The Structure of Intra-group Ties: Innovation in Taiwanese Business Groups

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Relation Between Business Groups and Innovation

- Business groups are a type of multi-business firm common in many economies
  - US in 19th century & W. Europe in early 20th century
  - Japan & Korea in mid 20th century
  - India, Taiwan, China, Argentina, Turkey late 20th century

- Definition: A set of legally independent companies, with activities in multiple industries, that are linked as affiliates through persistent informal links & formal relationships such as equity, director, and operating ties (Khanna and Rivkin 2001).

- Starting to understand why they exist, but have limited understanding of how they affect technological innovation
  - Scale and scope may help diffusion and creation of knowledge (Amsden & Hikino, 1994)
  - On the other hand, entry barriers may lead to entrenchment and stagnation (Morck and Yeung 2004; Mahmood and Mitchell 2004)

➢ The paradox of technological development is the faster an economy catches up, the sooner it faces the potential tradeoff between static efficiency gains and loss of dynamic efficiency

What do we know about business groups and innovation?

- Institutions matter; weaker the institutional infrastructures, the higher the benefits of group affiliation (Chang, Chung, & Mahmood, Organization Science, forthcoming, 2006)

- Type of industry also matters; within the same institutional context, group affiliation can benefit or hurt innovation depending on industry level of technological opportunity & Industry level of R&D uncertainty (Mahmood & Mitchell, Management Science, 2004)

- But within the same institutional and industrial setup, innovation seems to vary
  - Across different groups (Daewoo vs. Samsung prior to 1997)
  - Across different affiliates within same groups (Samsung Electronics vs. Samsung Electro-mechanics)

➢ Research on groups has focused on external drivers (industry type and institutional context), but has not looked at the internal organizational structures that can benefit or inhibit innovation

But intra-group ties matter: Ties as panacea

"Conglomerates, called keiretsu, protect companies from takeovers, minimize transaction costs, and spread risk. Sumitomo Bank, for example, doesn't need to do a Western-style financial analysis of fellow keiretsu member NEC Corp. before granting it a loan. …..

……..One reason NEC is a leader in integrated circuits is Sumitomo Bank's willingness to supply funds even when that business is unprofitable,……No U. S. bank would have given so much money to NEC."

Business Week, 1992

Changing times: Intra-group Ties As Problems

"In order to turn Nissan around, it was necessary for me to change the company's existing system of business partnerships, which meant dismantling the ***keiretsu****. Where Nissan previously contracted with about 1,200 parts suppliers, we have managed to narrow it down to about 700. ……..……*

On the other hand, we have maintained partnerships with those suppliers that have performed well for us. …..…. ……..…..

……..……..……..…Nissan has worked closely with Hitachi to support its parts production. But it is certainly not a keiretsu relationship."

Carlos Ghosn
August 2003

……..But Still Alive & Kicking…

"When hidden losses discovered in the accounts of SK Global threatened the stability of the entire conglomerate, SK Corp, the group's oil refining arm and a large shareholder and creditor of SK Global, agreed to contribute up to $830m to the rescue of its sister company, while other SK affiliates are expected to support the trading company by doing more business with it."

Korea Times, Aug, 2004

All in the family: Formosa Plastics

But how do ties matter?

- Understand how intra-group ties affect the innovativeness of individual affiliates of business groups as well as of groups as a whole
- Develop a deeper understanding of innovation in the multi-business firm (group is a type of multi-business firms) & network literatures (group is a type of network)

Business groups & Ties

- There can be different types of formal and informal intra-group ties. We choose 3 types to ties to examine:
  - Operating ties arise when affiliates are engaged in buyer-supplier relations.
  - Director ties arise when an individual sits on the board of multiple affiliates.
  - Equity ties arise when affiliates own equity stakes in each other through cross-shareholding.

- All three types of ties can influence a group's ability to innovate, providing both opportunities and constraints

(1)Duality of investment ties

- Benefits
  - Access to financial resources
    - Longer managerial time horizon (as firms are less likely to fail)
    - Facilitates risk sharing that may encourage investment in risky R&D
- Negative side:
  - Tunneling

(2) Duality of Directorial Interlocks

- Benefits:
  - Access to information
    - Business scan (Useem, Haunschild, Davis…)
    - Flow of information about business practices
- Negative side:
  - Loss of strategic control due to managerial overload that leads to managerial risk aversion

(3) Duality of Buyer-supplier Ties

- Benefits:
  - Both complementary resources and information
  - Conduits for information flow
  - Reduces secondary uncertainty
- Negative side:

  Insularity, soft budget constraint, lack of incentive for aggressive search (Is Keiretsu dead?)

- In theory each type of tie (equity, director, and operating tie) can benefit as well as inhibit innovation
  - Group literature tells us that ties are important but does not tell us how ties can affect innovation

No single body of work explains why some affiliates and some groups are more innovative than others.

- Innovation-diversification studies focus on no. of product markets & usually ignore internal corporate structure
  - MBFs should be more innovative (Nelson 1959; Cohen & Klepper 1996), but they often are not (Link & Long 1981)

- Network literature tells us that cost and benefits of ties will depend on structure of ties
  - Key network concepts: Unit *centrality* & network *density*
  - Central units of a network may be more innovative (Ahuja 2000) or more constrained (Uzzi 1996)
  - Density implications, but few direct tests: Dense networks may be more (Coleman 1990) or less (Burt 1992) innovative
  - Most of the studies are single network studies

Our approach is exploratory

- Because existing theory generates conflicting arguments, particularly in the context of multiple types of ties that involve differing resources, we will treat this as an exploratory investigation rather than state formal hypotheses.

