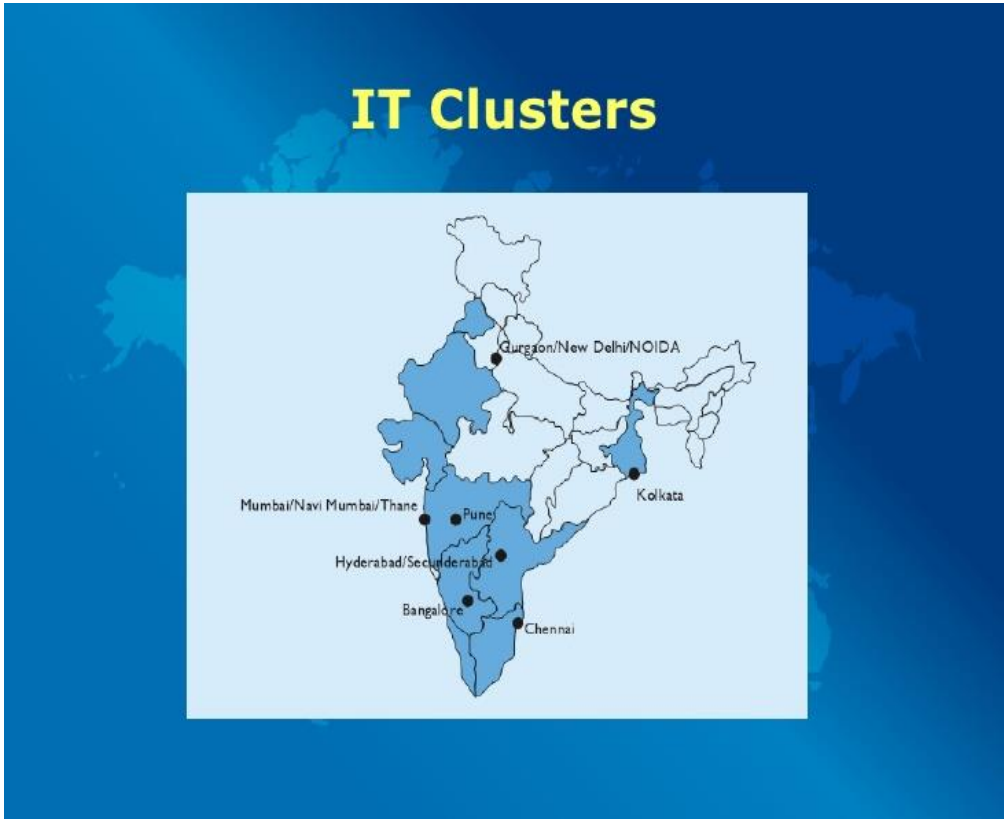
Technological Space and Network Structure in Industrial Clusters: Evidence from Bengaluru

