Ownership Networks and Firm Growth:

What Do Forty Million Companies Tell Us About the Chinese Economy?

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Motivation

- Better understanding of the **finance-growth nexus in China**
  - China's growth model: Allen, Qian, Qian (2005); Song, Storesletten and Zilibotti (2011)
  - A state-dominated banking sector contributes to the growth of the state-owned sectors: Hsieh and Klenow (2009); Song and Xiong (2018)
  - How did *unlisted firms* emerge and grow in a credit constrained environment without sufficient access to formal financing?

- Role of **financing networks**:
  - Prior literature looks at the finance-growth linkage from *individual* firm-level
  - We use the China's **SAIC** (**State Administration for Industry and Commerce**) big data to map out the *equity* networks of the whole economy using bilateral equity investments
  - Debt vs. equity financing: how to overcome information problems

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Research Questions

- The **allocation** of equity capital:

  - Construction and the structure of equity networks

  - How do firms' bilateral equity investments evolve over time:

    - Industry distribution: does capital mainly flow to risky industries (e.g. real estate)?

- How does a firm's (dynamic) **position in the networks contribute to its growth**?

  - In-network vs. out-of-network firms

  - Network positions (centrality) and firm growth

  - Equity capital *complement/substitute* bank loans in promoting growth?

    - Capital structure (leverage); does equity capital favor SOEs over non-SOEs?

    - Impact of a large credit supply shock (RMB 4 trillion stimulus) to the equity networks

Related Literature on Networks

- Social/economic networks and economic outcomes:
  - Decision making (Laumann et al., 1977; Larcker, So and Wang, 2013, Gao, 2015)
  - Information diffusion (Ahern, 2017)
  - **Production and supply chains:** Ahern and Harford (2014); Herskovic et al. (2019); Liu (2019)

- Papers also using (partial) data from SAIC:
  - Long and Zhang (2011): Industry clusters
  - Bai, Hsieh, Song, and Wang (2020) examine the SOEs and their private owners
  - Allen et al. (2021b) analyze the evolution of state ownership networks
  - Shi, Townsend, and Zhu (2019) show that equity-holding linkages play a role in propagating bank credit supply shocks

"Registered Capital" in China

- Before 2014, firm registration was based on a **paid-in** system
  - "Firm registration Rule" in China (1994, 2006, 2014 versions); "Company Law" (2005, 2014 versions)
    - ✓ For LLCs, all the shareholders are required to be recorded at the SAIC as well as the share changes.
    - ✓ For incorporated companies, all the original shareholders are required to be recorded at the SAIC while there is no mandatory requirement that the change later has to be recorded. Shareholders have incentives to register at the SAIC to get the government endorsement.
    - ✓ Ownership indicated by registered capital means both the cash flow rights and voting rights.
    - ✓ All registered capital has to be fully paid within the first two years after the firm is registered at the SAIC

- The "Company Law" (2014) changed the old paid-in system to a **subscription** system
  - The registered capital can be different from the actual paid-in capital.

SAIC Data: 1950 - 2020
China's State Administration for Industry and Commerce (工商行政管理总局)

- **Firm registration**
  - All the registered firms in China (over 40mm, excluding individually owned firms)
    - All firms are REQUIRED to register!
  - Key Variables
    - Firm registration date
    - Registration capital
    - Industry
    - Ownership type (e.g. SOE or other)
    - Status (existing or bankrupt)
    - Location, etc.

- **Shareholder**
  - Share / investment amount

- **Dynamic updates on shareholders and shares**

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Construction of EquiNet

- Start from the 2020 equity holding network

- Trace **holding change record** year by year
  - If no change record, remain unchanged
  - If there exists change record, roll back

- By tracing holding change record for each firm, we construct the dynamic equity holding network

Construction of Network Dynamics: summary

- Start in 2017, and map out all ownership links

- Go back to the previous year and track changes:
  - All ownership changes, and changes in firms