- The results highlight the innovative impact of different configurations of different types of ties within business groups and, more generally, within multi-business firms and networks

Scope of this study

- Three types of intra-group ties
  - Investment ties: Equity stakes via cross-shareholding
  - Director ties: Individual sits on boards of multiple affiliates
  - Operating ties: Buyer-supplier links between affiliates
- structure of ties
  - Centrality: No. of ties to other members of a group (degree centrality). Density: Proportion of total possible ties
  - For each type of tie, we have a centrality (affiliate-level) and a density (group-level)
- Innovation
  - Patents (our dependent variable) vs. R&D (our control)
- Level of analysis
  - Affiliate innovation: No. of domestic patent applications
  - Group innovation: Total applications by group affiliates

(1) Taiwan as the Empirical setting

- Taiwanese business groups play important roles in the Taiwanese economy.
  - Chung and Mahmood (OUP, 2006) report that the sales of the top 100 groups accounted for as much as 85% of the country's GDP in 2002, up from a 28% share in 1980.
- Between 1990 and 1999, business group affiliates received about 40% of the US patents awarded in Taiwan.
- Moreover, between 1970 and 1999, the U.S. Patent and Trademark Office reports that seven of the top ten Taiwan-based recipients of U.S. patents were business group affiliates.

Top 10 Patent Winners in Taiwan in terms of US patents (1970-1999)

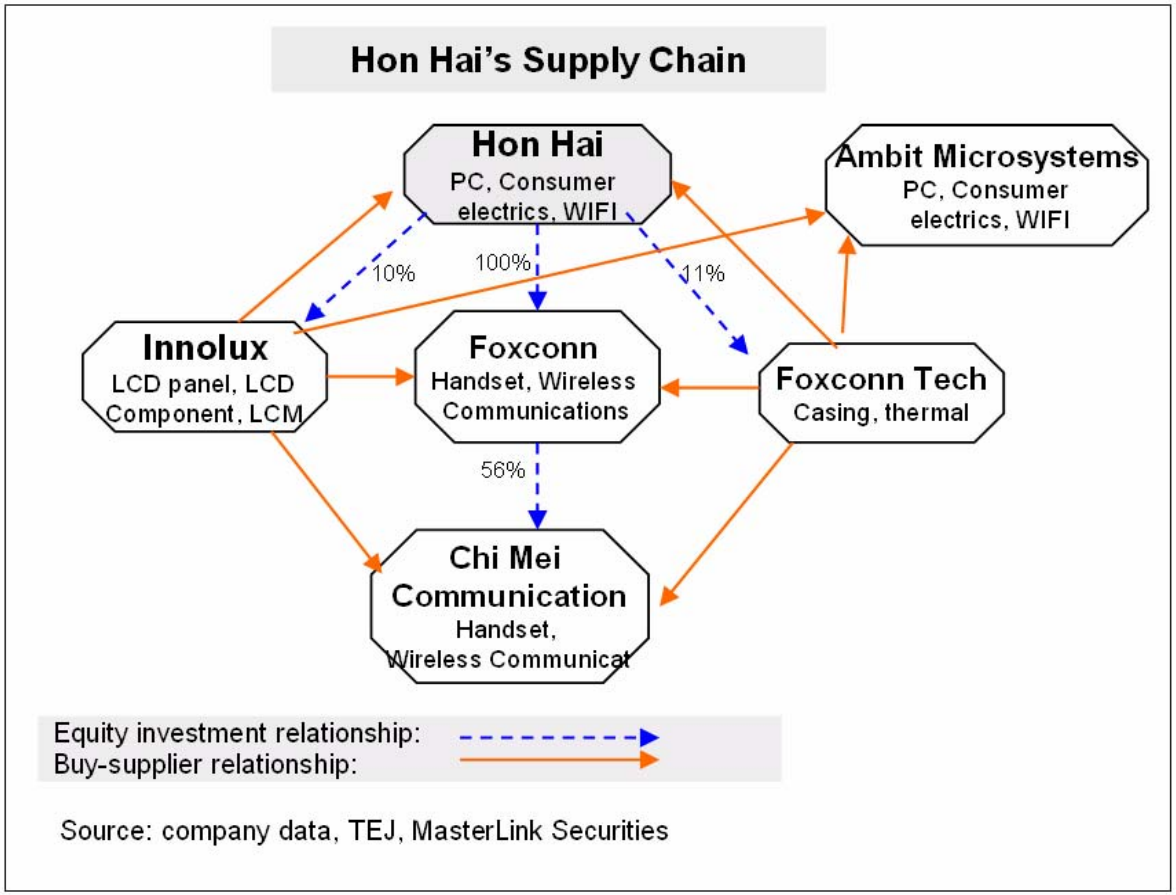
Assignee Name	Identity	Patent Count
Industrial Technology Research Inst.	Government Research Institute	1,229
United Microelectronics Corporation	UMC Group	946
Taiwan Semiconductor Manufacturing Co.	TSMC Group	752
National Science Council	Governmental Research Institute	367
Vanguard International Semiconductor	TSMC Group	301
Winbond Electronics Corp.	Walsin Lihua Group	216
Hon Hai Precision Ind. Co., Ltd.	Hon Hai Group	107
Mosel Vitelic, Incorporated	Mosel Pacific Group	85
Acer Peripherals, Inc.	Acer Group	70
Texas Instruments Inc	Multinational Company	60
Total patents for top 10 assignees		4,133
Other patents		15,850
Overall total 1970-99 for Taiwan		19,983
Fraction of patents held by top 25 assignees		20.6%