Ekaterina Turkina and Ari Van Assche, *HEC Montréal*

New Silicon Valleys

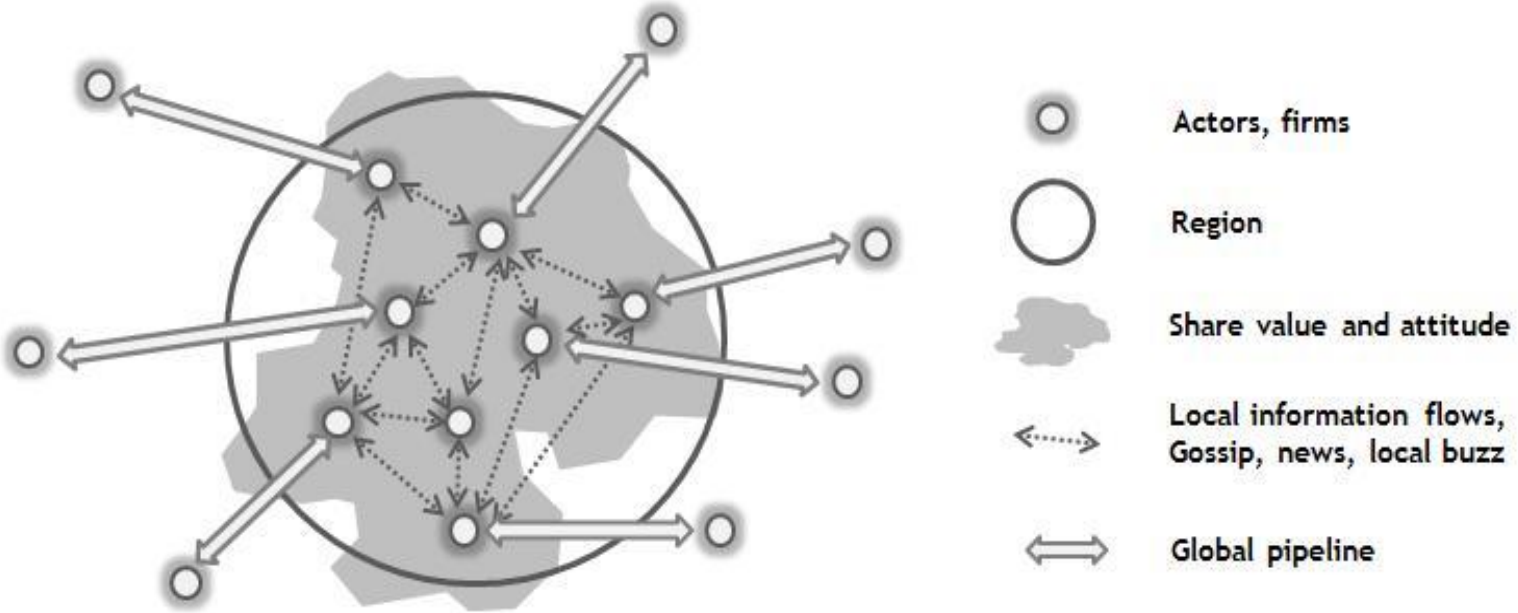


External connectivity

- Genesis of Bengaluru ICT cluster linked to founding of foreign subsidiaries (Patibandla and Petersen 2002; Karna et al. 2013) which brought in foreign knowledge and skills (Lorenzen and Mudambi 2012).
- Links with outside world further strengthened through Indian diaspora networks (Saxenian 2006; Sonderegger and Taübe 2010).
- Strong orientation towards global clients, often because of low domestic and regional demand for knowledge services (Manning 2013).

Where is the local buzz?

- Local network structure largely neglected.
- Efforts to serve global consumers considered to leave firms with limited resources to connect locally (Lema and Hesbjerg 2003; Vijayabaskar and Krishnaswamy 2004).



Source: Bathelt et al. (2004).

Question: what explains local network formation in the Bengaluru ICT clusters?

Knowledge-based view of clusters

- Localized knowledge spillovers are principal driver of agglomeration economies (Maskell and Malmberg 1999).
- Spillovers are not in the air, but emerge from purposeful and selective network linkages with other co-located actors (Owen-Smith and Powell, 2004; Singh, 2005).
- Knowledge networks in clusters are fragmented and hierarchically structured, with one or few cliques of firms in the core that are tightly connected to each other and a group of other firms in the periphery that are only loosely linked to the core (Boschma and Ter Wal 2007; Morrison 2008; Morrison and Rabellotti 2009).

Micro-foundations of inter-firm networks

- Little is known about the firm-level factors that drive the formation of network ties and how they contribute to the overall structural properties of local networks.
- Which type of cluster firms are more likely to form tightly-knit network communities with each other?
- Which type of firms will remain relatively peripheral in the network?

Technological proximity

- Technological proximity defines the technological overlap between firms.
- If technological distance is small, firms have both the incentives and absorptive capacity to collaborate (Cohen and Levinthal 1990; Nooteboom 2000), increasing the probability of link formation (Lane and Lubatkin 1998).
- Technological proximity is an important determinant in R&D alliances (Nooteboom et al. 2007).

- ***Hypothesis 1:*** *Technological proximity is a predictor of the community structure in local inter-firm networks.*

Horizontal versus vertical linkages

- Horizontal "partnership" linkages are created to jointly generate new knowledge and technological innovations (Li 2014, 2017).
- Vertical "buyer-supplier" linkages are created to improve efficiency by purchasing products and services from firms that have different fields of expertise.