- Until the year of firm establishment or 1950

- This process gives the dynamic networks
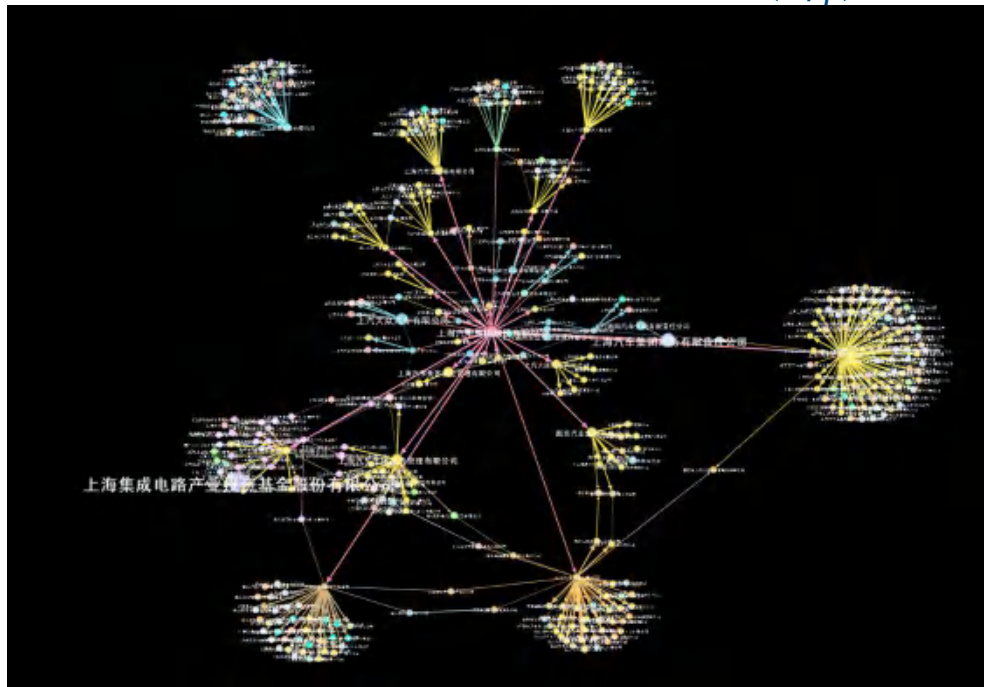
Construction of Equity Network (EquiNet)

