Technological Links and FDI Spillovers

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Motivation

- Developing countries have removed restrictions on FDI and adopted policies to attract FDI.
- FDI spillover channels:
    - Agglomeration channel: knowledge spillover; input-output linkage; worker training;
    - Competition channel: market stealing effect.
- Mixed empirical evidences on FDI spillovers
    - Most empirical studies in developing economies fail to find positive spillover;
    - Some exceptions: Javorcik (2004) among others.

What We Do

- Approach to identify knowledge spillovers through FDIs:
  - Technological links between domestic and foreign firms;
  - Exogenous shock using China's FDI liberalization in 2002.

- We investigate the FDI spillover to local firms in a large developing country context.

- Identification on FDI knowledge spillovers in two ways:
  - Construct a measure of technological links between firms to identify technological spillovers following Bloom et al. (2013);
  - Use the major deregulation on FDI flows in 2002 as the policy shock.
  - We also control for other channels of FDI spillovers found in the literature.

Our Findings

- Domestic firms having closer technological links with foreign multinationals can benefit more (larger increase in TFP)

- This effect is robust by controlling for product rivalry effect (the competition channel);

- Examine the relevance of several explanations to understand the effect of FDI knowledge spillovers on domestic firms
  - Horizontal vs. vertical FDI technology spillovers
  - FDI from developed vs. developing economies
  - Spillovers across geographical distance
  - Absorptive capacity of domestic firms

- Other firm measures: patenting, R&D investment, and export performance

Literature

- FDI on host country firms' productivity:
    - In developed countries, the effect is usually positive: e.g., Keller and Yeaple (2009)
    - In developing countries, the effect is usually negative: e.g., Aitken and Harrison (1999) for Venezuela; Lu, Tao and Zhu (2017) for China.
    - Javorcik (2004): positive FDI spillovers through vertical linkages

- Literature on technology spillovers
    - Jaffe (1986); Bloom et al. (2013), etc.

Road Map

- FDI policy in China
- Data
- Estimation strategy
- Main results
- Mechanism
- Conclusion

Background – FDI Regulations in China

- Since the open-door policy in 1978, a series of laws on FDI and implementation measures were introduced and revised.
- In July 1979, a "Law on Sino–Foreign Equity Joint Ventures" was passed to attract foreign direct investment.
- In September 1983, the "Regulations for the Implementation of the Law on Sino–Foreign Equity Joint Ventures" was issued by the State Council of China; it was revised in January 1986, December 1987, and April 1990.
- In April 1986, the "Law on Foreign Capital Enterprises" was enacted.
- In October 1986, "Policies on Encouragement of Foreign Investment" was issued by the State Council of China.

FDI Regulations in China

- Government guidelines for regulating the inflows of FDI
  - In June 1995, the central government of China promulgated "the Catalogue for the Guidance of Foreign Investment Industries"
  - Modifications made in 1997

- The Catalogue classified products into four categories
  - (i) FDI was supported, (ii) FDI was permitted, (iii) FDI was restricted, and (iv) FDI was prohibited.

- After the WTO accession in November 2001, central government substantially revised the Catalogue in March 2002, and made minor revisions in November 2004.

- Further modified in Dec 2007, Jan 2012, April 2015, July 2017, and Jan 2021 (periods not covered in our data).

Measure on Technological Links

- Use Jaffe index to measure technological links between a domestic firm i and a foreign firm j
- Jaffe's (1986) uncentered correlation of firm patent class distribution

$$TEC_{i,j} = \frac{T_i T_j'}{(T_i T_i')^{1/2}(T_j T_j')^{1/2}}.$$

  - $T_i = (T_{i1}, \ T_{i2}, \ \ldots, \ T_{i121})$
  - T_{ik}: share of domestic firm i's patents in technology class k ($k = 1, \ldots, 121$)
  - T_j for foreign firms

- Jaffe index assumes spillovers to occur within the same technology class for any firm pair i and j.
- As an extension, we use Mahalanobis distance measure $TEC_{i,j}^M$, and allow spillovers to occur between different technology classes.

