Can Innovation Help U.S. Manufacturing Firms Escape Import Competition from China?

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Motivation

- Increased interest in academia for effects of import from low-wage countries (e.g. Krugman, 1996 *Pop Internationalism* vs Leamer, 2007; Krugman, 2008)

The China Syndrome

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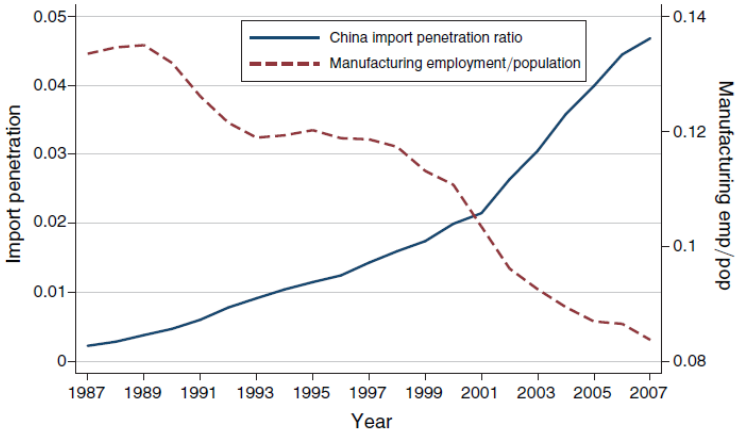

- China ⇒ decline in employment (Autor, Dorn and Hanson, 2013; Acemoglu et al., 2014)
- China ⇒ decline in firm performance (sales growth and profitability)

Solution = Innovation?

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  - **Policy response** (R&D subsidies, etc.)
    - e.g. EU's Lisbon Strategy (2001)
  - **Firms response** (Bloom et al. 2016, Autor et al. 2017, Chakravorty et al. 2017) $\Rightarrow \neq$ results
- **Little *direct* evidence** R&D effective shield against import competition

Our paper

1. Does returns to R&D $\Uparrow$ with trade shocks from low-wage countries?
2. Channel = Product differentiation vs higher productivity (lower costs)?
3. Real effects on investment and employment?
4. Implications for public policies?

Theory

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- Arrow (1962): Competition reduces ***pre*-innovation rents**

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- Joint combination: “Inverted U-shape” (Aghion et al. 2005)

Estimate Returns to R&D

Ex-post R&D investment *following* $\Uparrow$ competition ("revealed preference"): **BUT**

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Ex-post R&D investment *following* $\Uparrow$ competition ("revealed preference"): **BUT**

- **Partial** estimate
  - Elasticity = f(Returns, Cost structure)
- **Biased** estimate
  - *Exogenous* trade shock $\Rightarrow$ **other constraints** to R&D
    - $\Downarrow$ R&D spending even if NPV>0 project

Empirical Design: Direct Approach

- **Q:** Are U.S. manufacturing firms with larger ex-ante stock of R&D more resilient to trade shocks from China?
- Identification challenge: need exogenous variations in
  (a) Imports from China

  (b) Firm-level investment in R&D

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    (2) adoption of Permanent Normal Trade Relations (PNTR) in 2001
  (b) Firm-level investment in R&D
    → instrument using eligibility to R&D subsidies
- **A: Yes**
  - Moving from 25^{th} to 75^{th} percentile of R&D distribution **offsets about half** of the adverse effects of Chinese competition

Literature

1. **Trade shocks ⇒ Firms and workers**
   - Output and survival: Bernard, Jensen and Schott (2006)
   - Employment and wages: Autor, Dorn and Hanson (2013)
   - Cost of debt: Valta (2012)
   - Leverage: Xu (2012)
   - Capital expenditure: Fresard and Valta (2014)
2. **Trade shocks × Characteristics ⇒ Firms and workers**
   - Physical capital: Bernard, Jensen and Shott (2006)
   - Workers' education: Autor, Dorn, Hanson and Song (2014)
3. **Competition ⇒ Innovation**
   - Theory: Schumpeter (1943), Arrow (1962), Aghion, Bloom, Blundell, Griffith and Howitt (2005)
   - Evidence: Aghion et al. (2005), Aghion et al. (2009), Amiti and Khandelwal (2013), Bloom, Draca and Van Reenen (2016), Autor et al. (2016)

