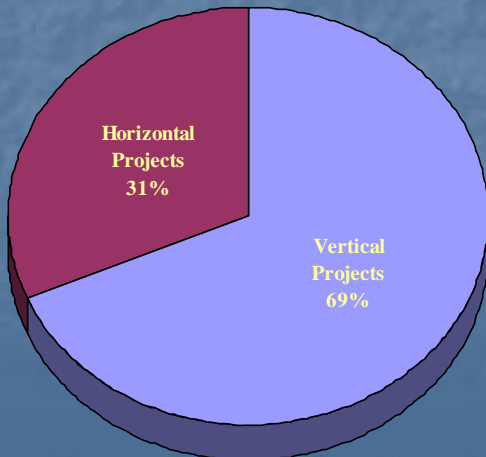


U.S.

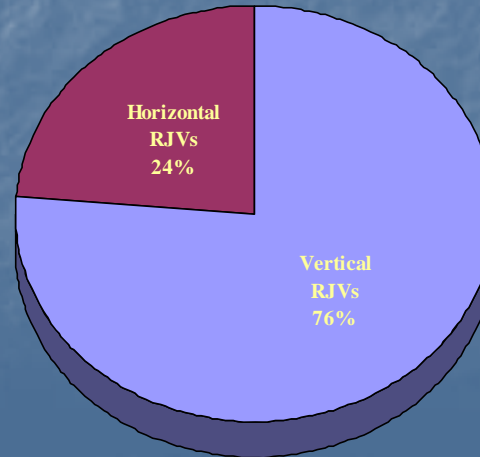


## Shapes of Research Linkages

Korea



U.S.



# Measure of Technological 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<sub>ij</sub></i>	342	616
Sum <i>t<sub>ij</sub></i>	80.7339	1,361.7735
Ave <i>t<sub>ij</sub></i>	0.2361	2.2107
Min <i>t<sub>ij</sub></i>	-10.2659	-6.1058
Max <i>t<sub>ij</sub></i>	26.5707	13.3676
StDev <i>t<sub>ij</sub></i>	3.4955	2.3523
Var <i>t<sub>ij</sub></i>	12.2185	5.5334
Normality-Test	2.2610	38.1373
<i>CJ<sub>ij</sub></i>	210	
<i>R</i> <sup>2</sup> ( <i>CJ<sub>ij</sub></i> )	0.6618	
<i>R</i> <sup>2</sup> ( <i>Ct<sub>ij</sub></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<sub>ij</sub>* : All observed pairs of industrial activities

*t<sub>ij</sub>* : Measure of industrial relatedness

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

*CJ<sub>ij</sub>* : *J<sub>ij</sub>* commonly observed both in KIRDC and NCRA-RJV

*R*<sup>2</sup> (*CJ<sub>ij</sub>* or *Ct<sub>ij</sub>*) : *R*<sup>2</sup> of commonly observed *J<sub>ij</sub>* or *t<sub>ij</sub>*



## Strategic (non-random) Behavior

- **Non-random Strategic Behavior in both cases**
  - Average  $t_{ij}$  is NOT 0 by normality tests at 95% confidence level
- **Research Networks in RJVs (US) is more strategic than those in Projects (Korea)**
  - Higher sum and average  $t_{ij}$
  - Smaller range of  $t_{ij}$
  - Lower standard deviation & variance of  $t_{ij}$
- **Different Research Networks**
  - 210 pairs are common (out of 342 in KIRDC and 616 in NCRA-RJV)
  - Low (0.226)  $R^2$  ( $Ct_{ij}$ )
  - Remaining 132 in KIRDC and 406 in NCRA-RJV pairs are exclusive to each other

# Measure of Technological Coherence

Variable	<i>KIRDC</i>		<i>NCRA-RJV</i>	
	$WAR_i$	$WARN_i$	$WAR_i$	$WARN_i$
$K$		2,125		493
$I$		51		51
$\Sigma m_k$		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
$\beta_1$	-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 active<sup>1</sup>

$m_k$  : Number of observed industrial activities in  $K$

$WAR_i$  : Weighted Average Relatedness of industry  $i$

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

$R^2$ ,  $F$ ,  $\beta_1$ ,  $t$ ,  $p$ -value : Statistics for simple regressions of  $m_k$  on  $WAR_i$  or  $WARN_i$