Source: United States Patent and Trademark Office (2005)

(2) Taiwan as the Empirical setting

- Governance of groups in Taiwan involves substantial variety in the structure of equity, director, and operating ties, which offers a rich context in which to examine variation in innovativeness.
  - Taiwanese groups exert less hierarchical control than *chaebol*, but more coordination than *keiretsu (*Hamilton and Kao, 1990)
  - The major coordination mechanisms inside many Taiwanese groups involve a moderate degree of control by socially-related leaders, rather than strong control by a single group president or looser coordination via a president's council (Hamilton 1997:265).
- Moreover, Taiwan offers clear definitions of group membership for identifying ties.

Hon-Hai Group



Example

- Formosa Plastics Group

Data & Sample

- For ties: *Business Groups in Taiwan* (BGT), compiled by the *China Credit Information Service* (CCIS) in Taipei, an affiliate of Standard & Poor's, US
  - The BGT directory collects information on the top 100 groups in sales and is confined to groups whose core firms are registered in Taiwan. The CCIS defines a business group as "a coherent business organization including several independent enterprises."
  - Data on top 100 groups……5 years (1981, 1986, 1990, 1994, and 1998)……**592** cases of Taiwanese groups and their **5,339** affiliated firms….after excluding service firms, end up with 2,527 firm-year observations
- For patents: Intellectual Property Office of Taiwan (http://www.patent.org.tw) ….The dependent variable is the patent application counts by affiliate *i* of group *j* over a two-year period [t+1, t+2]……."New invention patents" designated wholly new products, materials, or manufacturing processes. Taiwan established its patent system in 1945. In total, the study uses 2,562 new invention patent applications by business group affiliates during the 10 years.
  - Taiwanese patent examiners follow standards similar to U.S. examiners regarding patentable inventions (Yang 2004). In accordance to the Trade Related Aspects of Intellectual Property Rights agreement of the World Trade Organization, Taiwan restructured its patent systems in 1994, extending a patent's life from 15 to 20 years.
  - We focus on local patents because we are interested in overall innovative activity rather than activity only by Taiwanese firms registered in the U.S. Since patenting abroad is more expensive than patenting domestically, focusing on U.S. patents might bias the analyses toward larger firms or firms that export heavily to the U.S., although we examine U.S. patents in sensitivity analysis.

Measures and issues

Measuring ties (the main explanatory variable):

- Group level measure: network density
- Firm level measure: degree centrality
- non-directional

Concerns:

- Does direction matter?.....less of a problem
- Not all ties are the same……more of a problem…..

Table 1. Number of Affiliates and Mean Density of Ties in Taiwanese Business Groups, 1981-1998

Year	Number of groups	Number of affiliates	Mean no. of affiliates	Mean equity tie density	Mean director tie density	Mean operating tie density
1981	100	716	7.2	0.17	0.37	0.22
1986	97	749	7.7	0.19	0.37	0.17
1990	101	819	8.1	0.20	0.36	0.13
1994	115	1,116	9.7	0.21	0.30	0.09
1998	179	1,938	10.8	0.20	0.30	0.07
Total	592	5,339	9.0	0.19	0.34	0.14

……..*Other measures (cont.)*

Innovation (the dependent variable)

- Patents are hardly perfect…..but better than the rest
- Local vs. US patents can have their own biases, so we look at both……(Chang, Chung, and Manmood, 2004)

Alternative explanations/ control variables

- Access to capital
- Industry characteristics (technological opportunity)
- Access to outside (extra-group) linkages (JV, Licensing, Acquisitions……..)
- Structure: diversification, ownership, etc.
- Potential outliers

Estimation

- The count nature of our dependent variable (number of patents), together with over-dispersion of values of the variable, suggests using negative binomial regression for the analysis (Hausman, Hall & Griliches 1984; Gurmu & Trivedi 1994).
- At the same time, the dependent variable is characterized by "many zeros". Indeed, only 24% of business groups patented during the study period, involving a minority of individual firms. Therefore, we adopt Zero-Inflated Negative Binomial (ZINB) regression to handle the preponderance of zeros (Mullahy 1986; Lambert 1992).
  - ZINB regression separates two regimes that may generate zero outcomes. In regime 1, the patent outcome is always zero (some firms never patent). In regime 2, the usual negative binomial process applies (some firms generate no patents in some years and positive counts in other years).
- We also cluster by groups within the firm-level ZINB models to address the possibility that affiliates share group-specific attributes.
- We use multi-variate kernel regression to examine the interaction between centrality and sensity