Setting

Setting: Firm Environment

- Firm **innovation** decision
  - Set innovation effort $R \geq 0 \Rightarrow$ Innovation success: $P[I = 1|R] = R$
  - Innovation cost: $c(R) = R + \theta R + \frac{\rho}{2} R^2$
- Firms face **import competition** of intensity T
  - Which may affect θ directly

Setting: Firm Environment

- Firm performance:

$$\pi_I = a_I - b_I T, \qquad \forall I \in \{0, 1\}$$

- We assume:
  - Innovation useful: $a_1 > a_0, \quad \forall\, T$
  - Competition reduces profit: $b_0 > 0, \quad b_1 > 0$

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- b_0: "**Escape competition / Arrow effect**" (by how much import reduces *pre*-innovation performance)

- b_1: "**Schumpeterian effect**" (by how much import competition reduces *post*-innovation performance)

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$$\pi = a_0 + (a_1 - a_0)I + [\overbrace{-b_0 + (b_0 - b_1)I)}^{\text{Sensitivity of performance to import}}]T \quad (1)$$

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- Escape competition ($b_0 > b_1$): competition shock $\Uparrow$ innovative edge
- Schumpeter effect ($b_0 < b_1$): competition shock $\Downarrow$ innovative edge

Setting: Firm Performance

- Rewriting firm performance:

$$\pi = \alpha + \gamma I + \beta T + \delta T I$$

- where $\alpha = a_0 > 0$, $\gamma = a_1 - a_0 > 0$, $\beta = -b_0 < 0$ and $\delta = b_0 - b_1$

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- **Our paper: estimate $\boldsymbol{\delta}$**

Previous Literature: Endogenous ex-post R&D Investment

Firm Optimal R&D Investment:

$$R^* = \arg\max_R E\big[\pi|R\big] - c\big(R\big) = \frac{1}{\rho}\big(\gamma + \delta T - (1+\theta)\big)$$

- Spending in R&D depends on:

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  - Technological parameter ρ (unobserved)
  - Opportunity cost θ
    - Credit constraints, agency issues, etc.

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$\Rightarrow$ **Two** limitations

Limits of ex-post R&D Investment

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2. *Biased* estimate: NPV>0 R&D can be cut because $Cov(\theta, T) > 0$
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- **Conclusions**:
  - $\neq$ in estimated R&D spending elasticity may come from $Cov(\theta, T)$ rather than $\neq$ in the position in the "inverted U-shape" curve
  - Need to **estimate directly** how firm performance Δ with $R\&D \times Competition$

Our Setting: Direct Approach

- Δ Firm performance (sales growth, profitability) wrt R&D and competition:

$$\boldsymbol{\pi} = \alpha + \gamma I + \beta T + \boldsymbol{\delta} T I$$

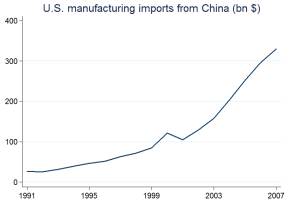
- δ: how returns to R&D Δ with import competition
- **Our paper: estimate δ**

Empirics

Trade shocks

- China's export boom

1. Large shock
2. Plausibly exogenous from U.S. perspective (China's transition to market economy, lowering of trade costs)
3. Cross-industry heterogeneity



1991-2007 change in U.S. imports from China (k$/worker)

Broad industries	Mean
Toys/Other	82.2
Machines/Electrical	33.6
Textile/Apparel/Leather	24.2
Wood/Furniture	17.4
Plastic/Rubber/Glass	12.4
Metal/Metal products	10.9
Chemical/Petroleum	6.5
Transportation	3.9
Paper/Print	2.6

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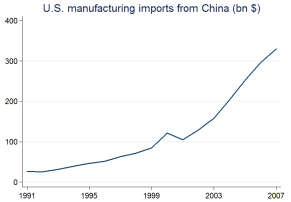

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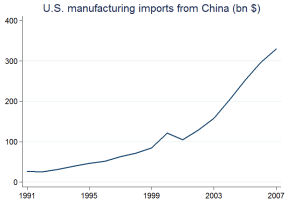

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Toys/Other	82.2	134.8
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Wood/Furniture	17.4	18.6
Plastic/Rubber/Glass	12.4	18.7
Metal/Metal products	10.9	12.2
Chemical/Petroleum	6.5	10.3
Transportation	3.9	9.5
Paper/Print	2.6	5.5