- ## EquiNet 2017

  - ### *Investor-Investee* equity holding relationship

  - ### Firm i and j

    $$a_{ij} = \text{investment share from firm } i \rightarrow j$$

  - ### EquiNet $\iff$ Adjacency matrix A

    $$A = (a_{ij})$$

Snapshot of EquiNet
centered at Shanghai Automobile

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EquiNet 2017

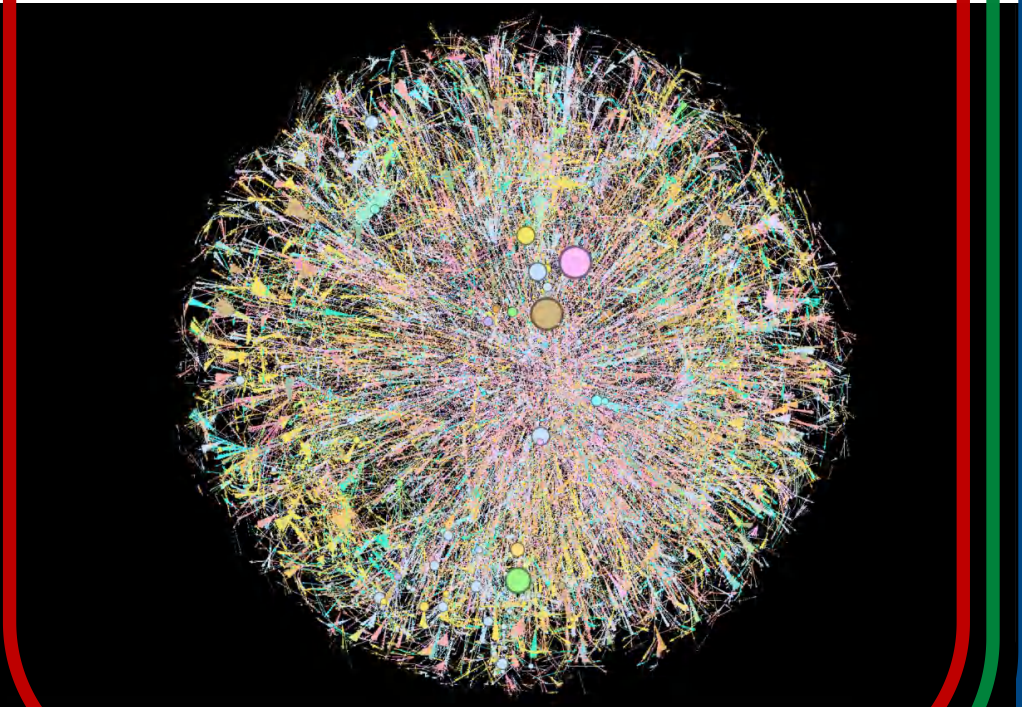**40m**
All
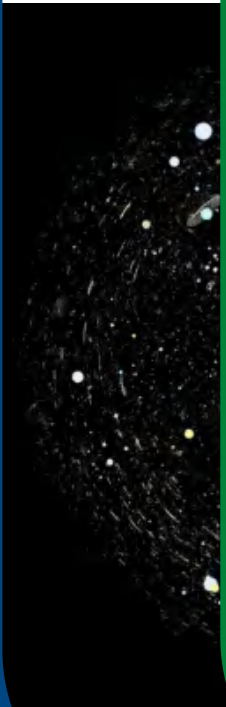
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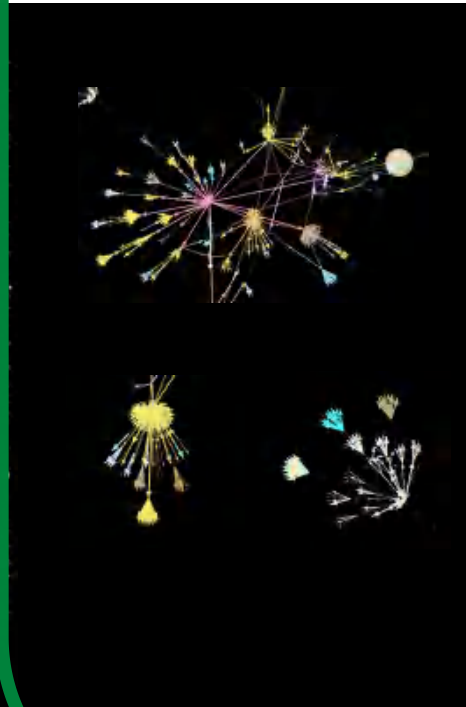
2.3m
Largest sub-network

Network Centrality: Local and Global Measures

- **Degree** centrality: *local* measure
  - In-degree (*attracting* investment), **out-degree (investor)**, degree;
  - Unweighted: the number of investors/investees for firm i;

- **Betweenness** centrality: 'broker' of more links
  - How well situated a node is in terms of the **shortest paths** that it lies on in all the networks (Bonacich, 1972); global measure
  - Weighted by investment share percentage (or investment amount)

- **Eigenvector** centrality: status of connected firms matters
  - Importance of firm i depends on the **importance of firms held by itself**; defined *recursively* (Bonacich, 1987, Bonacich and Lloyd, 2001; Bonacich, 2007)
  - Weighted by investment share percentage (or amount); global measure

NBS Data: 1998 – 2013
China's National Bureau of Statistics (国家统计局)

- **Annual Industry Survey** (工业企业年度调查)
  - Industrial firms (and some services sectors) above certain threshold

- NBS + SAIC
  - Merge rate **> 90%**

- Firms' financial, production and operation information

- Key variables
  - Basic information
    - Firm age, ownership type (SOE or non-SOE)
  - Financial information
    - Total assets, total debt, total return, paid-in capital

- *Growth*$_t$ = $\log(total\ asset_t) - \log(total\ asset_{t-1})$

Results, part 1

- Using the complete equity ownership networks for all the registered firms in China, we provide the first piece of evidence showing how capital is allocated in the network, and how it contributes to growth under state capitalism.

