Foreign Investment and Domestic Productivity: New Evidence on the Role of Competition and Knowledge Spillovers

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Introduction

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- How does the productivity of *domestic* firms change upon entry of MNCs?

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  - Specifically: How are Ukrainian firms in agro commodities and related sectors affected by entry of MNCs?

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- Policy question: Should we promote policies for foreign agro firms (such as Cargil, Inc. of the U.S.) to build plants in Ukraine?
  - Specifically: How are Ukrainian firms in agro commodities and related sectors affected by entry of MNCs?
  - During the 1990s, the answer seemed to be unambiguously yes (the Washington Consensus for developing countries).

Any academic research that supported this trend? Yes

Empirical international macro literature:
Using aggregate cross-country data, found a stylized fact: positive correlation between FDI and growth

Theoretical economic growth models:
Claim that long-run growth only through improvements in technology and innovation (work by Lucas, Aghion, Romer)

Policy push:

- Bringing foreign technology and know-how is the single most important factor to achieve sustainable long-run growth

Problems with previous macroeconomic finding

Correlation does not imply *causality*.

Econometric specification: $\text{Growth}_{i,t} = \beta\,\text{FDI}_{i,t} + \alpha_i + \delta_t + \epsilon_{i,t}$, where i=country and t=year.

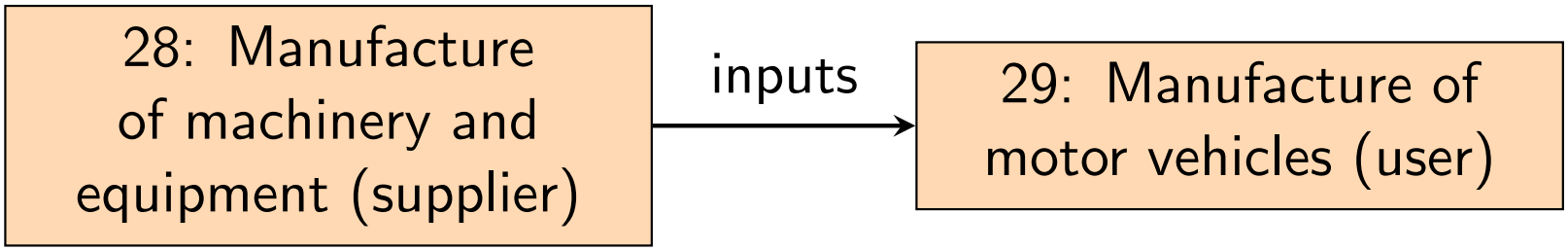
Possible channels at work:

- An increase in FDI leads to more growth (X causes Y)
- Growing countries attract more FDI (Y causes X)
- Better institutions and rule of law lead to more FDI and growth (Z causes X,Y)

Need for more precise econometric work using more granular data!
Do results hold if we rather use firm-level datasets?

Notions in FDI literature: Horizontal vs. Vertical FDI

Example: Consider the following observed supplier-user relationship between two 2-digit sectors implied by the input-output table.



- Magnitude of spillovers is proxied by sector-level foreign output.
- Horizontal FDI spillovers: between firms within a sector.
- Vertical FDI spillovers: between firms in supplier-user sectors.

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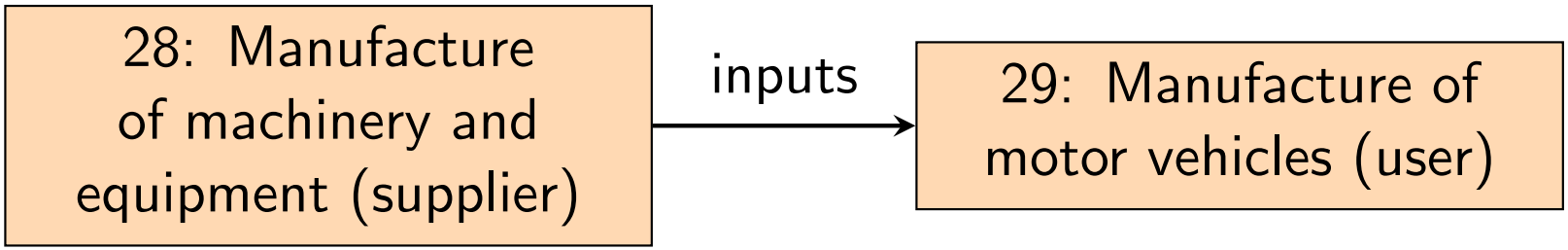

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What is the evidence on productivity spillovers from foreign to domestic firms using firm-level data?

Evidence on productivity spillovers from firm-level data

- Horizontal FDI spillovers: mixed results
  - Haskel, Pereira and Slaughter (2007) and Keller and Yeaple (2009) positive in the U.K. and the U.S.
  - Aitken and Harrison (1999) negative in Venezuela.
  - Javorcik (2004), Blalock and Gertler (2008), Barrios, Gorg and Strobl (2011) no effect in Lithuania, Indonesia and Ireland.
- Vertical FDI spillovers: overwhelming **positive** results:
  - Javorcik (2004), Blalock and Gertler (2008).

Evidence on productivity spillovers from firm-level data

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- Vertical FDI spillovers: overwhelming **positive** results:
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- Important: So far, the literature measures spillovers at broad 2-digit sector level.

This paper

- Revisit the issue of identifying Horizontal Spillovers at the two-digit industry level.
- Address the limitations of the previous literature:
  - Aggregate 2-digit sector does not allow to separate (positive) knowledge spillovers from (negative) competition effects.
  - One-country approach makes causal interpretation harder (global sectoral tech shocks) .

Contribution: Break down 2-digit "horizontal spillover" into "competition effects" and "knowledge spillovers"

Example

Let France be the host country and take domestically-owned manufacturer of steel tubing for nuclear steam generation *Valinox Nucleaire*.

- 2-dgt sector 24 "Manuf. of basic metals" (as in the literature).
- 4-dgt sector 2420 "Manuf. of tubes, pipes, of steel" (our paper).
- Sector TFP growth of 25% during 2000-2008.

We break down the effect of MNC according to their presence:

1. In the same 4-digit sector (direct product market competitors).
2. In the same 2-digit sector (non-direct product market competitors – maybe close in the "technology space").