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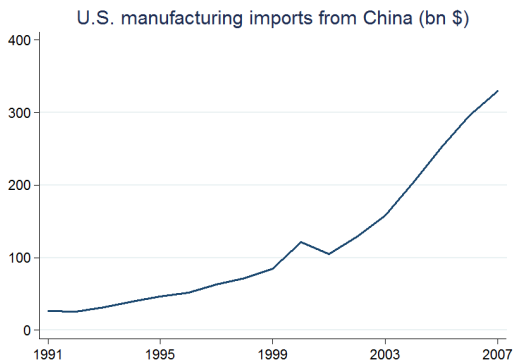

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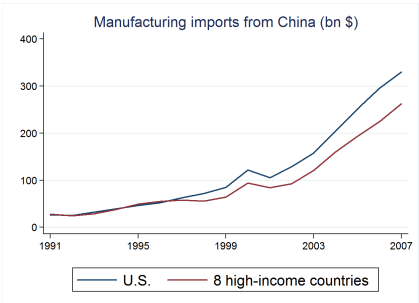
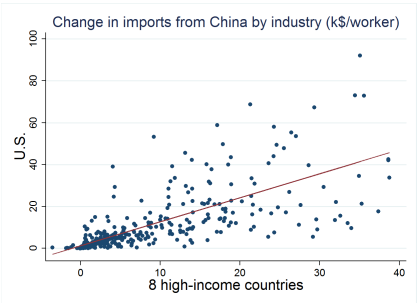




sub-periods | individual country | by industry

Trade shocks

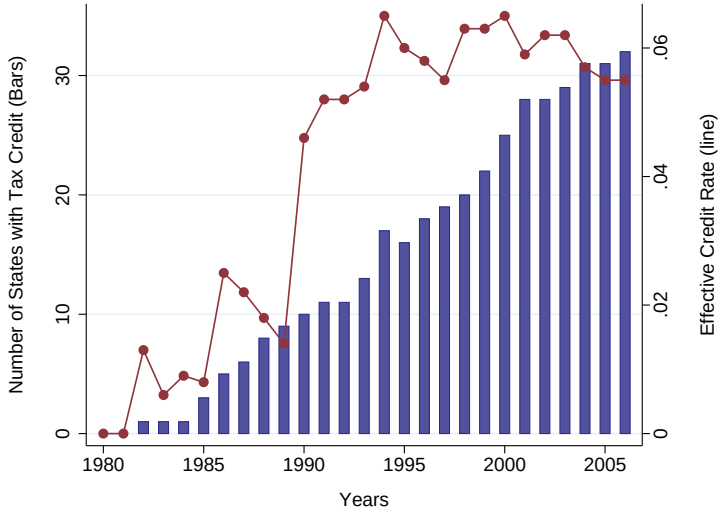
- First stage (188 four-digit industries, 1991–2007):

	U.S. Imports/Worker
Other High-Income Countries' Imports/Worker	1.36***
	(0.13)
Observations	2,885
Industry FE	Yes
Year FE	Yes
Adjusted R2	0.94

(F-test clustered by industry and year = 127)

R&D tax credits

- Staggered adoption since 1982 (Minnesota)



R&D tax credits

- Eligibility depends on *where R&D is conducted* (exogeneity)
- Patent data to:
  i. identify patents filed by Compustat firms
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  iii. compute the share of inventors in each state over 10-year rolling window
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- **First stage**:
  (F-test = 12.4)

	R&D/Total assets
User cost of R&D	-0.11***
	(0.03)
Observations	55,541
Firm FE	Yes
Year FE	Yes
Adj-R2	0.73

R&D price ↓ 1% $\Longrightarrow$ R&D/Assets ↑ 0.11 p.p. (mean=6.8%)
$\Longrightarrow$ R&D ↑ 1.5%

Stock of R&D

- Cumulate instrumented R&D flow into R&D stock
  - assuming zero stock in first year in Compustat
  - using 15% depreciation rate (Hall, Jaffe and Trajtenberg, 2005)

Specification

- Compustat manufacturing firms i in industry j with at least one patent, 1991–2007

$$\begin{aligned} FirmOutcome_{ijt} = & ImportPenetration_{j,t-1} + R\&DStock_{i,t-1} \\ & + ImportPenetration_{j,t-1} \times R\&DStock_{i,t-1} \\ & + Controls_{i,t-1} + \text{Firm FE} + \text{Year FE} \end{aligned}$$

(bootstrap standard errors clustered by industry and year)