- What does the network look like? - The equity ownership network has been **expanding dramatically since 2000s**

  - The number of in-network firms tripled
  - Large firms are more likely to connect to other firms, as investors/investees; new entrants have fewer connections
  - Cross share holding is rare in China (below 0.5%)

Capital flows by industry

	Invested amount/Firm num, in RMB (across industry)	Total investment amount/Firm num, in RMB (across & within industry)	Firm num
Financial industry	7,369	10,825	136,020
Construction/Real estate	**4,342**	**6,557**	**482,433**
Mining	**4,280**	**5,147**	**31,256**
Utilities	3,659	7,075	67,576
Water, Environmental Services and Infrastructure Services	3,316	3,628	34,440
Transportation, Warehousing and Postal Services	2,628	8,966	121,430
Rental and Business Services	2,235	4,236	878,427
Education	1,612	1,660	12,914
Health Care and Social Assistance	1,469	1,639	16,357
Professional, Scientific and Technical Services	1,153	1,461	396,993
Public Services, Social Welfare and Social Organization	1,013	1,307	3,711
Information, Software and Technology Services	914	1,654	194,360
Household Services, Repairing & Other Services	883	936	105,194
Arts, Entertainment and Recreation	776	968	88,378
Manufacturing	684	1,271	845,650
Wholesale and Retail Trade	560	768	1,120,982
Agriculture, Forestry, Fishing and Hunting	531	649	845,650
Accommodation and Food Services	429	468	95,004
International Organizations	384	393	4,303

Allen, Cai, Gu, Qian, Zhao and Zhu (2022)

Dynamic EquiNet

- One EquiNet for each year of the sample period

- EquiNet 2017
  - 5.6m in-network; 35m out-of-network

Total number of registered firms
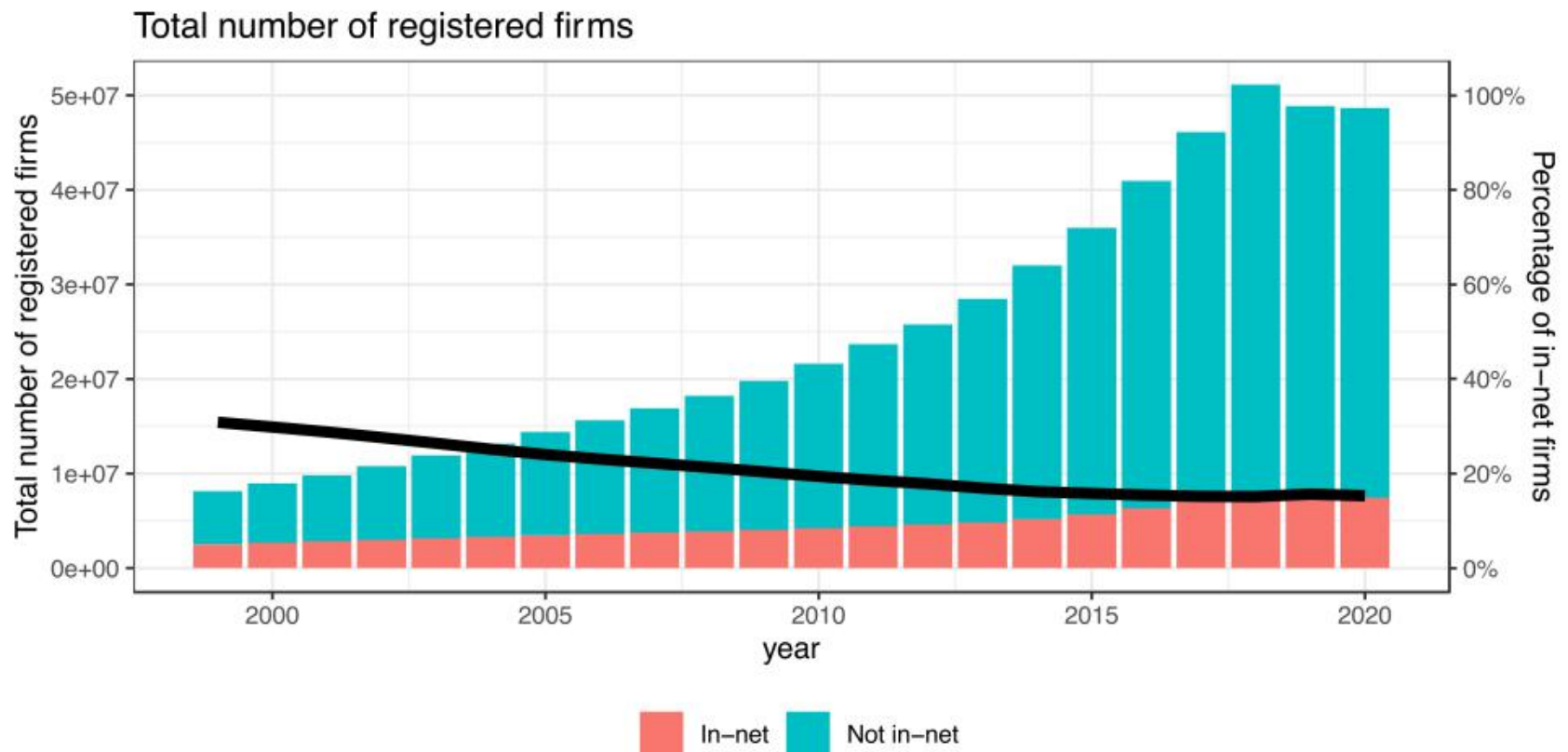
Results, part 2