# Entrepreneurial Research Networks

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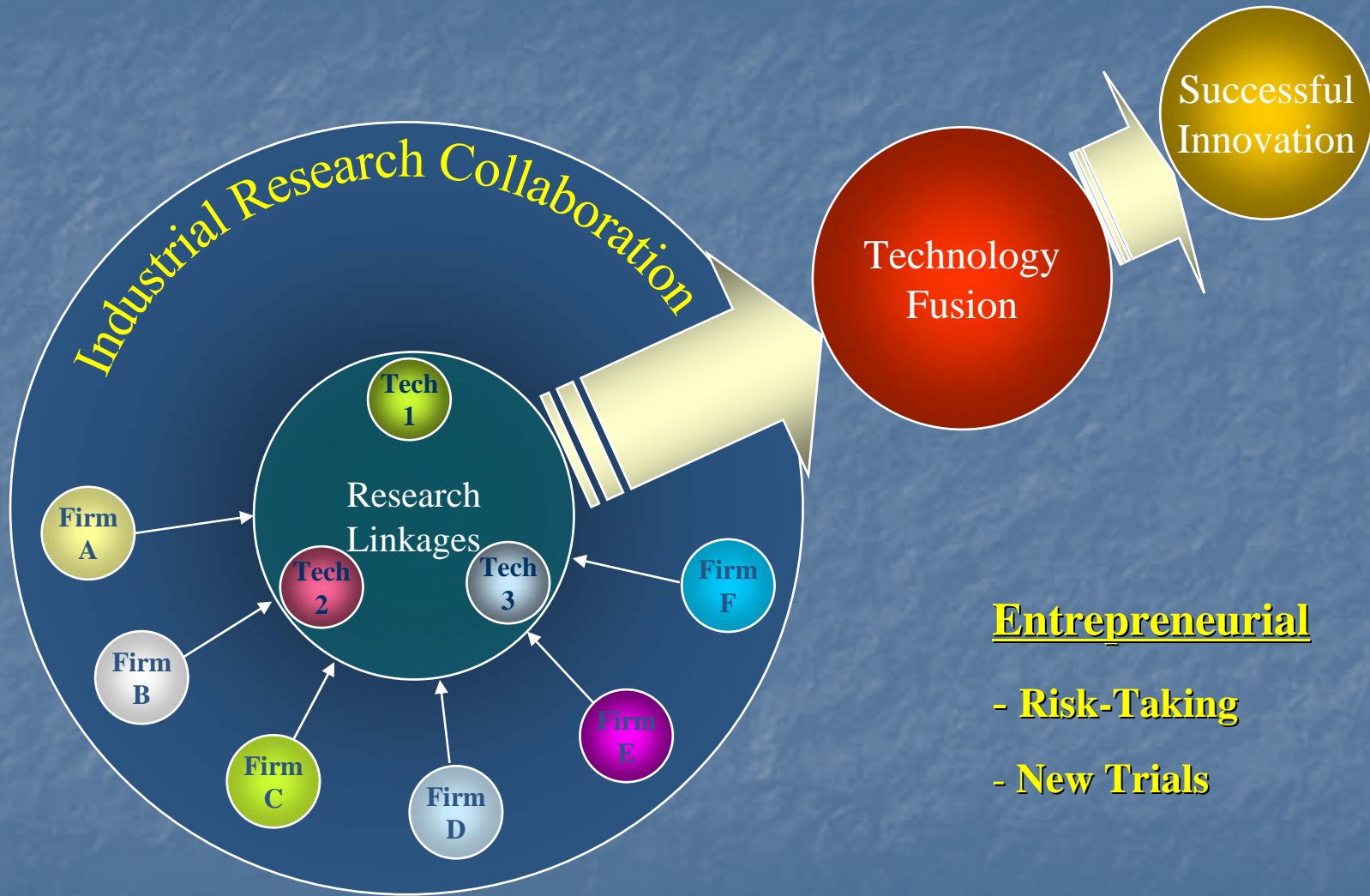
- **Research Networks are entrepreneurial in both cases**
  - Decreasing WAR (- signs of WAR) but not stable WARN (+ or - signs)
- **Research Networks in RJVs is more entrepreneurial than those in Projects**
  - Projects intensifies its interests into more related technologies (positive  $\beta_1$  of WARN)
  - RJVs blends slightly less related industries (negative  $\beta_1$  of WARN)
  - 616 pairs in 493 RJVs vs. 342 Projects in 2,125 Projects

# Implications

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- **Research Networks in both cases are**
  - **Vertical rather than Horizontal**
  - **Strategic behavior**
  - **Entrepreneurial**
- **Research Networks in RJVs (U.S.) are MORE vertical, strategic, and entrepreneurial than those in Projects (Korea)**
  - **Autonomous environment for research collaboration is important**
- **Foreboding Technology Fusion**

# Foreboding Technology Fusion



# Entrepreneurial Research Networks at Various Levels

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Given 'Entrepreneurship' is Desirable toward Innovation,

- **At Basic Research**

- Entrepreneurial Interdisciplinary Research
- Appropriate Data: SCI Publications or Funded Basic Research

- **At Applied Research**

- Entrepreneurial Industrial Generic Research
- Foreboding Technology Fusion
- Appropriate Data: Funded Industrial Research

- **At Development Research**

- Entrepreneurial Technology Fusion
- Appropriate Data: Patent Data

# Thank You!

Yongsuk Jang, Ph.D.

[jang@gwu.edu](mailto:jang@gwu.edu)

Center for International Science and Technology Policy  
The George Washington University