Measure on Product Market Similarity

- Analogous construction of product market "closeness"
  - Define $S_i = (S_{i1}, S_{i2}, \ldots, S_{i602})$ where S_{il} is the share of firm i's total sales in 4 digit industry l ($l = 1, \ldots, 602$)
  - If spillovers only occur within the same technology class: $PROX_{i,j} = (S_i S_j')/[(S_i S_i')^{1/2}(S_j S_j')^{1/2}]$ for any firm pair i and j
  - If spillovers can occur between different classes using Mahalanobis distance: $PROX_{i,j}^M$

- FDI technology spillover pool for domestic firm i:

$$FDI\_SPILLTEC_i = \sum_{j \neq i} TEC_{i,js} \cdot G_{js} \cdot DeregFDI_s.$$

  - $TEC_{i,js}$: technological link between domestic firm i and foreign firm j that operates in industry s.
  - G_{js}: R&D investment of foreign firm j operating in industry s
  - $DeregFDI_s$: an indicator for FDI deregulated industry s

- FDI product market "spillover" pool for domestic firm i:

$$FDI\_SPILLPROX_i = \sum_{j \neq i} PROX_{i,js} \cdot \widetilde{G}_{js} \cdot DeregFDI_s.$$

  - $PROX_{i,js}$: product market proximity between domestic firm i and foreign firm j operating in industry s.
  - $\widetilde{G}_{js}$: output of foreign firm j operating in industry s
  - $DeregFDI_s$: an indicator for FDI deregulated industry s

Data on FDI Deregulation

- 1995: the *Catalogue for the Guidance of Foreign Investment Industries* (the *Catalogue*)
- 1997: modifications were made
- 2002: substantially revisions
- 2004: minor revisions

- In Catalogue 1997 and 2002, products were classified into four categories:
    1. Supported category
    2. Permitted category
    3. Restricted category
    4. Prohibited category

Data on FDI Deregulation

- For each product, compare the 1997 and 2002 versions of the *Catalogue*. Three possible outcomes:

			2002			
			(1) Supported Category	(2) Permitted Category	(3) Restricted Category	(4) Prohibited Category
1997	(1)	Supported Category	No-change	Less welcome	Less welcome	Less welcome
	(2)	Permitted Category	More welcome	No-change	Less welcome	Less welcome
	(3)	Restricted Category	More welcome	More welcome	No-Change	Less welcome
	(4)	Prohibited Category	More welcome	More welcome	More welcome	No-Change

Data on FDI Deregulation

- Aggregate the changes in FDI regulations from the *Catalogue* product level to industry level in firm-level data.
- Throughout the aggregation process, we have four possible scenarios:
  1. (**More-Welcome) Deregulated Industries:** An improvement in FDI regulations for some products and no change in FDI regulations for the others. (112 industries out of 424 industries)
  2. Less-Welcome Industries: A deterioration in FDI regulations for some products and no change in FDI regulations for the others. (7 industries)
  3. **No-Change Industries:** No change in FDI regulations for all the possible Catalogue products. (300 industries)
  4. Mixed Industries: An improvement in FDI regulations for some products, but a deterioration in FDI regulations for some other products. (5 industries)

Firm-Level Data

- *Annual Survey of Industrial Firms* (ASIF)
  - conducted by the National Bureau of Statistics of China for the 1998–2007 period
  - cover all SOEs and all of the non-SOEs with annual sales over 5 million Chinese yuan (about US$827,000)
  - the number of firms covered varies from approximately 162,000 to approximately 270,000
  - more than 100 variables, including the basic information, and the financial and operational information extracted from accounting statements
- Definition for foreign firm: firm's foreign equity share above 25%.
- Benchmark: measure firm TFP using ACF (2015) approach
- Alternative TFP measure using De Loecker et al (2016) approach to address omitted firm output price issue
  - using quantity data of single-product firm

Patent Data

- State Intellectual Property Office (SIPO): firm's patent filings
  - contains information on firm's name, location, patent class, date of filing
  - types of the patent (i.e., invention patent, utility model patent, and design patent)
- Construct the firm pairwise technology closeness in the patent space
- Match SIPO with ASIF data to obtain firm ownership information, i.e., whether a firm is an FIE or not.
  - technological link between FDI firms and domestic Chinese firms

- Specification:

$$\log TFP_{ikrt} = \lambda_i + \lambda_{kt} + \lambda_{rt} + \beta FDI\_SPILLTEC_i \times Post_t$$
$$+ \gamma FDI\_SPILLPROX_i \times Post_t + \boldsymbol{\theta} \mathbf{X}_{it} + \varepsilon_{ikrt},$$

  - λ_i: firm FE; λ_{kt}: industry-year FE; λ_{rt}: prefecture-year FE;
  - $Post_t = 1$ if $t \geq 2002$ (FDI liberalization happened in 2002)
  - $\mathbf{X}_{it}$: firm-level controls including age, age squared, and SOE dummy.