- Network and growth - A firm's position affects firm's future growth.

  - A large proportion (roughly 43%) of financing comes from equity capital.

  - **Entering ownership networks** is associated with significantly higher real growth

  - In-network firms with **higher network centrality** tend to have improved real growth

    - Of network measures, eigenvector centrality has the largest economic impact, closely followed by degree centrality

    - One-std-dev increase in eigenvector centrality can improve growth by 23.7 percent

Network and firm growth: baseline results

- Among the five measures of centrality, *eigenvector* has the largest economic effect, closely followed by *out-degree* and *degree* centrality.
- *Ceteris paribus*, one-std-dev increase in *Log eigen* can improve firm growth by 23.7 percent, all else being equal.

Dep. Var	Firm growth				
	(1)	(2)	(3)	(4)	(5)
In net	0.0505***	0.0120***	0.0145***	0.0431***	0.00463**
	(0.00205)	(0.00227)	(0.00278)	(0.00189)	(0.00230)
Log indeg	-0.00821***				
	(0.00108)				
Log outdeg		0.0239***			
		(0.000974)			
Log deg			0.0188***		
			(0.00137)		
Log btw				0.00489***	
				(0.000646)	
Log eigen					0.0308***
					(0.00113)
Other controls	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
# of obs.	2,336,536	2,336,536	2,336,536	2,336,536	2,336,536
R-squared	0.443	0.443	0.443	0.443	0.443

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Network dynamic effects

- Longer being in the network, the stronger the network effect
- Local effect diminishes; while global effect increases over time
  - Eigenvector centrality has stronger effect, compared to betweenness

Dep. Var	*Firm growth*			
	(1)	(2)	(3)	(4)
	Investees		Investors	
Investee	-0.0501***	-0.0359***		
	(0.00741)	(0.00764)		
Investors			-0.118***	-0.0912***
			(0.00548)	(0.00590)
Year – Entry year	0.00866***	0.00770***	0.0131***	0.0135***
	(0.000780)	(0.000765)	(0.000618)	(0.000621)
Log indeg	0.0323***	0.0202***	0.0114***	0.0187***
	(0.00357)	(0.00387)	(0.00187)	(0.00274)
(Year – Entry year)* Log indeg	-0.00576***	-0.00577***	-0.00430***	-0.00770***
	(0.000441)	(0.000442)	(0.000371)	(0.000513)
Log outdeg	0.0230***	0.0200***	0.0612***	0.0491***
	(0.00151)	(0.00227)	(0.00261)	(0.00367)
(Year – Entry year)* Log outdeg	-0.00270***	-0.00450***	-0.00963***	-0.0137***
	(0.000288)	(0.000441)	(0.000404)	(0.000558)
Log btw	-0.00452***		0.000444	
	(0.00160)		(0.00144)	
(Year – Entry year)* Log btw	0.00229***		0.00101***	
	(0.000354)		(0.000326)	
Log eigen		0.00638***		-0.00724*
		(0.00243)		(0.00393)
(Year – Entry year)* Log eigen		0.00342***		0.00817***
		(0.000474)		(0.000760)
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
# of Obs	437,157	437,157	553,698	553,698
R-squared	0.402	0.403	0.19	0.19

Results, part 3

- Heterogeneity
  - The effect of network on growth is more pronounced for **high-productivity** firms (especially for firms that are **more** financially ***constrained***) and *less pronounced for firms with state connections*
  - Global vs. Local effect
    - Controlling for local centrality, the effect of global centrality is still positive and significant
  - Time effect: the *longer time in the network, the stronger the effect on growth*

Heterogeneity: SOE vs. non-SOEs

- State connections tend to *mitigate* the effect of network centrality on growth.
- One std-dev increase in Log deg would improve firm growth by 14.7 percent for non-SOEs, while such effect is 8.7 percent less for SOEs.

