

# DO BOARD INTERLOCKS INCREASE INNOVATION? EVIDENCE FROM NATURAL EXPERIMENTS IN INDIA

Christian HELMERS §    Manasa PATNAM ‡    Raghavendra RAU ‡

§ Santa Clara University

‡ CREST (ENSAE)

‡ JBS, University of Cambridge

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- ▶ But what is the mechanism through which information flows between companies?
- ▶ Specifically, what role do corporate networks play in information sharing?
- ▶ **Even more specifically: What is the impact of corporate network size on innovation and patenting?**

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    - ▷ ITT effect: Required board restructuring that affects network size
  - ▷ TRIPS patent reform that affects patentability for a subset of peer firms
    - ▷ Mechanisms of network size effect: Why does network size influence innovation and patenting?
- ▷ We find:
  - ▷ Positive effect of network size on short-term R&D and patenting
  - ▷ Positive peer effects from networked firm on R&D

## WHY SHOULD WE CARE?

- ▶ Literature on inter-**firm** networks and innovation/patenting
  - ▶ Strategic alliances (Schilling & Phelps, 2007)
  - ▶ (In)formal research collaboration (Hagedoorn et al., 2000)
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- ▶ Another direct measure: interlocking boards of directors
  
- ▶ Role of directors:
  - ▶ Provision of information & advice to CEO and top management
  - ▶ Influence corporate strategy
  - ▶ Decide on Intellectual Property policy & strategy

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- ▶ Literature on board interlocks:
  - ▶ Motivation for board interlocks (Mizruchi, 1996)
  - ▶ Profitability (Baysinger and Butler, 1985; Burt, 1983)
  - ▶ CEO pay (Guedj and Barnea, 2009)
  - ▶ Mutual fund/Private equity investment (Cohen et al., 2008; Stuart and Yim, 2010)
  - ▶ Venture capital firm performance (Hochberg et al., 2007)



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- ▶ Channel for information transmission between companies

## IDENTIFICATION OF NETWORK SIZE EFFECT: SUMMARY

- ▶ **Objective:** analyze impact of firm (board) network size on patenting and R&D expenditure
- ▶ **Challenge:** Endogeneity of network formation
  - ▷ Endogeneity of network size

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- ▶ **Objective:** analyze impact of firm (board) network size on patenting and R&D expenditure
- ▶ **Challenge:** Endogeneity of network formation
  - ▷ Endogeneity of network size
- ▶ **Solution:** Corporate governance reform: subset of listed firms forced to re-structure boards
  - ▷ Exploit change in network size induced by restructuring

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- ▶ Required changes in the composition of the board of directors:
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- ▶ Reform **not** applicable to all listed companies

## IDENTIFICATION OF NETWORK SIZE EFFECT: REFORM

- ▶ 'Eligible' firms (based on net-worth or paid-up share capital):
  - ▶ Group 'A' (comply by March 2001): paid up share capital of  $\geq$  Rs. 25 crores
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- ▶ In our analysis: phased 'compliance period' (by A, B and C)

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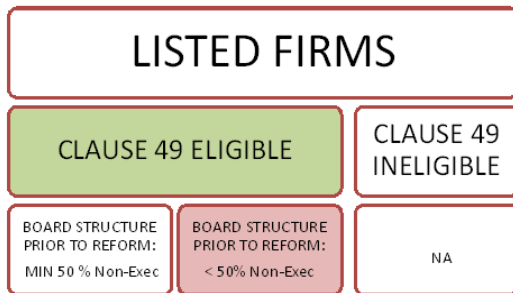
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- ▶ Control for direct effect of reform shock and eligibility on outcome:
  - ▷ Account for potential direct effect of reform (Dharmapala & Khanna)
  - ▷ Account for size-based eligibility



## EMPIRICAL SPECIFICATION

- ▶ Naive specification:

$$y_{it} = \alpha + \beta N_{it} + \gamma x_{it} + \mu_i + \gamma_t + u_{it} \quad (1)$$

- ▶  $y_{it}$  firm specific outcome measure: patents/R&D
- ▶  $N$  corporate network size
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  - ▶ Above spec. subject to endogeneity
- ▶ IV approach exploiting reform:

$$N_{it} = \alpha(B_i \times E_i \times R_t) + \gamma^f x_{it} + \mu_i^f + \varsigma^f t + \eta_{it} \quad (2)$$

$$y_{it} = \beta \hat{N}_{it} + \gamma x_{it} + \mu_i + \varsigma t + u_{it} \quad (3)$$