- $FDI\_SPILLTEC_i \times Post_t$: capture firm's exposure to FDI deregulation using information on *preexisting* technological links between domestic and foreign firms.

- Whether domestic firms that are closer to foreign multinationals in *preexisting* technology spaces would experience relatively larger changes in productivity induced by China's FDI liberalization?

Empirical Analysis
Notes on Estimation Strategy

- Comparing firms in the same industry and prefecture but having initially different technology class with foreign firms
- Industry-year fixed effects:
  - control for alternative channels such as industrial differential growth trends
  - control for horizontal and vertical FDI spillovers across industries
  - other ongoing policies at the industry level
- Prefecture-time fixed effects:
  - control for alternative channels such as regional differential growth trends
 - controlling for ongoing spatial policies such as special economic zones

- *Preexisiting* technological links: address the concern that endogenous formation of technological link between firms caused by China's FDI deregulation could affect domestic firm's productivity.
- Domestic firms sample only (robust results using full sample)
- Standard errors are cluster at the firm level

Main Results

	Dependent variable: Log firm TFP			
	(1)	(2)	(3)	(4)
FDI_SPILLTEC × Post	0.261***	0.253***	0.151***	0.151***
	(0.043)	(0.043)	(0.040)	(0.040)
FDI_SPILLPROX × Post				-0.001
				(0.001)
Observations	399407	399407	399293	399293
Outcome mean	4.09	4.09	4.09	4.09
Additional controls:				
Firm fixed effects	x	x	x	x
Year fixed effects	x			
Industry-year fixed effects		x	x	x
Prefecture-year fixed effects		x	x	x
Firm characteristics		x	x	x

Yearly effects on log TFP

Main Results
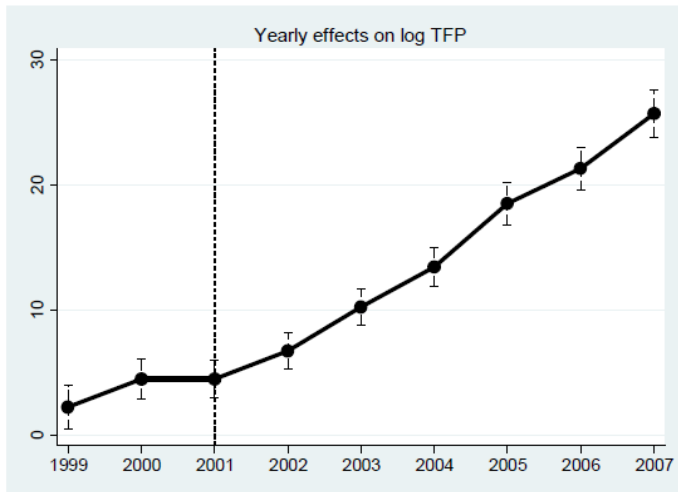
- Conditional on product competition effects, domestic firms that are more exposed to FDI deregulation through closer technological links with foreign multinationals significantly increase their TFP.

- It is much easier for domestic firms to learn foreign technology given that their technology spaces are similar with foreign firms.

- Figure shows that in the pre-WTO period, this spillover effect through technological links on firm productivity is quite stable over time.

Robustness Checks

- Mahalanobis distance index for $TEC_{i,j}$ (column 1)
- Using invention and utility patent separately for $TEC_{i,j}$ measure (columns 2–3)
- Exclude foreign pure exporter (as they have lower TFP than domestic firms) when calculating $TEC_{i,j}$, in column 4
- Exclude domestic processing firms in column 5
- Using alternative G_{js} measure (columns 6–7)

Robustness Checks

	Dependent variable: Log firm TFP						
	$TEC_{i,j}$ measure					G_{js} measure	
	Mahalanobis distance	Invention patent	Utility patent	Foreign pure exporters excluded	Domestic process. firms excluded	Output	Employees
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
FDI_SPILLTEC × Post	0.153***	0.256**	0.179***	0.151***	0.147***	0.042***	0.082***
	(0.037)	(0.130)	(0.049)	(0.040)	(0.042)	(0.011)	(0.021)
Observations	399293	399293	399293	399293	387865	399293	399293
Outcome mean	4.09	4.09	4.09	4.09	4.07	4.09	4.09
Additional controls:							
Firm fixed effects	x	x	x	x	x	x	x
Industry-year fixed effects	x	x	x	x	x	x	x
Prefecture-year fixed effects	x	x	x	x	x	x	x
FDI_SPILLPROX × Post	x	x	x	x	x	x	x
Firm characteristics	x	x	x	x	x	x	x