Dep. Var	Firm Growth				
	(1) indeg	(2) outdeg	(3) degree	(4) btw	(5) eigen
In net	0.0505***	0.0117***	0.0139***	0.0432***	0.00441*
	(0.00205)	(0.00227)	(0.00278)	(0.00189)	(0.00230)
Log (centrality)	-0.00757***	0.0249***	0.0202***	0.00578***	0.0313***
	(0.00110)	(0.000998)	(0.00140)	(0.000672)	(0.00116)
SOE*Log (centrality)	-0.00674***	-0.00847***	-0.0119***	-0.00703***	-0.00333*
	(0.00243)	(0.00181)	(0.00214)	(0.00149)	(0.00192)
Other controls	Yes	Yes	Yes	Yes	Yes
Firm/Year FE	Yes	Yes	Yes	Yes	Yes
# of obs.	2,336,536	2,336,536	2,336,536	2,336,536	2,336,536
R-squared	0.429	0.430	0.429	0.429	0.430

Heterogenous effects: high vs low productivity firms

- HTFP=1 if the TFP value is above median, and 0 otherwise.
- The effect of network centrality tends to be more pronounced for HTFP firms.

Dep. Var	Firm Growth				
	(1) indeg	(2) outdeg	(3) degree	(4) btw	(5) eigen
In net	0.0510***	0.0128***	0.0160***	0.0432***	0.00586**
	(0.00206)	(0.00228)	(0.00278)	(0.00190)	(0.00231)
HTFP	0.0355***	0.0355***	0.0352***	0.0358***	0.0354***
	(0.000818)	(0.000818)	(0.000820)	(0.000817)	(0.000818)
Log (centrality)	-0.0134***	0.0180***	0.0108***	-0.000324	0.0252***
	(0.00116)	(0.00106)	(0.00144)	(0.000800)	(0.00124)
HTFP * Log (centrality)	0.00830***	0.00922***	0.0124***	0.00773***	0.00804***
	(0.000723)	(0.000710)	(0.000732)	(0.000746)	(0.000744)
Other controls	Yes	Yes	Yes	Yes	Yes
Firm/Year FE	Yes	Yes	Yes	Yes	Yes
# of obs.	2,281,558	2,281,558	2,281,558	2,281,558	2,281,558
R-squared	0.429	0.430	0.430	0.429	0.430

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Results, part 4a: *Channels*
Financing channel: the impact of financial constraints

- Financing channel

  - firms with financial constraints benefit more from equity networks

Dep. Var	Firm growth			
	(1) indeg	(2) outdeg	(3) btw	(4) eigen
HTFP * Fin constraint	0.0395***	0.0298***	0.0365***	0.0343***
	(0.00218)	(0.00211)	(0.00204)	(0.00208)
HTFP* Fin constraint* In net	-0.0394***	-0.0112***	-0.0341***	-0.0273***
	(0.00333)	(0.00407)	(0.00303)	(0.00346)
Log (centrality)	-0.00507**	-0.0230***	-0.00620***	-0.0174***
	(0.00209)	(0.00145)	(0.00140)	(0.00171)
HTFP * Log (centrality)	-0.0151**	-0.00364***	-0.00454***	-0.00878***
	(0.00188)	(0.00133)	(0.00141)	(0.00149)
Fin constraint * Log (centrality)	-0.00401	-0.00122	-0.000268	-0.000837
	(0.00266)	(0.00180)	(0.00175)	(0.00207)
HTFP* Fin constraint * Log (centrality)	0.0213***	-0.000937	0.00393**	0.00794***
	(0.00266)	(0.00207)	(0.00177)	(0.00204)
Other controls	Yes	Yes	Yes	Yes
Firm/Year FE	Yes	Yes	Yes	Yes
# of Obs.	1,106,001	1,106,001	1,106,001	1,106,001
R-squared	0.197	0.198	0.197	0.197

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Resource sharing channel: number of branches

- Resource sharing channel
  - Firms *launch more branches in the same locations with its connected neighbors in the networks having higher centrality*
  - Firms might share markets or customers via branch offices through equity connections