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(bootstrap standard errors clustered by industry and year)

rd-geographic-distribution

Specification

- Concern: R&D stock is mechanically correlated with age
- A problem if firms of different age react differently to trade shocks
- $\longrightarrow$ Control for $ImportPenetration \times Age$

Sales growth

- On average across firms 1 s.d. ⇑ in import penetration = ⇓ annual sales growth by 2 pp

	(1)	(2)	(3)	(4)
Import penetration	-0.84***	-1.30***		
	(0.21)	(0.24)		
Import penetration × R&D Stock		0.83**	1.07***	1.11***
		(0.33)	(0.40)	(0.39)
Assets	0.01	0.03***	0.03***	0.03***
	(0.01)	(0.01)	(0.01)	(0.01)
Age	-0.20***	-0.23***	-0.23***	-0.23***
	(0.01)	(0.01)	(0.02)	(0.02)
R&D Stock		0.07***	0.07***	0.07***
		(0.02)	(0.03)	(0.03)
Import penetration × Age				-0.67
				(0.46)
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	–	–
Industry-Year FE	No	No	Yes	Yes
Observations	23,907	23,907	23,907	23,907

Sales growth

- On average across firms 1 s.d. ⇑ in import penetration = ⇓ annual sales growth by 2 pp
- 25th→75th percentile of R&D reduces the decline in sales growth by 1pp (half unconditional effect)

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				(0.46)
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	–	–
Industry-Year FE	No	No	Yes	Yes
Observations	23,907	23,907	23,907	23,907

ROA

- On average across firms a 1 s.d. increase in import penetration reduces ROA by 1.1 percentage point
- Moving from 25th to 75th percentile of R&D reduces the decline in ROA by 1 percentage point (same as unconditional effect)

	(1)	(2)	(3)	(4)
Import penetration	-0.49**	-1.06***		
	(0.20)	(0.22)		
Import penetration × R&D Stock		1.13**	1.41***	1.42***
		(0.47)	(0.54)	(0.54)
Assets	0.06***	0.01	0.01	0.01
	(0.01)	(0.01)	(0.01)	(0.01)
Age	0.06***	0.13***	0.15***	0.15***
	(0.01)	(0.02)	(0.02)	(0.02)
R&D Stock		-0.19***	-0.21***	-0.21***
		(0.02)	(0.03)	(0.03)
Import penetration × Age				-0.20
				(0.34)
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	–	–
Industry-Year FE	No	No	Yes	Yes
Observations	24,533	24,533	24,533	24,533

Real Effects?

- Do firms adjust the factors of production?
  - Capital
  - Labor

Capital expenditures

- On average across firms a 1 s.d. increase in import penetration reduces capex by 1.6% of fixed assets
- Moving from 25th to 75th percentile of R&D reduces the decline in capex by 1.4% of fixed assets (same as unconditional effect)

	(1)	(2)	(3)	(4)
Import penetration	-0.74*	-1.65***		
	(0.39)	(0.45)		
Import penetration × R&D Stock		1.67***	1.77***	1.79***
		(0.60)	(0.68)	(0.67)
Assets	0.03***	0.04***	0.05***	0.05***
	(0.01)	(0.02)	(0.02)	(0.02)
Age	-0.41***	-0.42***	-0.44***	-0.44***
	(0.02)	(0.03)	(0.03)	(0.03)
R&D Stock		0.01	0.02	0.02
		(0.04)	(0.04)	(0.04)
Import penetration × Age				-0.33
				(0.82)
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	–	–
Industry-Year FE	No	No	Yes	Yes
Observations	24,321	24,321	24,321	24,321

Employment

- Moving from 25th to 75th percentile of R&D reduces the decline in employment growth by 0.7 p.p.

	(1)	(2)	(3)	(4)
Import penetration	-0.18	-0.63**		
	(0.21)	(0.28)		
Import penetration × R&D Stock		0.77**	0.88**	0.92**
		(0.32)	(0.39)	(0.37)
Assets	0.02***	0.06***	0.07***	0.07***
	(0.01)	(0.01)	(0.01)	(0.01)
Age	-0.20***	-0.25***	-0.24***	-0.25***
	(0.01)	(0.01)	(0.02)	(0.02)
R&D Stock		0.13***	0.13***	0.13***
		(0.02)	(0.02)	(0.02)
Import penetration × Age				-0.81*
				(0.47)
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	–	–
Industry-Year FE	No	No	Yes	Yes
Observations	23,197	23,197	23,197	23,197

Robustness

- Exogenous increase in Chinese Import: suppression of the uncertainty about the renewal of China's tariffs NTR (Normal Tariff Relation) after 2001 (Pierce and Schott, 2016) (ntr)
- Non-monotonicity of the effect (arrow-schumpeter)
- Adjusting for trade shocks in input markets (input market)
- Multi-segment firms (multi-segment)
- Excluding California (excluding-california)
- Firm HQ instead of inventor location

Channel(s) ?