Contribution: Break down 2-digit "horizontal spillover"

Example: Domestic *Valinox* in sect.2420 "Manuf. of tubes"

In the same 4-digit sector in France we find *Salzgitter Mannesmann Precision (SMP)*, fully-owned subsidiary of the German global leader in the line pipes and precision tubes sector Salzgitter AG.

We identify the within 4-digit sector effects:

- **Claim 1:** Because *Valinox* and *SMP* are in the same 4-digit sector they are direct product competitors (negative market competition effects).
- **Claim 2:** Some positive knowledge may spillover from *SMP* to *Valinox* if the two companies are close in the technology space (positive horizontal knowledge spillovers).

Contribution: Break down 2-digit "horizontal spillover"

Example: Domestic *Valinox* in sect.2420 "Manuf. of tubes"

In the same 2-digit sector in France we find *Constellium Montreuil*, fully-owned subsidiary of the Dutch leading supplier of aluminium products for aerospace, transportation, defense, Constellium NV (sector 2442 "Aluminium production").

We identify the within 2-digit sector (outside the 4-digit) effects:

- **Claim 1:** *Valinox* and *Constellium* are in different segments → no product market competitors. We verified no commercial relationship between the two.
- **Claim 2:** Aluminium and steel share similar design problems/processes and rules (31% of patents registered by firms in sect.2420 overlap with those in sect.2442) → some positive knowledge may spill over from *Constellium* to *Valinox* (positive vertical knowledge spillovers).

Data

Firm-level data:

- Internationally harmonized administrative micro-datasets ORBIS and AMADEUS, provided commercially by Bureau van Dijk (BvD). Millions of public and private firms.
- 6 European countries (1999-2008): BE, ES, FI, FR, IT, NO ▸ Coverage.
- >10 employees (90% of total manufacturing)
- Balance sheet data (output-turnover, materials, employment, wage bill, capital, etc.) ▸ TFP estimation.
- Ownership data: time varying information on ownership stakes ▸ Coverage

Firm-patent match for Europe:

- source: Bloom, Draca, and Van Reenen (2016);
- Orbis-Amadeus matched to European patents (the European Patent Office).
- Variable: number of granted patents per firm.

Data

Sector Technology Closeness Measure:

- source: Bloom, Schankerman, and Van Reenen (2013);
- U.S. firm-level accounting data (Compustat) matched to U.S. patents (1980-2001);
- each firm pair (i,j) gets a technology distance based on overlap in patent portfolio (common technology class);
- we aggregate up at bilateral 4-digit sector (from the U.S. SIC to our NACE rev. 2) using information on technology distance between firm pairs and information on firms' R&D expenditure.

Sector Vertical Linkages Measure:

- source: U.S. input-output (IO) table from the Bureau of Economic Analysis;
- firm-to-firm information on sales is not available $\rightarrow$ IO tables used to measure input flows across industries;
- European countries do not provide IO tables at the 4 digit industry level;

Traditional Measures of Spillovers - Product Based

- Horizontal Spillovers: A measure of MNC presence in the same 4-digit sector (HORIZONTAL).

$$\text{HORIZONTAL}_{s4,t} = \frac{\sum_{i \in s4} \text{fo}_{i,t} \times \text{go}_{i,t}}{\sum_{i \in s4} \text{go}_{i,t}} , \tag{1}$$

- Vertical Spillovers: A measure of MNC presence adjusted for the input-output relationships within the same 2-digit but outside the 4-digit (VERTICAL_IO).

$$\text{VERTICAL\_IO}_{s4,t} = \sum_{\substack{\tilde{s}4 \in s2(s4) \\ \tilde{s}4 \neq s4}} \alpha_{s4,\tilde{s}4,t} \times \text{HORIZONTAL}_{\tilde{s}4,t} , \tag{2}$$

where $\alpha_{s4,\tilde{s}4,t}$ is the I-O coefficient that records the fraction of output that sector $s4$ provides to each given sector $\tilde{s}4$.

New Measures of Spillovers - Technology Based

We construct two sector measures, relying on the work of Bloom, Schankerman and Van Reenen (2013) to capture sectoral technological closeness.

- Horizontal Technology Spillover: A measure of MNC presence adjusted for the technology closeness of firms operating in the same 4-digit sector (HORIZONTAL_TEC).

$$\text{HORIZONTAL\_TEC}_{s4,t} = \text{WTECH}_{s4,s4,t} \times \text{HORIZONTAL}_{s4,t} \,. \tag{3}$$

- Vertical Technology Spillover: A measure of MNC presence adjusted for the technology closeness of firms operating within the same 2-digit but outside the 4-digit (VERTICAL_TEC).

$$\text{VERTICAL\_TEC}_{s4,t} = \sum_{\substack{\tilde{s}4 \in s2(s4) \\ \tilde{s}4 \neq s4}} \text{WTECH}_{s4,\tilde{s4},t} \times \text{HORIZONTAL}_{\tilde{s}4,t} \,, \tag{4}$$

- WTECH captures sectoral technological closeness and economic size of the sectors. ▸ Details