- ***Hypothesis 2:*** *Technological proximity is a more important predictor of the community structure in inter-firm partnership networks than in inter-firm buyer-supplier networks.*

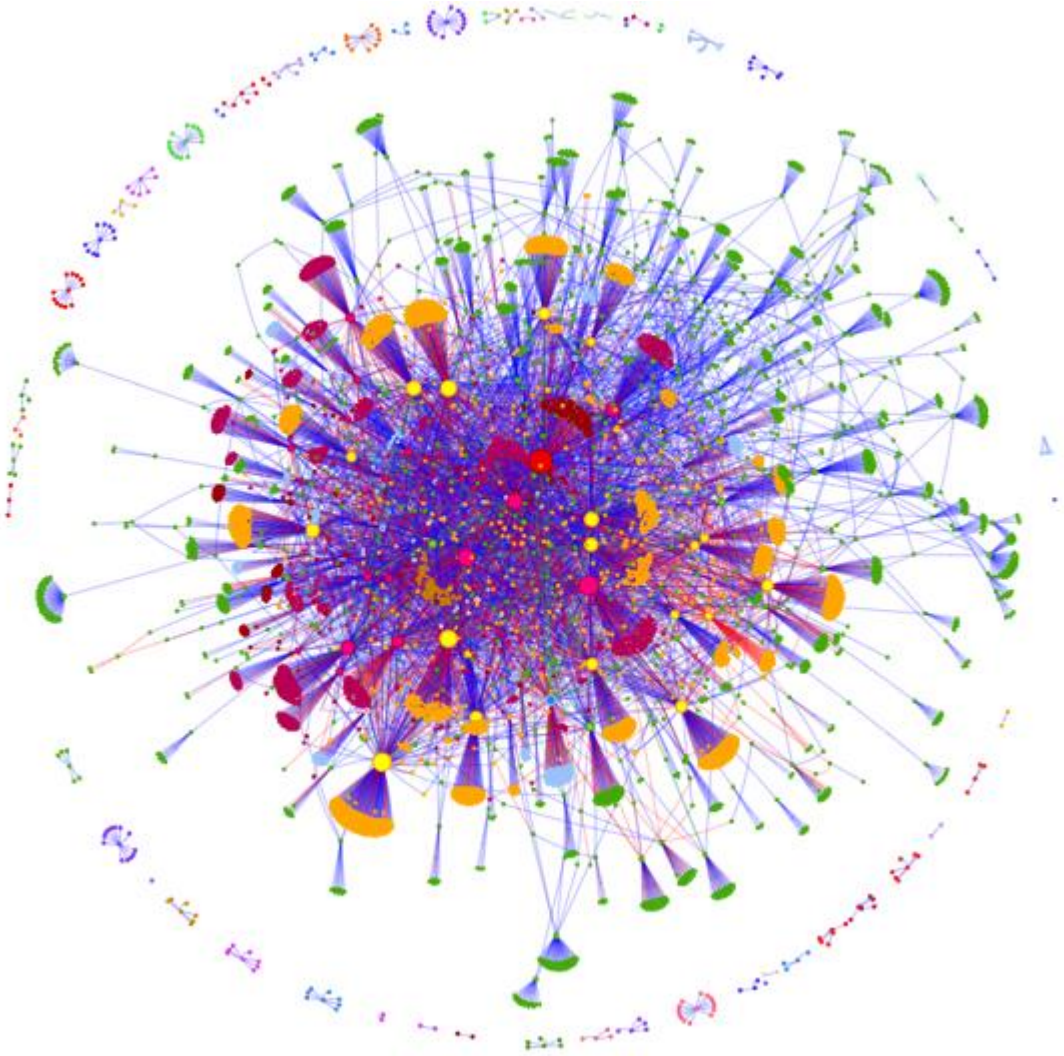
Boundary spanners

- Boundary spanners build "critical" links between disconnected sub-networks (Burt, 2004; Granovetter, 1973).
- If technological proximity explains network community formation, boundary spanners create critical links between groups of firms with different technological bases (McEvily and Zaheer 1999; Cassi and Plunket 2015; Broekel and Mueller 2017).
- Only sufficiently innovative products can cover the extra costs related to large technological distance (Boschma 2005; Nooteboom 2007).
- ***Hypothesis 3:*** *Boundary spanning firms which create partnership linkages with firms outside of their topological community specialize in rare patents.*