- R&D can:
  1. ⇑ product differentiation (Sutton, 1991)
  2. ⇑ productivity (e.g. Grossman and Helpman, 1991)

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  - (1) and (2) have positive *unconditional* effect on firm performance
  - but opposite *conditional* effect

Channel(s) ?

- R&D can:
  1. ⇑ product differentiation (Sutton, 1991)
  2. ⇑ productivity (e.g. Grossman and Helpman, 1991)
- Model of low-cost competition with vertical differentiation:
  - (1) and (2) have positive *unconditional* effect on firm performance
  - but opposite *conditional* effect
- ⇑ low-cost competition = ⇑ marginal benefit of vertical differentiation
- Resilience of R&D happens through **product differentiation**

Three Empirical Implications

1. *Benefit* of differentiation $\Uparrow$ with import penetration

2. *Incentives* to differentiate higher *following* $\Uparrow$ import penetration

3. Resilient effect of R&D stronger in industries where vertical differentiation more important

Measuring Differentiation

- Hyp: R&D allows firms to differentiate from Chinese competitors

- Hoberg and Phillips' (2010, 2015) text-based measure of product similarity $\in [0, 1]$ between each pair of U.S. firms

  $\rightarrow$ Differentiation w.r.t. U.S. competitors as proxy for differentiation w.r.t. Chinese competitors

Channel 1: Differentiation Becomes More Important

- Two ingredients:
  - R&D $\Rightarrow$ product differentiation unconditionally
  - Impact of differentiation on firm performance $\Uparrow$ with import penetration

Channel 1: Differentiation Becomes More Important

- R&D leads to higher differentiation, *unconditionally*

	Differentiation		Sales growth		ROA	
	(1)	(2)	(3)	(4)	(5)	(6)
R&D Stock	.0015**	.0011*				
	(.00067)	(.00062)				
Import penetration			-16**		-9.7***	
			(7.2)		(3.7)	
Import penetration × Differentiation(t-1)			16**	15*	9.4**	12***
			(7.4)	(9.2)	(3.9)	(4.5)
Differentiation(t-1)			-.51	-.73	.02	-.069
			(.37)	(.46)	(.17)	(.21)
FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	–	Yes	–	Yes	–
Firm Controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry-Year FE	–	Yes	–	Yes	–	Yes
Observations	15,637	15,637	12,767	12,767	12,767	12,767

Channel 1: Differentiation Becomes More Important

- R&D leads to higher differentiation, *unconditionally*
- Return to differentiation increases with import penetration

	Differentiation		Sales growth		ROA	
	(1)	(2)	(3)	(4)	(5)	(6)
R&D Stock	.0015**	.0011*				
	(.00067)	(.00062)				
Import penetration			-16**		-9.7***	
			(7.2)		(3.7)	
Import penetration × Differentiation(t-1)			16**	15*	9.4**	12***
			(7.4)	(9.2)	(3.9)	(4.5)
Differentiation(t-1)			-.51	-.73	.02	-.069
			(.37)	(.46)	(.17)	(.21)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	–	Yes	–	Yes	–
Firm Controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry-Year FE	–	Yes	–	Yes	–	Yes
Observations	15,637	15,637	12,767	12,767	12,767	12,767

Channel 2: Differentiation increases

- On average across firms a 1 s.d. increase in import penetration increases product differentiation by 0.05 s.d.
- Moving from 25th to 75th percentile of R&D amplifies the increase in differentiation by 25%