Spillovers Measures

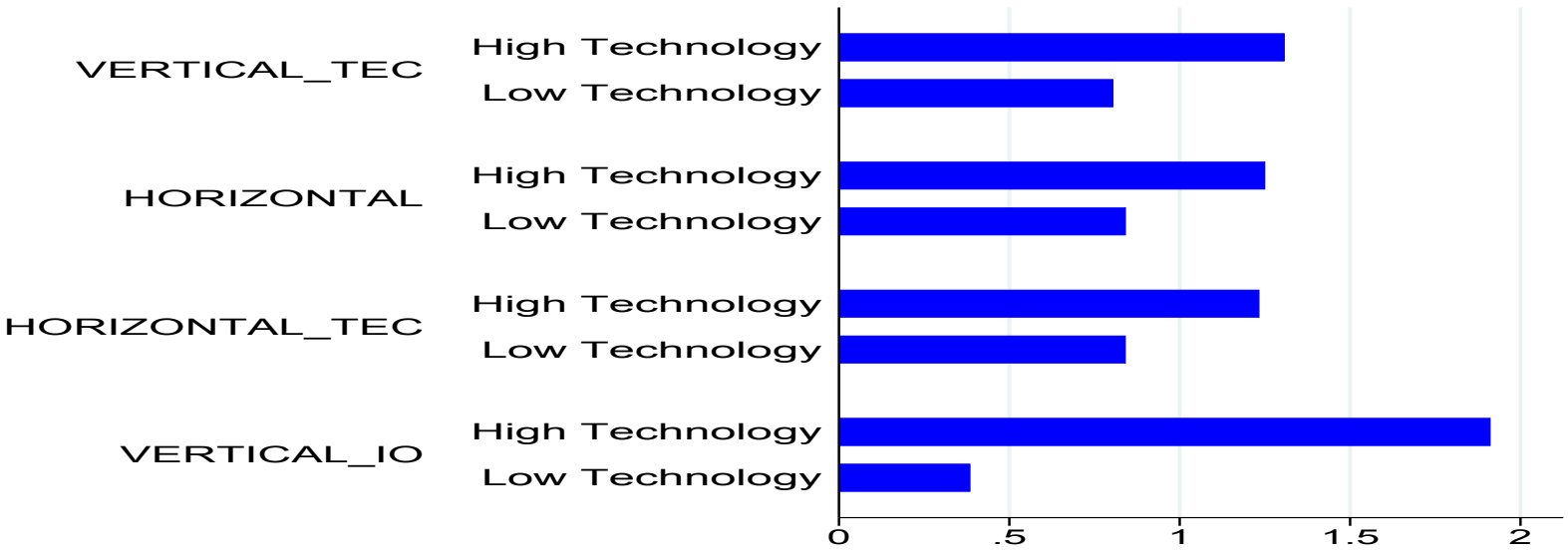


Figure: Spillover measures by technology sector in 2007. The "High" and "Low" classification is done by the OECD based on two indicators of technology intensity reflecting, to different degrees, "technology-producer" and "technology-user" aspects: i) R&D expenditures divided by value added; ii) R&D expenditures divided by production. ▸ FO Distribution

Results - Horizontal spillovers in the same 4-digit sector

DEPENDENT VARIABLE: log FIRM REVENUE TFP. SAMPLE: DOMESTIC FIRMS

$$\log(\text{TFPR}_{i,s4,c,t}) = \beta_1 \text{HORIZONTAL}_{s4,c,t-1} + \beta_2 \text{HORIZONTAL\_TEC}_{s4,c,t-1} + \alpha_i + \phi_{s4,t} + \delta_{c,t} + \epsilon_{i,s4,c,t}$$

	(1)	(2)	(3)	(4)
$\text{HORIZONTAL}_{s4,t-1}$	-0.094*	-0.173***		-0.330***
	(0.047)	(0.047)		(0.079)
$\text{HORIZONTAL\_TEC}_{s4,t-1}$			-0.033	0.228**
			(0.052)	(0.078)
Observations	322,516	322,516	322,516	322,516
Firm FE	✓	✓	✓	✓
Country-Year FE	✓	✓	✓	✓
Sec4-Year FE		✓	✓	✓

Notes: GLS. Cluster at c-s4-y. s.d.(HORIZONTAL)=0.16; s.d.(HORIZONTAL_TEC)=0.07.
Interpretation: Coefficient of -0.173 implies that a one std. dev. increase in foreign presence decreases domestic firms' productivity by about 0.17 percent.

- Within 4dig: large knowledge spillovers off-set by negatv. comp. effects.
- The positive will dominate in sectors that are technologically close.

Results - Technology Spillovers and Vertical Linkages

Four potential channels!

DEPENDENT VARIABLE: log FIRM REVENUE TFP. SAMPLE: DOMESTIC FIRMS

$$\log(\text{TFPR}_{i,s4,c,t}) = \beta_1 \text{HORIZONTAL}_{s4,c,t-1} + \beta_2 \text{HORIZONTAL\_TEC}_{s4,c,t-1} + \beta_3 \text{VERTICAL\_TEC}_{s4,c,t-1} + \beta_4 \text{VERTICAL\_IO}_{s4,c,t-1} + \alpha_i + \phi_{s2,t} + \delta_{c,t} + \epsilon_{i,s4,c,t}$$

	(1)	(2)	(3)	(4)	(5)
$\text{VERTICAL\_TEC}_{s4,t-1}$	0.237***		0.207***	0.207***	0.237***
	(0.059)		(0.059)	(0.059)	(0.059)
$\text{VERTICAL\_IO}_{s4,t-1}$		0.113**	0.057	0.064	
		(0.035)	(0.042)	(0.042)	
$\text{HORIZONTAL}_{s4,t-1}$				-0.330***	-0.330***
				(0.079)	(0.079)
$\text{HORIZONTAL\_TEC}_{s4,t-1}$				0.254**	0.247**
				(0.078)	(0.078)
Observations	322516	322516	322516	322516	322516
Firm FE	✓	✓	✓	✓	✓
Country-Year FE	✓	✓	✓	✓	✓
Sec4-Year FE	✓	✓	✓	✓	✓

Notes: GLS. Cluster at c-s4-y. s.d.(HORIZONTAL)=0.16; s.d.(HORIZONTAL_TEC)=0.07; s.d.(VERTICAL_TEC)=0.15 s.d.(VERTICAL_IO)=0.07

Results so far and their policy implications

- Amount of knowledge spillovers from FDI depends not just on how much foreign investment there is, but also critically on *in which firms* FDI takes place.
- Productivity enhancing effects of FDI for local firms will depend on the interaction between high FDI into high technological sectors that are close in technology space.

Results - Timing of Impacts

SAMPLE: DOMESTIC FIRMS

	(1)	(2)	(3)
Dependent Variable:	$\Delta^{j=1}$ log TFPR	$\Delta^{j=2}$ log TFPR	$\Delta^{j=4}$ log TFPR
Δ^{j}HORIZONTAL$_{s4}$	-0.019**	-0.009	-0.013**
	(0.006)	(0.006)	(0.005)
Δ^{j}HORIZONTAL_TEC$_{s4}$	-0.001	0.022	0.035**
	(0.016)	(0.015)	(0.012)
Δ^{j}VERTICAL_TEC$_{s4}$	0.002	0.018***	0.048***
	(0.005)	(0.003)	(0.004)
Observations	373,960	172,521	72,638
Firm FE			
Country-Year FE	✓	✓	✓
Sec4-Year FE	✓	✓	✓
Cluster	cs4y	cs4y	cs4y

Notes: GLS. Haskel, Pereira and Slaughter (2007) in the UK find 6.3 percent increase in productivity for five-year differences.