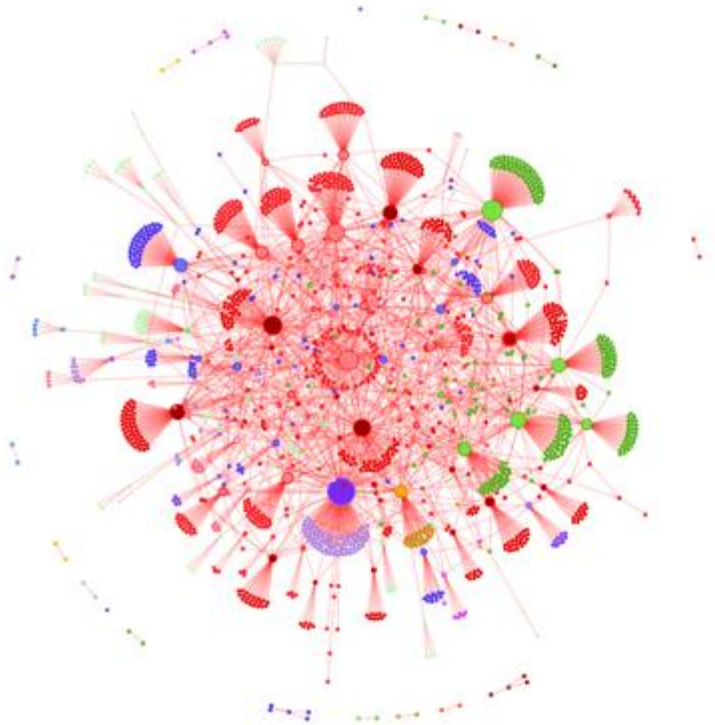
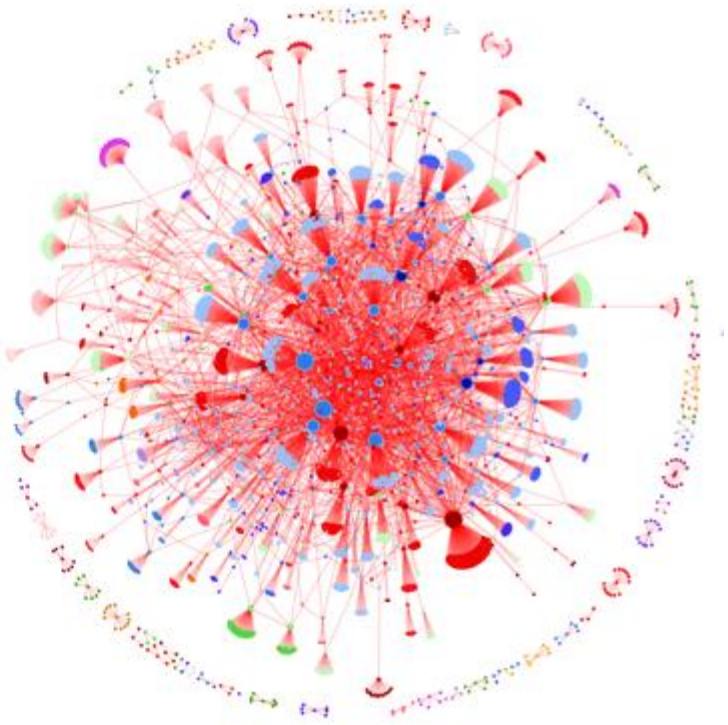
Network data

- Firm identification: Orbis, Fundoodata, NASSCOM, the list of IESA members (Indian Electronics and Semiconductor Association), Companiesinbangalore, Crunchbase, Yourstory (for start-ups and small companies) and Jobseekersindia.
  - In total, we identified 1823 relevant firms.
- Linkage identification: Thompson Eikon, Bloomberg databases, Spiderbook, NASSCOM, IESA, Yourstory.
  - Linkages measured 0/1
  - Distinction between vertical buyer-supplier and horizontal partnership linkages.
  - Only local linkages.