	Average product distance from U.S. peers			
	(1)	(2)	(3)	(4)
Import penetration	.035**	.024		
	(.016)	(.018)		
Import penetration × R&D Stock		.026	.023**	.023**
		(.017)	(.011)	(.011)
Assets	-.00082***	-.00021	-.00029	-.00029
	(.00026)	(.00034)	(.00034)	(.00034)
Age	.001**	.00034	.00058	.0004
	(.00052)	(.00058)	(.00059)	(.00059)
R&D Stock		.0018**	.00087	.00086
		(.00088)	(.00073)	(.00073)
Import penetration × Age				-.019
				(.022)
Observations	15,896	15,896	15,896	15,896
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	–	–
Industry-Year FE	No	No	Yes	Yes

Ancillary: Differentiation across Industries

- Effect concentrated on industries where **average** differentiation is higher

	Sales Growth		ROA	
	(1)	(2)	(3)	(4)
Import penetration × R&D Stock	0.25	0.48	0.01	0.21
	(0.35)	(0.40)	(0.62)	(0.64)
Import penetration × R&D Stock × Ind. Differentiation	1.55*	1.88**	2.43***	3.13***
	(0.90)	(0.97)	(0.92)	(1.00)
Observations	23,074	23,074	23,710	23,710
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	—	Yes	—
Controls-Interacted	Yes	Yes	Yes	Yes
Industry-Year FE	—	Yes	—	Yes

Take away

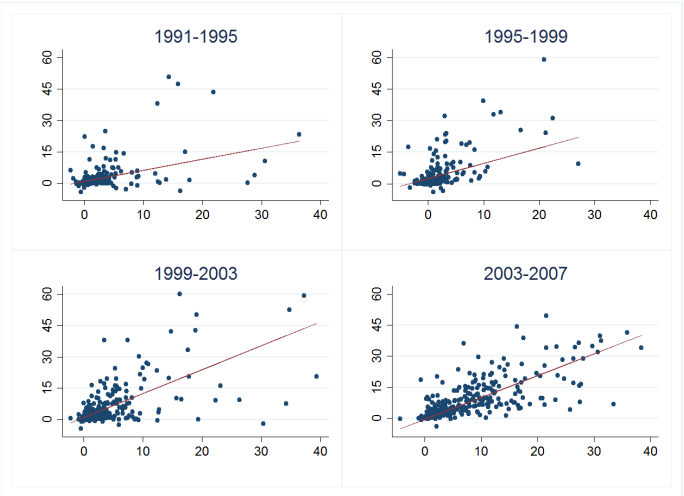
- Regressing R&D on *exogenous* competition shock does *not* identify returns to R&D wrt to competition
  - **Partial**
  - **Biased** if competition $\Rightarrow$ **other constraints** to R&D
    - R&D can be cut even if NPV> 0

Take away

- Regressing R&D on *exogenous* competition shock does *not* identify returns to R&D wrt to competition
  - **Partial**
  - **Biased** if competition $\Rightarrow$ **other constraints** to R&D
    - R&D can be cut even if NPV> 0
- Using direct approach: returns to R&D increases with trade shocks
- Suggestive evidence that R&D allows firms to differentiate their products
- Policy implications: relaxing credit constraints rather than subsidising R&D?