Results

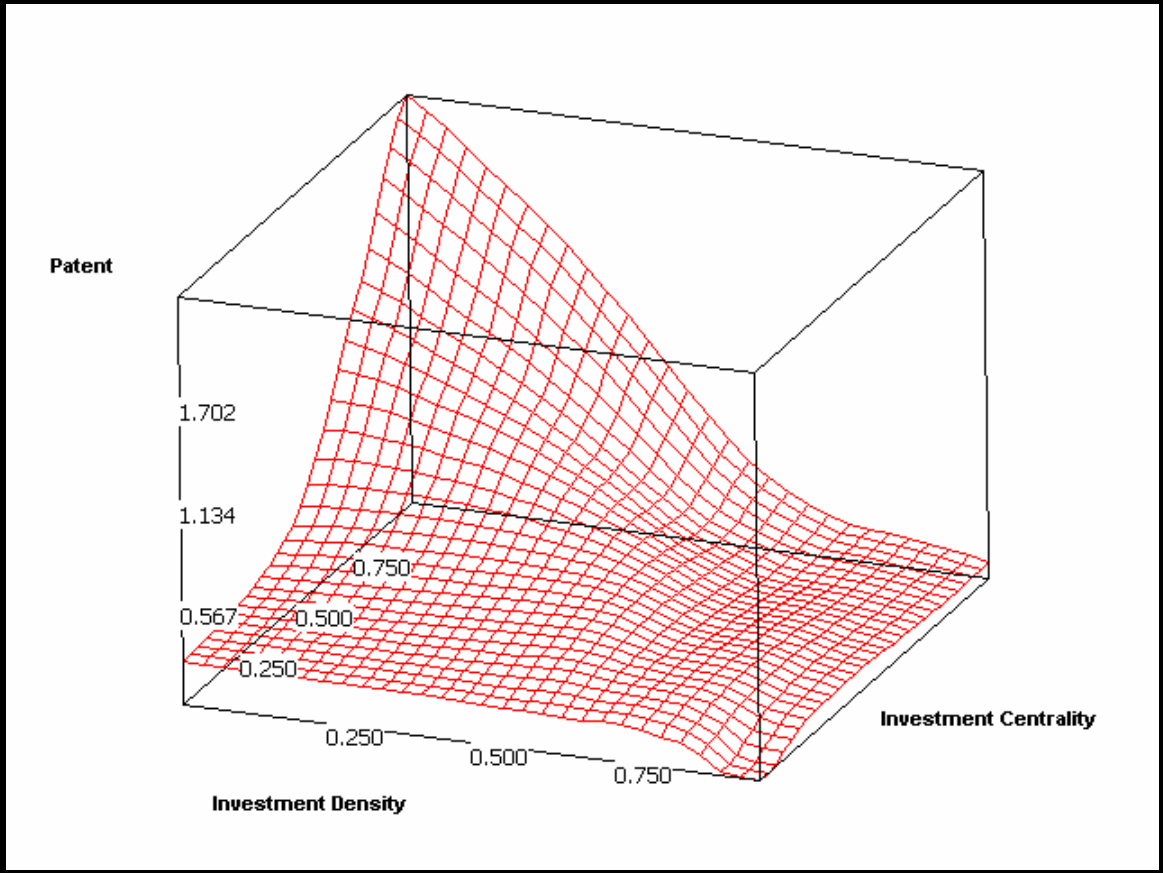
Table 3. ZINB Estimates of Influences of Tie Structure on Firm and Group Patenting
(positive coefficient = greater patenting)

	1 Firm	s.e.		2 Firm	s.e.		3 Firm	s.e.		4 Group	s.e.	
Tie structure variables												
Affiliate Equity Centrality	1.980	0.852	**	3.476	0.836	***	3.519	0.887	***			
Affiliate Director Centrality	-1.445	0.569	**	-1.085	0.504	**	-1.244	0.497	**			
Affiliate Operating Centrality	-0.901	0.824		-0.732	0.692		2.858	1.403	**			
Operating Centrality squared							-5.001	1.557	***			
Group Equity Density				-5.640	1.221	***	-5.639	1.410	***	1.491	1.296	
Group Director Density										-3.876	1.579	**
Group Operating Density										-1.538	0.572	***
Affiliate-level variables												
Affiliate Assets (x1000)	5.641	4.073		4.631	3.221		3.163	3.251				
Affiliate Industry R&D	0.882	0.238	***	0.932	0.202	***	0.938	0.214	***			
Affiliate Family Ownership Share	-0.040	0.022	*	-0.051	0.013	***	-0.049	0.014	***			
Affiliate Age	-0.002	0.034		-0.037	0.034		-0.044	0.034				
Affiliate Electronics Sector	-0.202	1.404		-0.722	0.786		-0.753	0.817				
Group-level variables												
Group Assets (x1000) (a)	-0.680	1.342		-0.814	1.292		-0.395	1.428		1.980	1.849	
Group Industry R&D										-0.153	0.109	
Group Diversification	-1.107	0.813		-1.246	0.730	*	-1.589	0.758	**	-3.009	0.897	***
Group Industry Concentration	1.247	1.818		1.047	1.865		1.469	1.816		-3.274	1.352	**
Group UMC-TSMC Dummy	-0.525	0.686		-1.153	0.571	**	-1.141	0.551	**	-3.308	2.642	
Prior Stock of Patents	0.482	0.165	***	0.568	0.163	***	0.552	0.163	***	0.016	0.008	**
Year of panel	-0.141	0.081	*	-0.233	0.089	***	-0.200	0.086	**	-0.142	0.040	***
Constant	278.7	161.3	*	463.5	177.8	***	396.9	171.6	**	286.9	80.8	***
Cases	3,119			3,119			3,119			582		
Log (pseudo) likelihood	-657.5			-648.6			-646.1			-510.3		
Log-likelihood ratio (df)				17.8	(1)		5.0	(1)				