- ▶ ITT: Triple interaction term ( $B_i \times E_i \times R_t$ ) identifying instrument

## EMPIRICAL SPECIFICATION

- ▶ Alternative Strategy: Exploit requirement thresholds, RDD approach; two thresholds:
  - ▶ Board structure threshold:  $PROP_{it}$  as the observed proportion of non-executives
    - ▶  $B_{it}$ : whether firm was below the required board composition criteria
  - ▶ Listing Categories threshold:  $MP_i$  amount of paidup share capital for a given firm
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- ▶ Can rewrite first-stage as RDD spec.:

$$\begin{aligned}
 N_{it} = & \underbrace{\alpha_1^{ITT}(B_{it} \times MP_i^A) + \alpha_2^{ITT}(B_{it} \times MP_i^B) + \alpha_3^{ITT}(B_{it}) + \alpha_4^{ITT}(MP_i^A) + \alpha_5^{ITT}(MP_i^B)}_{\text{Instruments}} \\
 & + \underbrace{f_B(PROP_{it}, \gamma_1) + f_{MP}(MP_{it}, \gamma_2) + f_{B,MP}(PROP_{it} \times MP_i, \gamma_3)}_{\text{Conditioning Polynomials}} + \varsigma t + \eta_{it}
 \end{aligned}$$

## COMPANY INFORMATION

- ▶ Accounting Data from Prowess:
  - ▶ Panel of all listed Indian private sector firms (BSE & NSE) 1997-2008
  - ▶ CMIE classification of firms into group and non-group firms
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- ▶ Corporate Networks:
  - ▶ Prowess: Detailed information on all directors on board (dynamic)

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- ▶ 2 significant changes in opposite directions since 1947
- ▶ 1970 Patents Act: no patentability of pharmaceutical *products* (although *process* patentable)
- ▶ 1995 WTO accession and TRIPS: 3 major amendments to the 1970 Patents Act
- ▶ Allowed pharmaceutical product patents — but 10-year transition period
- ▶ Between 1995-2005 pharmaceutical product patent applications through 'pipeline' system

## PATENT DATA

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- ▶ Indian filings:
  - ▶ 1995-2004 *EKASWA* (Gazette) by Patent Facilitating Centre (PFC)
  - ▶ 2005-2008 *iPairs* (Journal) online search facility by CGPDT
  - ▶ Complement with *BigPatents India*

## VARIABLES

- ▶ Variables - Outcome:
  - ▶ **International patent filings:** USPTO & EPO
  - ▶ **Domestic patent filings:** CGPDT
  - ▶ **R&D Expenditure:** Total outlay of the company on research and development during the year on both its current and capital account.

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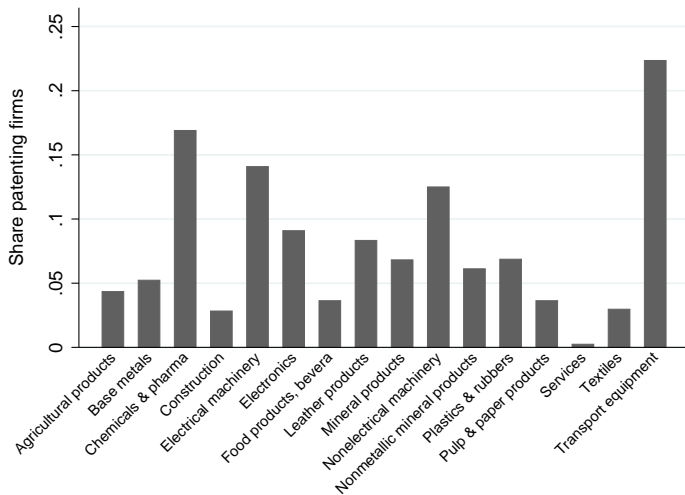
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- ▶ Firm level controls: Assets, Exports/Sales
- ▶ Business group: Patenting propensity
- ▶ Industry: Patenting propensity



## PATENT DISTRIBUTION BY INDUSTRY 1997-2008



## FIRST STAGE EXPLANATION

### Network Size Changes

	Total Network Size		Network gain from	
	Pre Reform (1)	Post reform (2)	hires - fires	remaining
			(Post-Pre) difference (3)	
Above Threshold	7.138	12.268	0.091	4.082
Below Threshold	5.649	10.094	0.117	3.368
Difference	<b>1.489**</b>	<b>2.174**</b>	-0.026	0.714**