- Agglomeration effect
  - Horizontal vs. vertical technology spillovers
  - FDI from OECD vs. non-OECD countries
  - FDI spillovers by geographical distance
  - Long-run TFP growth

- Absorptive capacity
  - Ownership structure (SOE vs. private firms)
  - R&D investment
  - Firm size

- Horizontal FDI technology spillovers:

$$HFDI\_SPILLTEC_i = \sum_{j \neq i} TEC_{ik,js} \cdot G_{js} \cdot 1(k = s) \cdot DeregFDI_s.$$

  - $1(k = s)$: an indicator if firm i and j operating in the same industry
- Backward FDI technology spillovers:

$$BFDI\_SPILLTEC_i = \sum_{j \neq i} TEC_{ik,js} \cdot G_{js} \cdot \alpha_{sk} \cdot DeregFDI_s.$$

  - α_{ks}: ratio of sector k's output supplied to sector s
- Forward FDI technology spillovers:

$$FFDI\_SPILLTEC_i = \sum_{j \neq i} TEC_{ik,js} \cdot G_{js} \cdot \beta_{ks} \cdot DeregFDI_s.$$

  - β_{ks}: ratio of inputs purchased by sector k from sector s

Mechanism II
Technology Spillovers by Distance

- FDI spillover by distance:

$$D\_FDI\_SPILLTEC_i = \sum_{j \neq i} TEC_{ir,ju} \cdot G_{js} \cdot Dist_{ru}^o \cdot DeregFDI_s.$$

  - $Dist_{ru}^o$: bilateral distance between prefecture r and u.
  - o: three distance intervals: $[0; 300); [300; 900); [900; \text{maximum})$.

- Distance-weighted FDI spillover:

$$Dist\_FDI\_SPILLTEC_i = \sum_{j \neq i} TEC_{ir,ju} \cdot G_{js} \cdot e^{-d_{ru}} \cdot DeregFDI_s$$

  - d_{ru}: bilateral distance between prefecture r and u, divided by average bilateral city distance

Mechanism III
Technology Spillovers by Source Country

- FDI from OECD countries:

$$FDI\_SPILLTEC_i^{OECD} = \sum_{j \neq i} TEC_{ir,ju} \cdot G_{js} \cdot OECD_{js} \cdot DeregFDI_s.$$

  - $OECD_{js} = 1$ if foreign firms from OECD countries (using foreign-invested data in 2001)

- FDI from non-OECD countries:

$$FDI\_SPILLTEC_i^{NonOECD} = \sum_{j \neq i} TEC_{ir,ju} \cdot G_{js} \cdot NonOECD_{js} \cdot DeregFDI_s.$$

  - $NonOECD_{js} = 1$ if foreign firms from non-OECD countries

Dependent variable:	Log firm TFP				TFP growth btw 2001-2007
	(1)	(2)	(3)	(4)	(5)
HFDI_SPILLTEC × Post	0.250				
	(0.490)				
BFDI_SPILLTEC × Post	1.995**				
	(0.934)				
FFDI_SPILLTEC × Post	2.391*				
	(1.321)				
FDI_SPILLTEC distance:					
[0, 300) × Post		0.331**			
		(0.152)			
[300, 900) × Post		0.231**			
		(0.114)			
[900, maximum) × Post		0.067			
		(0.073)			
Distance-weighted FDI_SPILLTEC × Post			0.389***		
			(0.092)		
FDI_SPILLTEC from:					
OECD countries × Post				0.454**	
				(0.198)	
Non-OECD countries × Post				0.098	
				(0.097)	
FDI_SPILLTEC × Post					0.021**
					(0.010)
Observations	399293	399293	399293	399293	23898
Outcome mean	4.09	4.09	4.09	4.09	0.15

Mechanism

- Column (1) for horizontal vs. vertical technological spillover:
  - both backward and forward FDI on firm TFP are positive and statistically significant
  - The horizontal FDI is still positive, with similar magnitude as in the baseline result, although statistically insignificant.

- Columns (2) and (3): FDI technological spillovers decreased as geographical distance between domestic firms and multinationals increases.

Mechanism

- Column (4): FDI from developed vs developing economies
  - Technological spillovers through multinationals from developed countries with advanced technology or sophisticated know-how are more beneficial to Chinese domestic firms.
  - The effect of FDI technological spillovers among foreign affiliates from developed countries is much larger comparing to those from developing countries.
- Column (5): find a positive long-run effect, indicating a positive dynamic effect of FDI technological spillovers in the long run.