Technology or Pricing?

- Our measured firm productivity, is revenue TFP.
  $\mathrm{TFPR}_{it} \equiv P_{it}\mathrm{TFPQ}_{\mathrm{it}} = \mu_{\mathrm{it}} \times \mathrm{MC}_{\mathrm{it}} \times \mathrm{TFPQ}_{\mathrm{it}}$, where P_{it} is firm output price and $\mathrm{TFPQ}_{\mathrm{it}}$ is physical productivity and MC_{it} is the marginal cost.
- Important issue: Markups may respond endogenously to competition effects.
- No firm-specific prices to isolate the physical productivity $\mathrm{TFPQ}_{\mathrm{it}}$ (common problem in the literature).
- We follow De Loecker and Warzynski (2012), compute firm-level markups, and study
  - ✓ whether the spillovers result in higher domestic firms' markups; and
  - ✓ what part of the change in TFPR induced by the spillovers is driven by higher markups and how much by physical productivity. ▸ Details

Results - Revenue TFP and Markups

SAMPLE: DOMESTIC FIRMS

Dependent Variable:	(1) log(TFPR)	(2) log(μ)	(3) MC	(4) Implied log(TFPQ)
HORIZONTAL$_{s4,t-1}$	-0.330***	-0.220**	0.110***	-0.220**
	(0.079)	(0.063)	(0.031)	(0.105)
HORIZONTAL_TEC$_{s4,t-1}$	0.247**	0.104	-0.052*	0.195*
	(0.078)	(0.072)	(0.026)	(0.109)
VERTICAL_TEC$_{s4,t-1}$	0.237***	0.104**	-0.148***	0.281***
	(0.059)	(0.059)	(0.030)	(0.089)
Observations	322516	322516	322516	
Firm FE	✓	✓	✓	
Country-Year FE	✓	✓	✓	
Sec4-Year FE	✓	✓	✓	

Notes: GLS. Cluster at c-s4-y. s.d.(HORIZONTAL)=0.16; s.d.(HORIZONTAL_TEC)=0.07; s.d.(VERTICAL_TEC)=0.15

- Increase competition decreases markups and increases MC due to lower scale of production.
- Knowledge spillovers decrease marginal cost.

Results - Direct Evidence on Technology Spillovers

DEPENDENT VARIABLE: log(Patents + 1)
SAMPLE: DOMESTIC FIRMS

	Full Sample (1)	Permanent Sample (2)
$\text{HORIZONTAL}_{s4,t-1}$	-0.094**	-0.258**
	(0.047)	(0.081)
$\text{VERTICAL\_TEC}_{s4,t-1}$	0.178***	0.210**
	(0.044)	(0.075)
$\text{HORIZONTAL\_TEC}_{s4,t-1}$	0.039	0.236**
	(0.052)	(0.083)
Observations	322516	101408
Firm FE	✓	✓
Country-Year FE	✓	✓
Sec4-Year FE	✓	✓
Cluster	cs4y	cs4y

Notes: OLS. s.d.(HORIZONTAL)=0.16; s.d.(HORIZONTAL_TEC)=0.07; s.d.(VERTICAL_TEC)=0.15

Results - Robustness

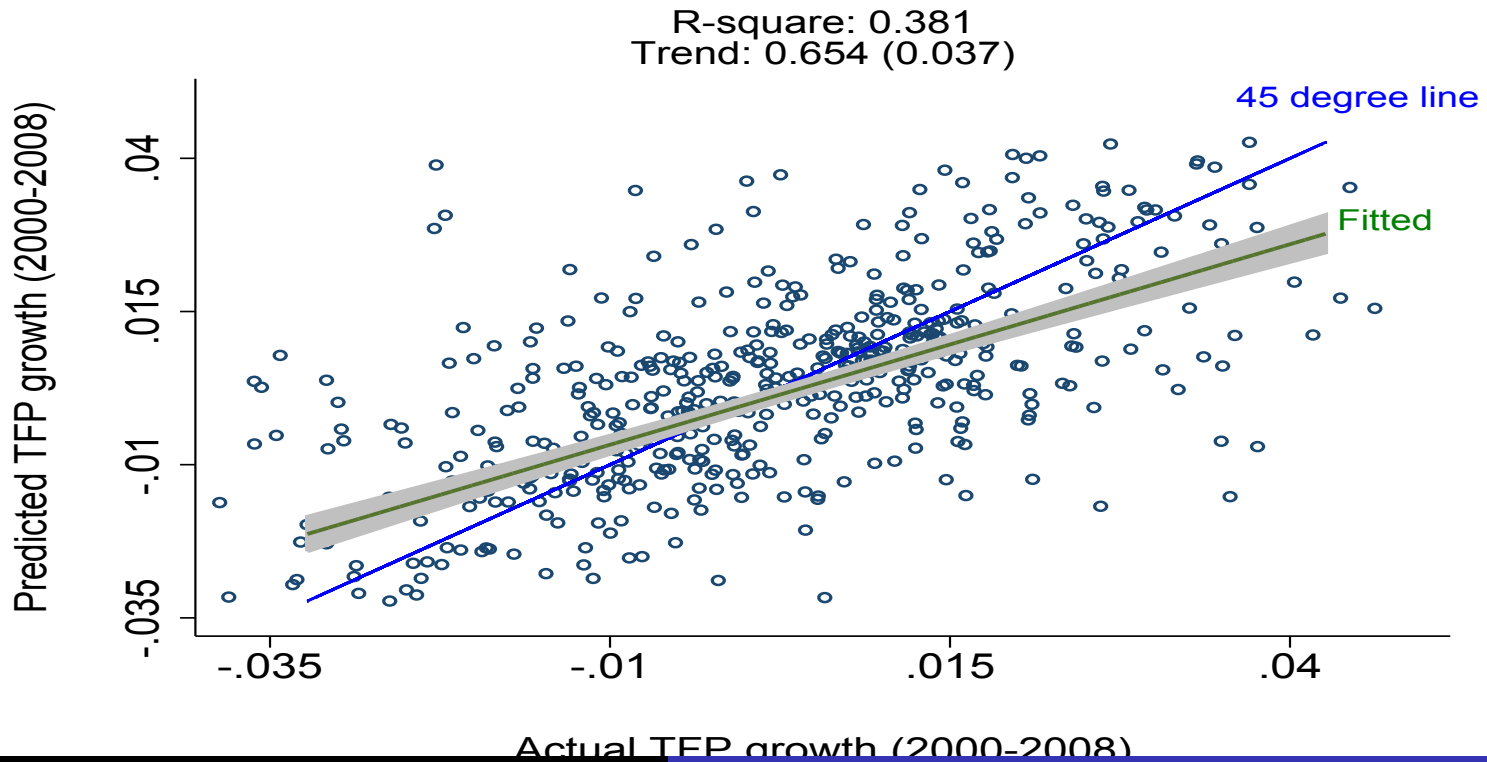
Dependent Variable: log Firm Revenue TFP
Sample: Domestic Firms