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## RESULTS: FIRST STAGE VALIDITY

### Balancing Test

	Average firm-level characteristics for firms appointing directors post-reform			
	Below required	Above required	Difference	
	<u>proportion</u>	<u>proportion</u>	<u>t-statistic</u>	<u>Wilcoxon z-statistic</u>
R&D (log)	0.222	0.251	1.196	1.474
Current R&D	0.180	0.198	0.838	1.600
Capital R&D	0.074	0.088	1.128	1.228
Total Patent Count	0.226	0.230	0.048	-0.275
Domestic Patent Count	0.189	0.196	-0.114	-0.634
International Patent Count	0.029	0.040	0.418	-0.563
Patent Propensity (total)	0.150	0.222	0.775	-0.266
Patent Propensity (domestic)	0.142	0.209	0.727	-0.780
Patent Propensity (int.)	0.007	0.012	0.707	0.785
Assets (log)	4.486	4.453	-0.384	0.182
Exports by sales (log)	0.104	0.094	-0.905	0.562

## RESULTS: R&D EXPENDITURE

	(1) R&D (OLS)	(2) Network Size (IV I)	(3) R&D (IV II)	(4) Current R & D (IV II)	(5) Capital R&D (IV II)
Network Size		0.002** (0.001)			
Reform $\times$ Below Threshold					
Time Fixed Effects		Yes			
Firm Fixed Effects		Yes			
<i>N</i>		11,358			
First-Stage F					

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Network Size	0.002** (0.001)				
Reform $\times$ Below Threshold		-2.680*** (0.555)			
Time Fixed Effects	Yes	Yes			
Firm Fixed Effects	Yes	Yes			
<i>N</i>	11,358	11,358			
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Network Size	0.002** (0.001)		0.009 (0.006)		
Reform $\times$ Below Threshold		-2.680*** (0.555)			
Time Fixed Effects	Yes	Yes	Yes		
Firm Fixed Effects	Yes	Yes	Yes		
<i>N</i>	11,358	11,358	11,358		
First-Stage F			23.27		

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Reform $\times$ Below Threshold		-2.680*** (0.555)			
Time Fixed Effects	Yes	Yes	Yes	Yes	
Firm Fixed Effects	Yes	Yes	Yes	Yes	
<i>N</i>	11,358	11,358	11,358	11,358	
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Reform $\times$ Below Threshold		-2.680*** (0.555)			
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes
<i>N</i>	11,358	11,358	11,358	11,358	11,358
First-Stage F			23.27	23.27	23.27

## RESULTS: PATENTS

(OLS)	(1) Patent Count (IV I)	(2) Network Size (IV II)	(3) Patent Count (IV II)	(4) India Patent (IV II)	(5) Int. Patent
Network Size	0.013* (0.007)		0.093* (0.055)	0.058 (0.039)	0.035** (0.017)
Reform $\times$ Below Threshold		-2.680*** (0.555)			
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes
<i>N</i>	11,358	11,358	11,358	11,358	11,358
First-Stage F			23.27	23.27	23.27

## RESULTS: RDD RESULTS

	(1) R&D	(2) Current R&D	(3) Patent Count	(4) India Patent	(5) Int. Pat
Network Size	0.030*** (0.005)	0.027*** (0.004)	0.083** (0.042)	0.053* (0.029)	0.030** (0.015)
Polynomials Net Worth (Eligibility)	Yes	Yes	Yes	Yes	Yes
Polynomials Prop. NE (Requirement)	Yes	Yes	Yes	Yes	Yes
Polynomials Eligibility $\times$ Requirement	Yes	Yes	Yes	Yes	Yes
<i>N</i>	13,773	13,773	13,773	13,773	13,773
First-Stage F	24.577	24.577	24.577	24.577	24.577

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TRIPS  $\times$  Clause 49A reform  $\times$  Proportion of Pharma firms in peer group

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- ▶ Results show that
  - ▶ A 1% increase in network average R&D increases own firm's R&D by 1.051%



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  - ▶ Analysis of long-run data needed to explore this issue further (beyond the scope of this paper)

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- ▶ Firms are more likely to extend patent protection by patenting inventions abroad that they have already patented in India.