Note: The firm-level analyses cluster the observations by group
(a) "Group assets" excludes the focal firm for the firm-level analysis in models 1 to 3
*** p< .01, ** p<.05, * p<.10 (two-tailed tests)

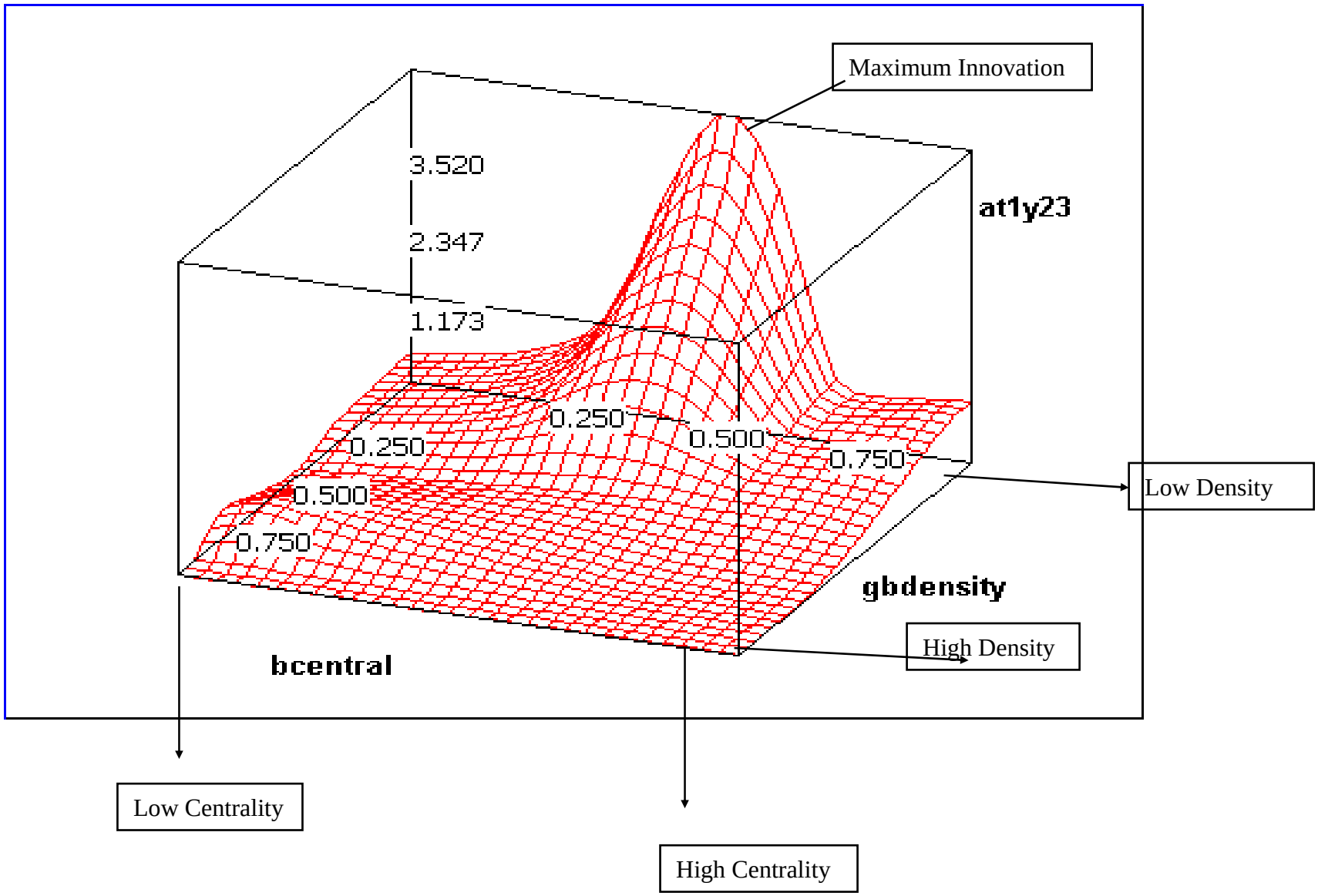
Firm-Level Innovation: Combined Effects of Affiliate Equity Centrality and Group Equity Density

Multivariate kernel estimation using Nadaraya-Watson estimator



Moderating effect of operating density on the operating centrality-innovation link

Legend: bcentral = operating centrality; gbdensity = operating density; at1y23 = patent applications



Implications for group innovation

- The central implication is that affiliates have fertile opportunities for innovative activity if they have broad access to financial resources within otherwise sparse equity networks, access to a moderate degree of operating knowledge from other members of the group, and autonomy from inter-affiliate director interlocks and over-embedded buyer-supplier ties that would impose strategic constraints.