	(1) Benchmark	(2) Permanent	(3) OLS	(4) empl10	(5) sec2-year	(6) HHN
$\text{HORIZONTAL}_{s4,t-1}$	-0.330***	-0.533***	-0.361**	-0.485***	-0.503***	-0.283***
	(0.079)	(0.129)	(0.173)	(0.097)	(0.079)	(0.079)
$\text{HORIZONTAL\_TEC}_{s4,t-1}$	0.247**	0.586***	0.111	0.300**	0.638***	0.312***
	(0.078)	(0.153)	(0.189)	(0.093)	(0.078)	(0.078)
$\text{VERTICAL\_TEC}_{s4,t-1}$	0.237***	0.406**	0.326**	0.348***	0.311***	0.207***
	(0.059)	(0.120)	(0.133)	(0.061)	(0.059)	(0.059)
$\text{HERFIN}_{s4,t-1}$						-0.582***
						(0.116)
Observations	322516	101408	322516	221767	322523	322516
Firm FE	✓	✓	✓	✓	✓	✓
Country-Year FE	✓	✓	✓	✓	✓	✓
Sec4-Year FE	✓	✓	✓	✓		✓
Sec2-Year FE					✓	
Cluster	cs4y	cs4y	cs4y	cs4y	cs4y	cs4y

Evaluation - Predicted Effects

- Predicted effect on TFP:

$$\Delta \log(\mathrm{TFPR_i}) = \hat{\beta}_1 \Delta \mathrm{HORIZONTAL}_{s4(i)} + \hat{\beta}_3 \Delta \mathrm{HORIZONTAL\_TEC}_{s4(i)} + \hat{\beta}_4 \Delta \mathrm{VERTICAL\_TEC}_{s4(i)} \ .$$



Evaluation - Aggregate Effects

- Aim: quantify the average effects implied by changes in foreign ownership of a certain magnitude
- Consider the effect of an across-the-board change in foreign ownership in sector s4 of magnitude $\Delta \mathrm{fo}_{s4}$, evenly distributed across firms in each sector.
- The predicted change in firm-level TFPR is:

$$\begin{aligned}\Delta \log\left(\mathrm{TFPR}_{\mathrm{i,s4}}\right) &= \hat{\beta}_1 \Delta_{\mathrm{HORIZONTAL-pred}_{s4}} \\ &\quad + \hat{\beta}_3 \Delta_{\mathrm{HORIZONTAL\_TEC-pred}_{s4}} \\ &\quad + \hat{\beta}_4 \Delta_{\mathrm{VERTICAL\_TEC-pred}_{s4}} \ ,\end{aligned}$$

Evaluation - Aggregate Effects

- The total effect of an across-the-board change ($\Delta \text{fo}_i = \Delta \text{fo}_{s4} = \Delta \text{fo}$) is:

$$\Delta \log \left(\text{TFPR}_{\text{s4,pred1}} \right) = \left(\hat{\beta}_1 + \hat{\beta}_3 \, \text{WTECH}_{s4,s4} + \hat{\beta}_4 \right) \Delta \text{fo} \; .$$

- The effect of an increase of $2 * \Delta \text{fo}$ in the 50 percent of the sectors which have average connectedness above the median:

$$\begin{aligned} \Delta \log \left(\text{TFPR}^{\text{high}}_{\text{s4,pred}} \right) \quad = \quad & \Bigg(\hat{\beta}_1 * D_{high \; s4} * 2\Delta FO + \\ & \hat{\beta}_2 \, \text{WTECH}_{s4,s4} * D_{high \; s4} * 2\Delta FO + \\ & \hat{\beta}_3 * \sum_{\substack{\tilde{s}4 \neq s4 \\ \tilde{s}4, s4 \in s2}} \text{WTECH}_{s4,\tilde{s}4} \times D_{high \; \tilde{s}4} * 2\Delta FO \Bigg) \; . \end{aligned}$$

Predicted Effects of Increases in FDI

Sample: Domestic Firms

		(1)=(2)+(3)+(4)	(2)	(3)	(4)
Δ fo	Targeted Sectors	Δ log TFPR	ΔHORIZONTAL	ΔHORIZONTAL_TEC	ΔVERTICAL_TEC
10%	Across the Board Increase	0.10	-0.21	0.15	0.16
20%	Highly Connected Sectors	0.21	-0.32	0.27	0.26
20%	Less Connected Sectors	-0.13	-0.20	0.02	0.05

- An increase in foreign ownership of 10 percentage points leads to a predicted increase in productivity of 0.10 percent.
- Concentrating FDI in the 50 percent of sectors that are closest to other sectors in technology space on average → predicted TFP effect is twice as large (0.21 percent).
- Concentrating FDI in the 50 percent of sectors that are least connected to other sectors in technology space on average → negative spillovers (-0.13)

Conclusion

- We identify knowledge spillovers from foreign investment to domestic firms using novel measures of "closeness" of foreign-owned and domestic firms in the product and technology space.
  1. separate competition effects on domestic firms from knowledge spillovers when domestic and foreign-owned firms are close in product space,
  2. identify spillovers from foreign-owned firms that are close to domestic firms in technology space.

Conclusion

- We identify knowledge spillovers from foreign investment to domestic firms using novel measures of "closeness" of foreign-owned and domestic firms in the product and technology space.
  1. separate competition effects on domestic firms from knowledge spillovers when domestic and foreign-owned firms are close in product space,
  2. identify spillovers from foreign-owned firms that are close to domestic firms in technology space.