Full network



HEC MONTREAL

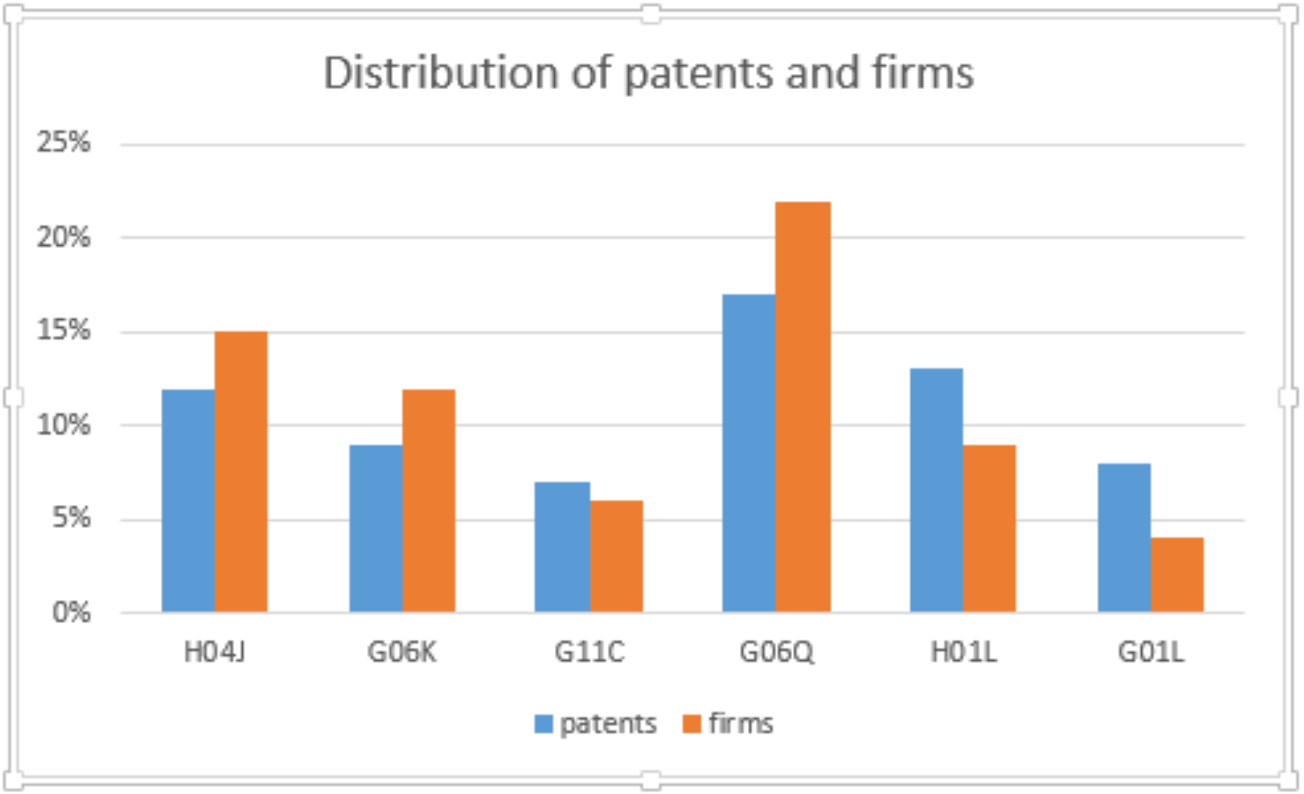
Byer-supplier subnetwork	Partnership subnetwork
	