Dep. Var	Number of branches	
	(1)	(2)
Eigenvector centrality	1.399***	0.216***
(> median)	(0.426)	(0.0452)
Firm/Year FE	Yes	No
Firm × Year FE	No	Yes
Observations	692,622	665,052
R-squared	0.499	0.994

Results, part 4b:
The impact of other possible *industrial linkages*

- **Industry-chain (pair) dummy** indicates the linkage between the investor and the firm itself (e.g. production networks)
- Largest sub-network is a dummy indicating where the firm lies in the largest sub-network of the whole networks

Dep. Var	*Firm growth*				
	(1) indeg	(2) outdeg	(3) degree	(4) btw	(5) eigen
In net	0.0475***	0.0110***	0.0141***	0.0411***	0.0292***
	(0.00210)	(0.00234)	(0.00284)	(0.00197)	(0.00199)
Largest sub-network	0.0129***	0.00614**	0.00559**	0.00774***	0.00137
	(0.00243)	(0.00240)	(0.00243)	(0.00243)	(0.00242)
Log (centrality)	-0.00866***	0.0255***	0.0183***	0.00582***	0.0244***
	(0.00113)	(0.00107)	(0.00143)	(0.000734)	(0.000936)
Other controls	Yes	Yes	Yes	Yes	Yes
Firm/Year FE	Yes	Yes	Yes	Yes	Yes
Industry chain FE	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
# of obs.	2,336,536	2,336,536	2,336,536	2,336,536	2,336,536
R-squared	0.429	0.429	0.429	0.429	0.429

Results, part 4b (New)
The impact of geographic proximity

- **City pair FE** indicates the fixed effects if city pair between investor and investee.

Dep. Var	Firm growth				
	(1) indeg	(2) outdeg	(3) degree	(4) btw	(5) eigen
In net	0.0491***	0.00970***	0.0140***	0.0416***	0.0288***
	(0.00204)	(0.00226)	(0.00277)	(0.00189)	(0.00193)
Log (centrality)	-0.00942***	0.0260***	0.0184***	0.00546***	0.0241***
	(0.00111)	(0.00103)	(0.00138)	(0.000714)	(0.000901)
Other controls	Yes	Yes	Yes	Yes	Yes
Firm/Year FE	Yes	Yes	Yes	Yes	Yes
City pair FE	Yes	Yes	Yes	Yes	Yes
# of obs.	2,336,368	2,336,368	2,336,368	2,336,368	2,336,368
R-squared	0.431	0.431	0.431	0.431	0.431

Results, part 5

- The Stimulus Plan announced in Nov 2008

  - Provides a shock to bank credit to SOEs (Cong et al. 2019)

  - Overall, the effect of network centrality tends to be *less pronounced* after the Stimulus Plan ("Four-trillion" Plan) than before, suggesting a *crowding-out* effect on equity capital.

  - Equity vs. bank credit

    - ✓ For **bank-affiliated non-SOEs** (within 3 steps of network connections), the effect of network centrality is **more pronounced** after the Stimulus Plan, whereas this effect is mitigated for bank-affiliated SOEs.

  - The **equity ownership network substitutes** for bank loans in promoting growth for **SOEs**, whereas it **complements** bank loans in promoting growth for **non-SOEs**.

The impact of the 2008-09 Stimulus

- A **shock** to bank lending to SOEs, especially those with close relationship with banks
- *Fiscal Stimulus Plan (2009)*- a combination of fiscal and credit program, mostly in the form of newly issued bank loans (Chen, He, Liu, 2019; Cong et al., 2019; Acharya, Qian and Yang, 2019).
- Bank subs =1 if the firm is affiliated with banks within 3 layers of the ownership network