- We find significant effects for productivity of domestic firms as a result of the MNC presence within the same broad 2-dgt sector.
  - ✓ When MNCs enter the same four-digit sector as domestic firms, knowledge spillovers are fully off-set by negative competition effects.
  - ✓ Knowledge spillovers from MNCs that are close in technology space are positive and highly significant.

- The benefits for a host country from foreign investment is highly dependent on which sectors this investment takes place.

Thank you for attention!

New Spillovers Measures - Technology Based (Details)

- We construct two sector measures:
  - A measure of technology closeness of firms operating in the same four-digit sector (HORIZONTAL_TEC).
  - A measure of technology closeness of firms operating within the same two-digit but outside the four-digit (VERTICAL_TEC).

- We rely on the work of Bloom, Schankerman and Van Reenen (2013)
  - U.S. firm level Compustat data
  - Calculate the average share of patents each firm holds in each of the 426 technology classes over the period 1980-2001.
  - Define for each firm "i" its vector of technological activity: $t_i = (t_{i1}, t_{i2}, ..., t_{i426})$ where t_{ix} is the share of patents of firm i in technology class x.
  - For each firm pair i, j construct measures of technology closeness.

Back

Spillovers New Measures - Technology Based (Details)

- Firm technology closeness: Following Jaffe(1986) compute the uncentered correlation of patent share vectors t_i and t_j

$$\text{tech}_{ij} = \frac{(t_i t_j')}{(t_i t_i')^{1/2}(t_j t_j')^{1/2}} . \tag{5}$$

Spillovers New Measures - Technology Based (Details)

- Firm technology closeness: Following Jaffe(1986) compute the uncentered correlation of patent share vectors t_i and t_j

$$\text{tech}_{ij} = \frac{(t_i t_j')}{(t_i t_i')^{1/2}(t_j t_j')^{1/2}} . \tag{5}$$

- Sector technology closeness: Aggregate to the sector level - for each four-digit sector pair, we compute the *sectoral* technological closeness as the R&D-weighted sum of the technology closeness of firms operating in sector pairs $s4$ and $\tilde{s}4$

$$\text{SPILL\_RD}_{s4,\tilde{s}4} = \sum_{i \in s4} \sum_{j \in \tilde{s}4} \text{tech}_{ij} \times \underbrace{\left(\frac{r_i + r_j}{\sum_{k \in s4} \sum_{l \in \tilde{s}4} (r_k + r_l)} \right)}_{\text{R\&D weight}}, \tag{6}$$

Spillovers New Measures - Technology Based (Details)

- Firm technology closeness: Following Jaffe(1986) compute the uncentered correlation of patent share vectors t_i and t_j

$$\text{tech}_{ij} = \frac{(t_i t_j')}{(t_i t_i')^{1/2}(t_j t_j')^{1/2}} . \tag{5}$$

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$$\text{SPILL\_RD}_{s4,\tilde{s}4} = \sum_{i \in s4} \sum_{j \in \tilde{s}4} \text{tech}_{ij} \times \underbrace{\left(\frac{r_i + r_j}{\sum_{k \in s4} \sum_{l \in \tilde{s}4} (r_k + r_l)} \right)}_{\text{R\&D weight}}, \tag{6}$$

- Relative importance of the sector: We introduce weights that reflect the economic importance of the four-digit sectors $\tilde{s}4$ that are technologically linked to a given four-digit sector $s4$

$$\text{WTECH}_{s4,\tilde{s4},t} = \frac{\text{SPILL\_RD}_{s4,\tilde{s}4} \times \text{GO}_{\tilde{s}4,t}}{\sum_{\tilde{s}4 \in s2(s4)} \text{SPILL\_RD}_{s4,\hat{s}4} \times \text{GO}_{\hat{s}4,t}}, \tag{7}$$

Spillovers New Measures - Technology Based (Details)

- Vertical Technology Spillover:

$$\text{VERTICAL\_TEC}_{s4,t} = \sum_{\substack{\tilde{s}4 \in s2(s4) \\ \tilde{s}4 \neq s4}} \text{WTECH}_{s4,\tilde{s}4,t} \times \text{HORIZONTAL}_{\tilde{s}4,t} \ , \qquad (8)$$

- Horizontal Technology Spillover:

$$\text{HORIZONTAL\_TEC}_{s4,t} = \text{WTECH}_{s4,s4,t} \times \text{HORIZONTAL}_{s4,t} \ . \qquad (9)$$

Back

Technology or Pricing?

- Revenue total factor productivity:

$$\mathrm{TFPR}_{it} \equiv P_{it}\mathrm{TFPQ}_{\mathrm{it}} = \mu_{\mathrm{it}} \times \mathrm{MC}_{\mathrm{it}} \times \mathrm{TFPQ}_{\mathrm{it}} \,, \tag{10}$$

- Turning to percentage changes (denoted by Δ) and re-arranging, change in physical productivity:

$$\Delta\mathrm{TFPQ}_{it} \;=\; \Delta\mathrm{TFPR}_{\mathrm{it}} - \Delta\mu_{\mathrm{it}} - \Delta\mathrm{MC}_{\mathrm{it}} \,. \tag{11}$$

Technology or Pricing?

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$$\Delta\mathrm{TFPQ}_{it} \;=\; \Delta\mathrm{TFPR}_{\mathrm{it}} - \Delta\mu_{\mathrm{it}} - \Delta\mathrm{MC}_{\mathrm{it}}\,. \tag{11}$$

- Markup estimation following De Loecker and Warzynski (2012)

$$\mu_{it} \equiv \frac{P_{it}}{MC_{it}} = \underbrace{\frac{\partial \mathcal{F}_{it}(\cdot)}{\partial \mathcal{J}_{it}} \frac{\mathcal{J}_{it}}{\mathcal{F}_{it}(\cdot)}}_{OutputElasticity} \Big/ \underbrace{\frac{P_{it}^{\mathcal{J}_{it}} \mathcal{J}_{it}}{P_{it}\mathrm{y}_{it}}}_{ExpenditureShare}\,, \tag{12}$$