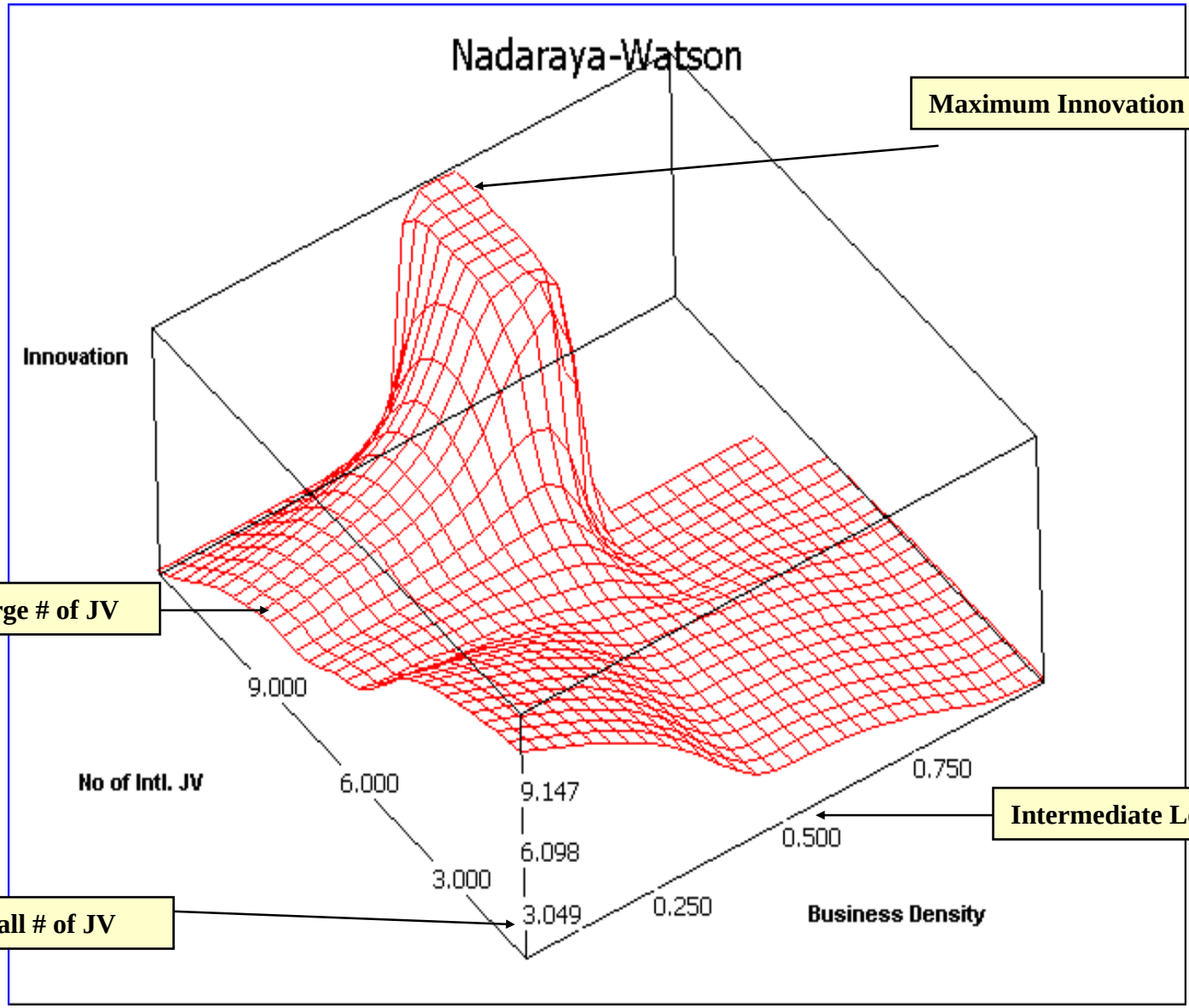
- By contrast, groups with dense networks of inter-locking directorships and operating ties often constrain innovative activity.

- Thus, innovation influences are strongest when a group with limited financial and strategic interconnections can focus financial and operating resources on the innovative activities of their central businesses, which can draw on the knowledge and resources of other affiliates.