Absorptive Capacity

	Dependent variable: Log firm TFP					
	Firm ownership		Firm R&D intensity		Firm size	
	Private	State-owned	High	Low	Large	Small
	(1)	(2)	(3)	(4)	(5)	(6)
$FDI\_SPILLTEC \times Post$	0.098**	0.221***	0.119**	0.140**	0.165***	0.057
	(0.048)	(0.076)	(0.058)	(0.062)	(0.041)	(0.150)
Observations	300500	98225	44774	353709	249609	149194
Outcome mean	4.30	3.45	4.17	4.08	4.13	4.01
Additional controls:						
Firm fixed effects	x	x	x	x	x	x
Industry-year fixed effects	x	x	x	x	x	x
Prefecture-year fixed effects	x	x	x	x	x	x
$FDI\_SPILLPROX \times Post$	x	x	x	x	x	x
Firm characteristics	x	x	x	x	x	x

Absorptive Capacity

- Columns (1)–(2): SOE vs. private firms
  - FDI deregulation significantly increases productivity for those technologically linked domestic firms, especially SOEs.
  - This is in line with the conventional wisdom that SOEs usually are more capable in terms of absorbing the technological spillovers from foreign multinationals.

- Columns (3)–(4): Firms with high vs. low R&D investment
  - Technological spillovers of FDI to domestic firms do not differ significantly across the two sub-samples.

- Columns (5)–(6): Large vs. small-sized firms
  - Technological spillovers are indeed much larger for larger domestic firms.

Other Firm Outcomes

		Dependent variable: Log firm TFP				
	Patent	R&D Investment	New product	Export dummy	Export intensity	Exit dummy
	(1)	(2)	(3)	(4)	(5)	(6)
FDI_SPILLTEC × Post	0.108**	0.818***	1.497***	0.067**	0.029***	-0.138***
	(0.046)	(0.235)	(0.274)	(0.027)	(0.010)	(0.014)
Observations	451813	256235	413134	451813	451813	451813
Outcome mean	0.03	0.85	1.07	0.23	0.11	0.08
Additional controls:						
Firm fixed effects	x	x	x	x	x	x
Industry-year fixed effects	x	x	x	x	x	x
Prefecture-year fixed effects	x	x	x	x	x	x
FDI_SPILLPROX × Post	x	x	x	x	x	x
Firm characteristics	x	x	x	x	x	x

Other Firm Outcomes

- Columns (1)–(3): As more foreign companies enter China and bring more advanced technologies, the innovation activities of domestic companies have become more active.
- Columns (4)–(5): The entrance of multinational enterprises help domestic firms learn more information about the foreign market and enhance their international market participation.
- Column (6): The presence of FDI technology spillovers has a negative effect on the firm exit rate in the next period (increase the survival rate of domestic firms).

Heterogeneous Effects

| | Dependent variable: Log firm TFP | | | |
| | Industry tech specificity | | Regional IPR | |
	High (1)	Low (2)	High (3)	Low (4)
FDI_SPILLTEC × Post	0.365***	0.115***	0.112**	0.214***
	(0.113)	(0.042)	(0.049)	(0.065)
Observations	114962	282298	213321	185575
Outcome mean	4.39	3.97	4.42	3.71
Additional controls:				
Firm fixed effects	x	x	x	x
Industry-year fixed effects	x	x	x	x
Prefecture-year fixed effects	x	x	x	x
FDI_SPILLPROX × Post	x	x	x	x
Firm characteristics	x	x	x	x

Heterogeneous Effects

- Columns (1)–(2): high vs. low tech specific industry
  - Technologies in some industries are more specific in the sense that technologies used in these industries are more concentrated in patent classes.
  - Technology spillover effect is stronger in those industries with high technology specificity, suggesting stronger spillovers for given technological links in these industries.

- Columns (3)–(4): regional IPR protection difference
  - In regions with better intellectual property protection, certain technological spillover will be restricted.
  - Intellectual property rights differ quite significantly across provinces in China.
  - We find that technological spillover effect from FDIs to domestic firms is stronger in regions with relatively worse intellectual property rights.

Conclusion

- There is significant positive spillover effect from FDIs to domestic firms.
- The effect hings on the technological links between domestic firms and FDIs.
- This positive spillover is robust to control for product rivalry effect.
- Confirm the spillover channel in the literature: input-output linkage; origin of FDIs; absorptive capacity.