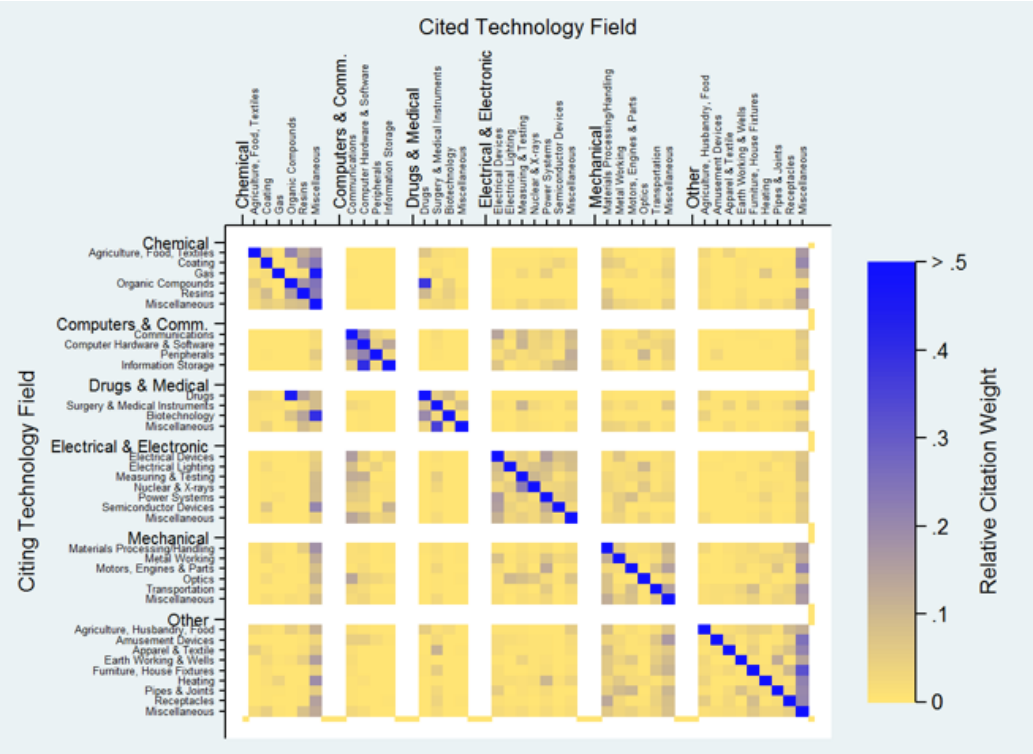
  P_{it} is the output price, MC_{it} is marginal cost, $\mathcal{F}_{it}(\cdot)$ is the production function, $\mathcal{J}_{it}$ is inputs, and $P_{it}\mathrm{y}_{it}$ is nominal value added.

- Marginal Cost approximated with Average Cost: (material and wage cost normalized by revenue) Back

Citation Matrix (Acemoglu, Akcigit, Kerr (2016))

Back

Citation matrix, 1975-1984.



Effect of customer-supplier relationships

Dependent Variable: log Firm Revenue TFP. Sample: Domestic Firms
Vertical spillovers inspired by Javorcik (2004) but at 4-dgt

	(1)	(2)	(3)	(4)	(5)
VERTICAL_TEC$_{s4,t-1}$	0.296***	0.281***	0.370***	0.370***	0.326***
HORIZONTAL$_{s4,t-1}$	-0.503***	-0.503***	-0.503***	-0.519***	-0.471***
HORIZONTAL_TEC$_{s4,t-1}$	0.617***	0.644***	0.677***	0.703***	0.794***
BACKWARD_WITHIN2$_{s4,t-1}$		0.042	0.035	-0.007	0.035
BACKWARD_OUT2$_{s4,t-1}$		0.146**	0.120**	0.051	0.051
BACKWARDTECH_OUT2$_{s4,t-1}$			0.989***	1.054***	1.126***
log DEMAND$_{s4,t-1}$				0.942***	0.837***
log HERFIN$_{s4,t-1}$					-0.582***
Observations	323,730	322,523	322,523	322,523	322,523
Cluster	cs4y	cs4y	cs4y	cs4y	cs4y

Notes: Backward spillover measures are a weighted sum of the foreign presence in industries that are being supplied by sector $s4$.

OLS. Firm, Country-Year, Sec2-Year FE included. Coefficients are standardized

Our data covers large portion of the output (Turnover) from Eurostat

Value of total output from our firm-level data relative to value of total output produced by Eurostat (SBS).

	Belgium	Finland	France	Italy	Spain	Norway
A: Total Economy						
2000	0.65	0.40	0.57	0.50	0.64	0.63
2004	0.63	0.51	0.70	0.57	0.68	0.67
2006	0.62	0.51	0.68	0.58	0.71	0.67
2008	0.73	0.57	0.79	0.72	0.80	0.59
B: Manufacturing Sector						
2000	0.8	0.34	0.76	0.66	0.77	0.60
2004	0.8	0.41	0.83	0.73	0.79	0.72
2006	0.78	0.4	0.84	0.79	0.83	0.75
2008	0.78	0.49	0.9	0.9	0.85	0.69

Our data matches well the Eurostat by size distribution in manufacturing

The share of gross output (turnover) accounted for by firms belonging in three size categories in the year 2006.

	Belgium	Finland	France	Italy	Spain	Norway
A: ORBIS-AMADEUS						
1 to 19 employees	0.05	0.08	0.05	0.12	0.13	0.11
20 to 249 employees	0.30	0.38	0.23	0.49	0.40	0.40
250 + employees	0.66	0.54	0.72	0.40	0.47	0.49
B: EUROSTAT (SBS)						
0 to 19 employees	0.08	0.06	0.09	0.20	0.14	0.13
20 to 249 employees	0.27	0.21	0.27	0.41	0.38	0.36
250 + employees	0.65	0.74	0.64	0.39	0.49	0.51

Notes: back

Measuring TFP

- Total Factor Productivity (TFP)

$$\log TFP_{i,t} = \log(Y_{i,t} - M_{i,t}) - \alpha_1 \log L_{i,t} - \alpha_2 \log K_{i,t}$$

- Y: output, M: materials, L: employment and K: capital.