Robustness Test/ Additional analyses

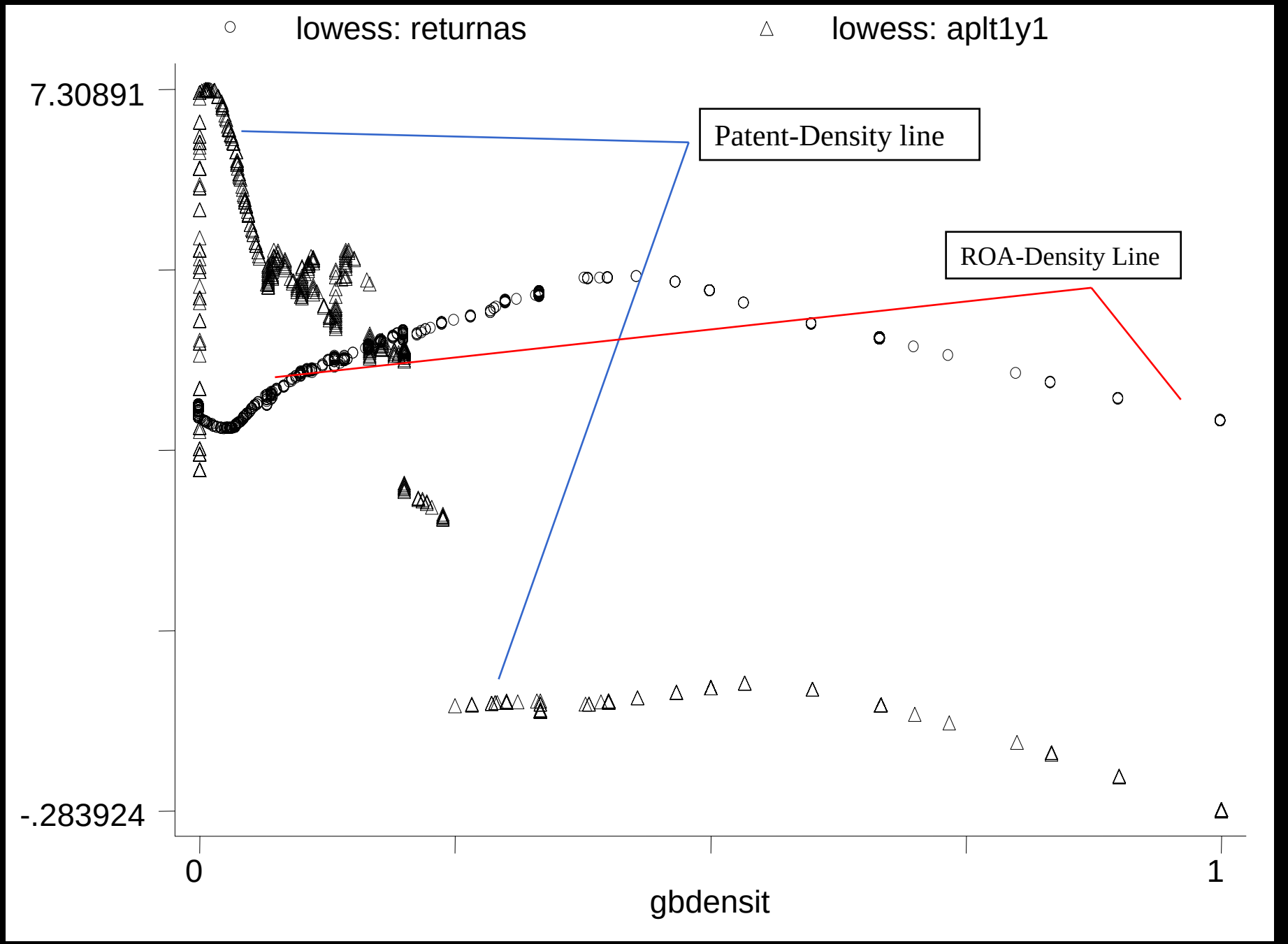
- Issue of causality
  - Using the interaction between IJV and operating density to highlight the mechanism by which excess density hurts innovation
- Local vs. US patents: the issue of motivation for patenting
- In-degree vs. out-degree centrality

Moderating effect of International joint ventures on the business-density-innovation link



But…..

- If density is so bad, why do we see so many groups with high density of intra-group ties?
  - Is there a tradeoff between financial performance vs. innovative performance?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Implications for network theory

- This structure combines the benefits of strong ties and loose connections. Affiliates with central financial positions and moderate operating positions have ties to other affiliates that allow them to gather knowledge and spread costs. At the same time, the overall group is loosely enough connected that it does not constrain its individual members to focus so strongly on current activities that they do not devote resources to innovation. Implications for type of group networks

- Conceptually, this pattern is similar to Burt's (1992) notion of structural holes, coupled with ideas from evolutionary economics (Nelson and Winter 1982). In structural holes theory, individuals or organizations that tie together otherwise unconnected actors can use those positions to draw on the resources of their disparate partners.

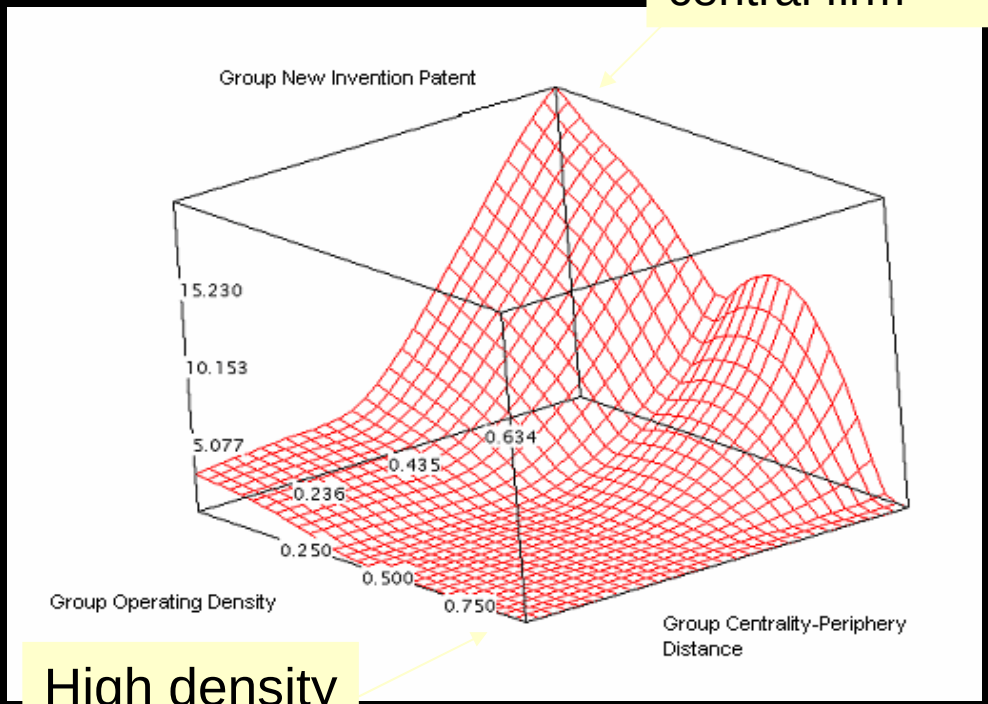
- In evolutionary economics, meanwhile, organizations have opportunities to search for differentiated knowledge and then innovate by combining that knowledge in novel ways. Central units within loosely-connected multi-business firms fill such structural holes and can act as innovation integrators of ideas that arise in peripheral unit.