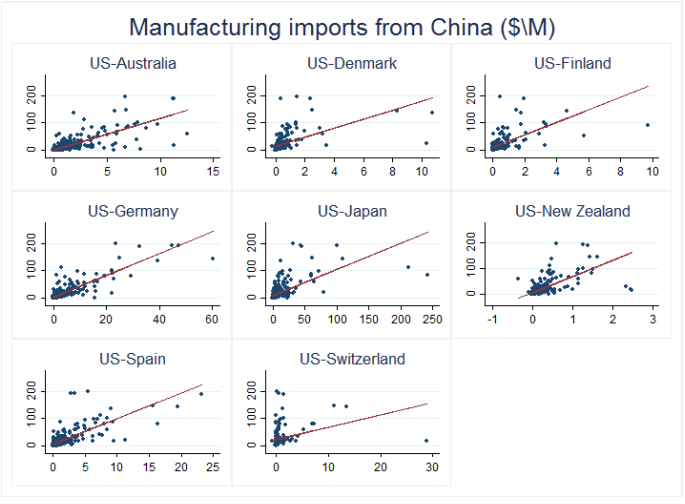
Thank You

Correlation Across Sub-Periods



back

Correlation by Country



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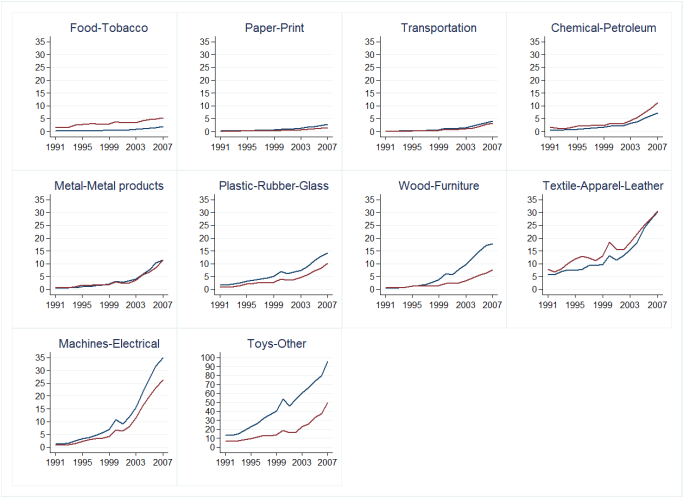
Correlation by Industry



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Geographical Distribution of R&D by Industry

Industry-by-industry ranking of states	Share of industry R&D in the state
Top state	32.9%
2nd state	17.2%
3rd state	11.3%
4th state	8.2%
5th state	6.1%
6th state	4.7%
7th state	3.6%
8th state	2.9%
9th state	2.4%
10th state	2.0%

back

Alternative Shock from China

- Since 1930, non-market economies are exposed to higher tariffs (”non-NTR”)
- In 2000, Congress granted PNTR to China $\Rightarrow$
  - $\Downarrow$ Expected tariff
  - $\varnothing$ Uncertainty

Alternative Shock from China

- Since 1930, non-market economies are exposed to higher tariffs ("non-NTR")
- In 2000, Congress granted PNTR to China ⇒
  - ⇓ Expected tariff
  - ∅ Uncertainty

- Pierce and Schott (2016): industries in high NTR gap experienced higher employment loss and increased imports from China post 2000
- $NTRGap_i$ = $NonNTRRate_i$ - $NTRRate_i$

$$
\begin{aligned}
FirmOutcome_{ijt} = & NTRGap_i \times Post2000_t + R\&DStock_{i,t-1} \\
& + NTRGap_i \times Post2000_t \times R\&DStock_{i,t-1} \\
& + Controls_{i,t-1} + \text{Firm FE} + Year \times SIC4FE
\end{aligned}
$$

Alternative Shock from China

- *Unconditional* negative impact

Dep. Var	Sales Growth		ROA		Capex		Emp Growth	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
NTR Gap × Post	-0.12**		-0.10***		-0.14**		-0.05	
	(0.06)		(0.03)		(0.06)		(0.04)	
NTR Gap × Post × R&D Stock		0.17***		0.09**		0.31***		0.15***
		(0.05)		(0.04)		(0.06)		(0.04)
R&D Stock	0.08***	0.05*	-0.14***	-0.18***	0.03	-0.03	0.15***	0.12***
	(0.02)	(0.03)	(0.02)	(0.02)	(0.03)	(0.03)	(0.02)	(0.02)
Assets	0.03***	0.03***	0.01	0.00	0.04***	0.04***	0.06***	0.07***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Age	-0.24***	-0.23***	0.06***	0.08***	-0.33***	-0.32***	-0.24***	-0.22***
	(0.01)	(0.02)	(0.01)	(0.01)	(0.02)	(0.02)	(0.01)	(0.01)
Observations	23,471	23,471	23,471	23,471	23,471	23,471	22,234	22,234
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	–	Yes	–	Yes	–	Yes	–
Industry-Year FE	–	Yes	–	Yes	–	Yes	–	Yes

Alternative Shock from China

- *Unconditional* negative impact
- R&D absorb negative shock in **similar magnitude** as before

Dep. Var	Sales Growth		ROA		Capex		Emp Growth	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
NTR Gap × Post	-0.12**		-0.10***		-0.14**		-0.05	
	(0.06)		(0.03)		(0.06)		(0.04)	
NTR Gap × Post × R&D Stock		0.17***		0.09**		0.31***		0.15***
		(0.05)		(0.04)		(0.06)		(0.04)
R&D Stock	0.08***	0.05*	-0.14***	-0.18***	0.03	-0.03	0.15***	0.12***
	(0.02)	(0.03)	(0.02)	(0.02)	(0.03)	(0.03)	(0.02)	(0.02)
Assets	0.03***	0.03***	0.01	0.00	0.04***	0.04***	0.06***	0.07***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Age	-0.24***	-0.23***	0.06***	0.08***	-0.33***	-0.32***	-0.24***	-0.22***
	(0.01)	(0.02)	(0.01)	(0.01)	(0.02)	(0.02)	(0.01)	(0.01)
Observations	23,471	23,471	23,471	23,471	23,471	23,471	22,234	22,234
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	–	Yes	–	Yes	–	Yes	–
Industry-Year FE	–	Yes	–	Yes	–	Yes	–	Yes

back

Schumpeter vs. Arrow?