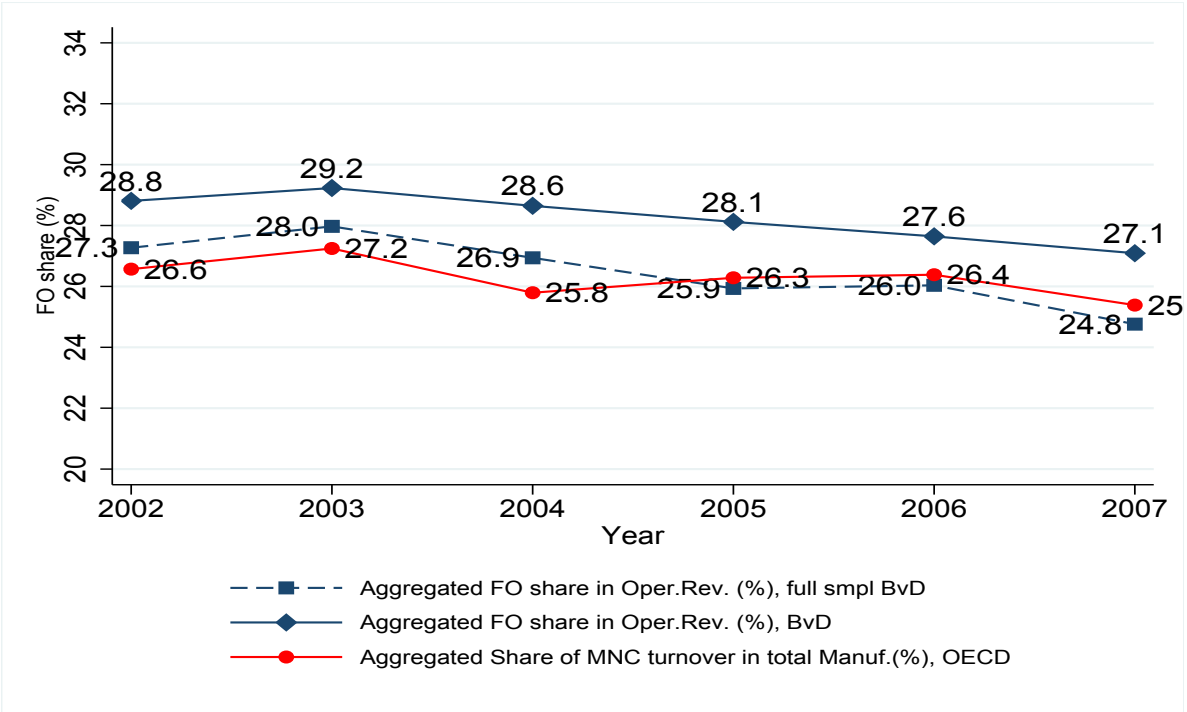
- α_1 and α_2 estimated, by country-sector, using the non-parametric approach of Levinsohn and Petrin (2003) and Wooldridge (2009) (WLP) that takes into account the Ackerberg, Caves and Frazer (2015) critique.

- We use revenue productivity (TFPR).
- There can be a role for firm-specific demand/mark-up changes as a result of change in ownership.

Notes: back

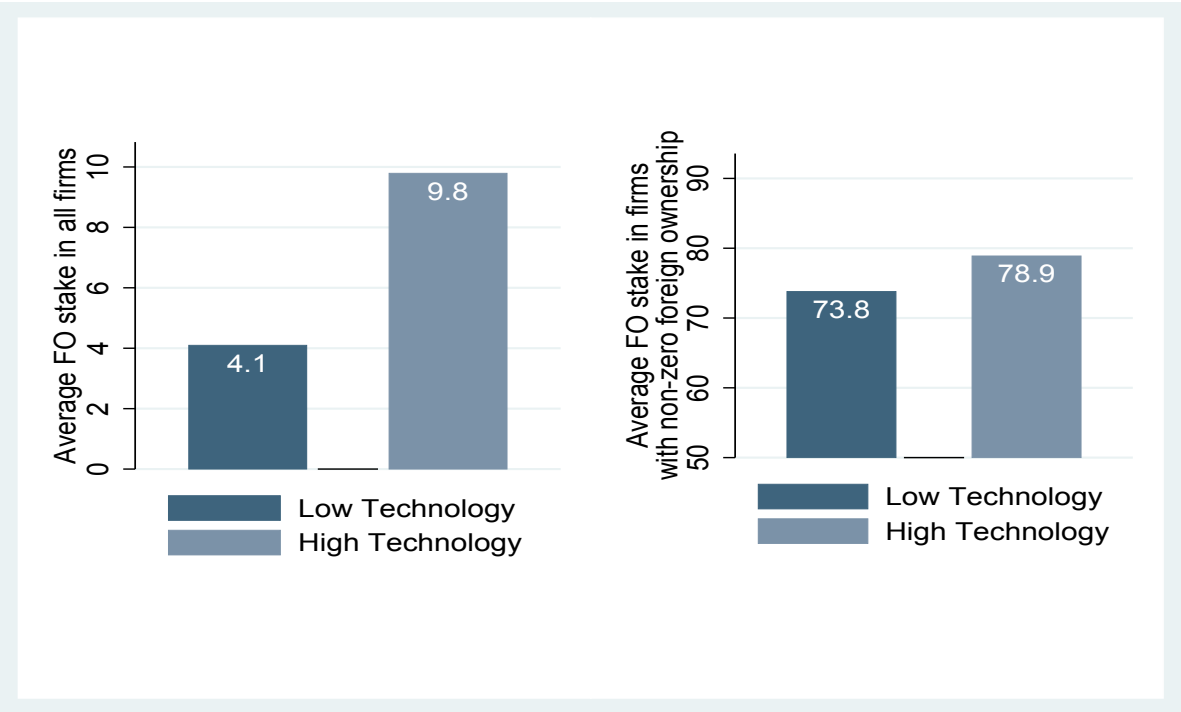
BvD compared to OECD database

Figure: Foreign Shares in Turnover: BvD vs. OECD Data



Notes: The shares from the BvD data are computed as the ratios of the aggregated foreign turnover to total turnover over firms i, sectors $s4$ and countries c in the balanced (permanent) firm sample (solid line with diamonds) and in the full sample (dashed line with squares). Foreign presence from the OECD data (solid line with circles) is the sum of the multinational turnover in manufacturing divided by the total manufacturing turnover in these countries.

Foreign Ownership Distribution



Notes: back