(3) Implication for multi-business firms

- The results in this study suggest that multi-business firms that possess limited overall operating and strategic interdependence among their units will place few constraints on the innovative activities of their subsidiary units.
- In turn, rather than simply act as a conglomerate holding company, multi-business firms will facilitate innovation if they have a few central units that receive corporate financial support and maintain several operating linkages with other more peripheral units. The peripheral units can experiment with technologies and markets, and then pass ideas to the central units through their operating linkages.

Implications of group structure for overall group innovativeness (aggregate patenting by firms in a group): Moderating effect of center-periphery distance on the operating density-group innovativeness link

Low density group with one central firm



High density

Interaction of operating density & core-periphery distance (difference in centrality of most central & second-most central affiliates). Core-periphery distance = extent to which a group has a central affiliate & a set of peripheral affiliates.

Scout-integrator effect: Group innovativeness is greatest when group operating density is low & there is a large gap between the most central affiliate & the group's other affiliates (rear point).

Director centrality was similar.

- Benefit of combining scouts & integrators

Stylized Example: Scouts & Integrators

- Consider two groups, A & B, each with four affiliates. In Group A, a1 has ties to a2, a3, & a4, none of which have ties to the other affiliates within the group: Group A has network density of 0.5 (3/6 ties), while a1 has degree centrality of 3 ties & the other three affiliates have degree centrality of 1 tie. In Group B, each affiliate has ties with each other affiliate: network density is 1.0 (6/6 ties) & all four affiliates have degree centrality of 3 ties.
- Apparent contradiction when comparing groups A & B. The density results suggest that Group A will be more innovative (Group A has lower density). But the affiliate result that higher affiliate centrality often leads to greater affiliate innovativeness suggests Group B will be more innovative (Group B has 4 central affiliates & Group A has only 1 central firm) – Group B should have 4 innovative affiliates & Group A only 1 equally innovative affiliate.
- The interaction of density & centrality addresses the contradiction. Operating & equity centrality provide fewest benefits when density is high – Group B affiliates will not reach the high innovativeness that their centrality implies. So long as a1's innovativeness is sufficiently larger than that of the Group B affiliates, Group A will be more innovative.
- Why might a1 might be more innovative than its equally-central affiliates in Group B? If a1 has innovation advantages or Group B has disadvantages.
  - Lower density of Group A, combined with centrality of a1, aid intra-group specialization of external search & internal integration that fosters innovation. Peripheral affiliates have few internal ties & are likely to explore outside group boundaries for ideas, as well as searching within the group's existing activities. Because none of Group A's peripheral affiliates is central enough to be able to commercialize many of the ideas that it generates, each explorer will pass its discoveries to the central partner expecting that it can share in successful innovations. The central affiliate, with its ties to the exploratory affiliates, can integrate the others' discoveries, combining them with its own ideas.
  - The greater density of Group B reduces the incentives of any one affiliate to trade information needed for innovation, because each will often seek to promote its own interests. Also, even if Group B affiliates do trade information, the density of intra-group activity may lead affiliates to search within the group for most new ideas rather than look outside group boundaries. Thus, Group B will tend to generate fewer novel ideas than Group A & will have fewer incentives to integrate the ideas that its affiliates generate.

Contributions

- This study operates at the interface of three areas of research: networks, innovation, and business groups.
  - This is the first study to examine how intra-group tie structure affects innovation in an emerging market. In turn, the study informs research on multi-business firm innovation, which typically emphasizes benefits that arise from presence in multiple product markets, rather than considering how inter-unit ties within the diversified firm facilitate the opportunities and/or create constraints.
- Future directions
  - It would be useful to investigate tie structure tradeoffs between innovation and other performance outcomes such as profitability, growth, and survival. Such performance tradeoffs might explain why some groups retain tie structures that inhibit innovation.
  - formal and informal ties beyond those we used in this study – such as mutual debt guarantees, management rotations, and links based on friendship and ethnicity – may influence innovativeness.
  - considering intensity as well as number of ties would provide a more complete picture of the innovation story.