Dep. Var	*Firm Growth*				
	(1) indeg	(2) outdeg	(3) degree	(4) btw	(5) eigen
In net	0.0444***	0.0124***	0.00472*	0.0431***	-0.00630***
	(0.00206)	(0.00229)	(0.00284)	(0.00189)	(0.00237)
Bank subs	0.00348	0.0177**	0.0148	-0.00540	0.0322***
	(0.0168)	(0.00770)	(0.0132)	(0.00800)	(0.0106)
Post FS* Bank subs	-0.0975***	-0.0371***	-0.0994***	-0.0487***	-0.0834***
	(0.0163)	(0.00664)	(0.0123)	(0.00706)	(0.00950)
Log Centrality	0.00399***	0.0249***	0.0321***	0.00904***	0.0456***
	(0.00116)	(0.00105)	(0.00146)	(0.000861)	(0.00130)
Post FS * Log Centrality	-0.0356***	-0.00399***	-0.0250***	-0.00509***	-0.0254***
	(0.000799)	(0.000699)	(0.000764)	(0.000799)	(0.000802)
Bank subs* Log Centrality	0.00395	0.00687**	-0.00776	0.00168	-0.0206***
	(0.00687)	(0.00323)	(0.00548)	(0.00139)	(0.00399)
Post FS*Bank subs* Log Centrality	0.0727***	0.0208***	0.0648***	0.0137***	0.0557***
	(0.00692)	(0.00300)	(0.00544)	(0.00138)	(0.00389)
Other Controls	Yes	Yes	Yes	Yes	Yes
Firm, year FE	Yes	Yes	Yes	Yes	Yes
# of obs.	2,336,536	2,336,536	2,336,536	2,336,536	2,336,536
R-squared	0.430	0.430	0.430	0.429	0.430

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Allen, Cai, Gu, Qian, Zhao and Zhu (2022)

Subsample of bank-affiliated firms

- The positive effect of network centrality on growth is more significant for bank-affiliated nonSOEs, less so for bank-affiliated SOEs (offset by state-connections, in col 3).
- After the Stimulus Plan in 2009, it is easier for bank-affiliated SOEs to obtain loans; the network effect is less pronounced for them.
- Taken together, ownership network may *substitute* loans in promoting growth for SOEs, whereas *complement* loans in promoting growth for nonSOEs.

Dep. Var	*Firm Growth*				
	(1) indeg	(2) outdeg	(3) degree	(4) btw	(5) eigen
Post FS * SOE	-0.00235	-0.0320	0.0337	-0.0177	0.00623
	(0.0458)	(0.0238)	(0.0405)	(0.0252)	(0.0318)
Log Centrality	-0.0183*	0.0390***	0.0106	0.00955***	0.00531
	(0.0108)	(0.00492)	(0.00827)	(0.00243)	(0.00646)
Post FS * Log Centrality	0.0290***	0.0145***	0.0329***	0.00643***	0.0254***
	(0.00657)	(0.00287)	(0.00524)	(0.00176)	(0.00371)
SOE * Log Centrality	-0.00861	-0.0135*	-0.00177	-0.00166	-0.00553
	(0.0198)	(0.00762)	(0.0132)	(0.00470)	(0.00948)
Post FS*SOE* Log Centrality	-0.0199	-0.0163*	-0.0415**	-0.0110**	-0.0269**
	(0.0221)	(0.00965)	(0.0172)	(0.00529)	(0.0122)
Other controls	Yes	Yes	Yes	Yes	Yes
Firm,Year FE	Yes	Yes	Yes	Yes	Yes
Observations	32,023	32,023	32,023	32,023	32,023
R-squared	0.459	0.463	0.460	0.461	0.461

Ongoing work: Identification

- Using the 2008-09 global crisis as an exogenous shock:

  - To import sectors, which changed networks and positions of connected firms (via equity investment)

  - Compare the performance of non-export firms: affected firms vs. non-affected firms

  - Main challenge: recover the industry classifications of all the firms

- Quasi-experiment:

  - ***Creating pseudo networks*** by dropping 100 firms with the highest eigenvector centrality in the network of 2017

  - The centrality-growth nexus remains statistically significant and economically meaningful after network structure changes

Summary and conclusion

- Using a complete equity ownership network for all the registered firms in China, we provide the first evidence showing how capital is allocated in the network, and how it contributes to growth.

- The network has been expanding rapidly since 2000s, though new entrant firms tend to attract and make less investment so obtain less global importance.

- **Entering the network is associated with higher future growth; in-network firms with higher centrality tend to have higher growth**.

    - Such effect of network position on growth tends to be more pronounced for high-productivity firms and non-SOEs.

    - Over time, the average effect of network centrality on growth decreases, and has been diminishing since the Stimulus Plan in 2009, suggesting a *crowding-out* effect of the sudden increase in bank credit.

    - Equity ownership network serves as a substitute to bank credit for SOEs, while as a complement to bank credit for non-SOEs in promoting real growth.