Transitivity	Transitivity
3.19%	28.5%

Technological space data

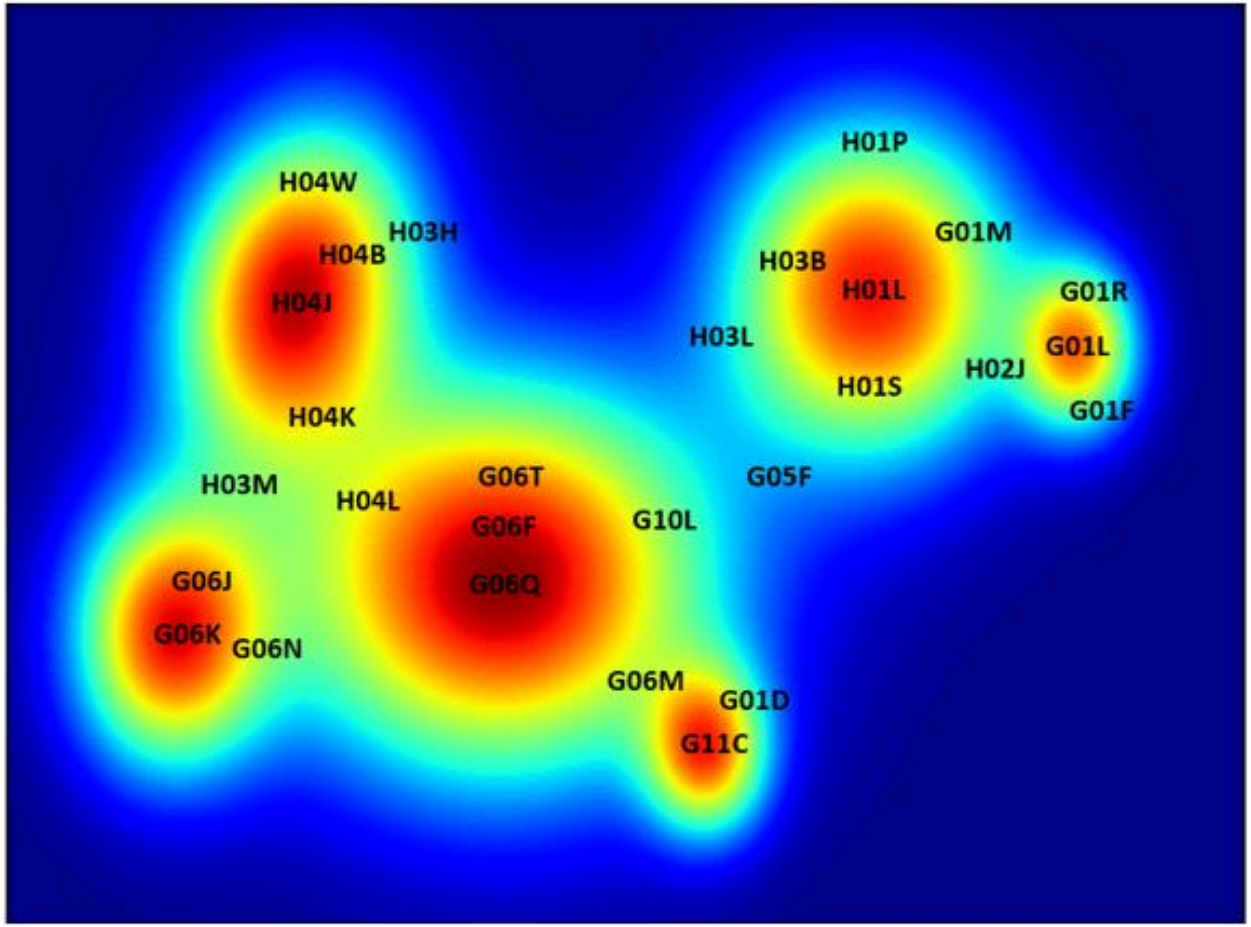
- India's Patent Advanced Research System
- Matched location of first inventor (Bengaluru) and the company name with patent data
- Focus on ICT patents using the International Patent Classification (IPC; WIPO)
- ICT technology sub-fields are identified using the IPC classification and OECD definition of codes for the ICT industry
- Code-firm matrix: co-occurrence probabilities for codes by aggregating over firms.

number of technological fields (major categories, percentage values, 2011-2016)



Software-communications	Electronics
Digital and mobile communications: H04B, H04J, H04W, H04K	Information communication devices: H01L, H03B, H01S
Large-capacity information processing: G06F, G06Q, G06T, H04L	Electronic measurement: G01L, G01R
Computing systems: G06J, G06K, G06N	
Digital storage: G11C, G01D, G06M	

Figure 4: Patent Heat Map in Bengaluru's ICT cluster



Digital and mobile communications: H04B, H04J, H04W, H04K	*Information communication devices:* H01L, H03B, H01S
Large-capacity information processing: G06F, G06Q, G06T, H04L	*Digital storage:* G11C, G01D, G06M
Computing systems: G06J, G06K, G06N	*Electronic measurement:* G01L, G01R

Partitionings

Partitioning order	Partnership	Buyer-supplier	Overall
First order (2 technology groupings, network core)	0.125	0.219	0.072
Second order (6 technology groupings)	0.058	0.742	0.153
Third order (4-digit IPC code, cluster cores and technological epicenters)	0.006	0.611	0.284
Fourth order (complete IPC code)	0.409	0.811	0.637

Hypothesis 1: *Technological proximity is a predictor of the community structure in local inter-firm networks.*

Hypothesis 2: *Technological proximity is a more important predictor of the community structure in inter-firm partnership networks than in inter-firm buyer-supplier networks.*

Rare Patents

Hypothesis 3: *Boundary spanning firms which create partnership linkages with firms outside of their topological community specialize in rare patents.*

- The probability that firms producing rare patents will belong to the same cluster is -0.85 (p value 0.001).

- The probability that these firms would have a linkage with a firm that also produced a rare patent is 0.67 (p value 0.008).

Conclusion

- Among the first papers that empirically investigates how community organisation in an industrial cluster can be explained by technological relatedness.

- Proximity of technology classes is a strong predictor of topological clustering in the "horizontal" partnership sub-network.

- Boundary-spanning firms which create critical links that cross structural holes between network communities are disproportionately responsible for develop rare patents in Bengaluru's ICT cluster.