- Effect of competition on returns to R&D?
  - Schumpeter (1943): Competition reduces post-innovation rents $\Rightarrow$ Reduces returns to innovation
  - Arrow (1962): Competition reduces pre-innovation rents $\Rightarrow$ Increases returns to innovation
- Evidence: Aghion et al. (2005) inverse U-shaped
- Our data: Increasing on average. Non-monotonic?

Arrow!

	Sales Growth	ROA	Capital Expenditures	Employment Growth
	(1)	(2)	(3)	(4)
Import penetration × R&D Stock	2.63**	2.72**	6.82***	3.09***
	(1.07)	(1.17)	(1.75)	(0.90)
Import penetration^2 × R&D Stock	-13.13*	-11.61	-43.76***	-18.76***
	(7.75)	(7.87)	(12.78)	(6.71)
Assets	0.03***	0.01	0.05***	0.07***
	(0.01)	(0.01)	(0.02)	(0.01)
Age	-0.23***	0.15***	-0.44***	-0.24***
	(0.02)	(0.02)	(0.03)	(0.02)
R&D Stock	0.07**	-0.22***	0.00	0.12***
	(0.03)	(0.03)	(0.04)	(0.02)
Import penetration × Age	-0.76**	-0.63***	-1.13**	-0.55**
	(0.30)	(0.24)	(0.51)	(0.27)
Import penetration^2 × Age	1.53	1.14	5.77**	1.80
	(1.45)	(1.20)	(2.42)	(1.26)
Firm FE	Yes	Yes	Yes	Yes
Industry-Year FE	Yes	Yes	Yes	Yes
Observations	23,907	24,533	24,321	23,197
R2	.34	.72	.41	.36

- Decreasing for import penetration above ≈100 k$/worker = 98th percentile of the sample distribution
- ⇒ Returns to R&D (almost) always increasing in import penetration

back

Trade shocks in input markets

- Net import penetration = Import penetration of final market − Average import penetration of input markets (weighted using I-O matrix)

	Sales Growth		ROA		Capital Expenditures		Employment Growth	
Net import penetration	-0.89***		-0.63**		-0.76*		-0.25	
	(0.24)		(0.25)		(0.44)		(0.23)	
Net import penetration × R&D Stock		1.34***		1.70***		1.55**		0.95**
		(0.48)		(0.62)		(0.75)		(0.44)
Assets	0.01	0.03***	0.06***	0.01	0.03***	0.05***	0.02***	0.07***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)
Age	-0.20***	-0.23***	0.06***	0.15***	-0.41***	-0.44***	-0.20***	-0.24***
	(0.01)	(0.02)	(0.01)	(0.02)	(0.02)	(0.03)	(0.01)	(0.02)
R&D Stock		0.08***		-0.21***		0.03		0.14***
		(0.03)		(0.03)		(0.04)		(0.02)
Net import penetration × Age		-0.62**		-0.59***		-0.41		-0.35
		(0.26)		(0.18)		(0.35)		(0.22)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	–	Yes	–	Yes	–	Yes	–
Industry-Year FE	No	Yes	No	Yes	No	Yes	No	Yes
Observations	23,843	23,843	24,461	24,461	24,250	24,250	23,136	23,136
R2	.24	.33	.68	.72	.34	.41	.24	.35

back

Trade shocks in input markets: same industry supplier

- Customers-Suppliers from Compustat: $SupplierSameSIC4$ = (firm has at least one supplier in the same 4-digit SIC)

Sample	All				Exc. Supplier Same SIC-4			
Dep. Var	Sale Growth	ROA	Capex	Emp Growth	Sale Growth	ROA	Capex	Emp Growth
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Import penetration ×R&D Stock	1.38*** (0.43)	1.59*** (0.56)	1.98*** (0.69)	1.11*** (0.37)	1.47*** (0.46)	1.67*** (0.58)	2.31*** (0.68)	1.27*** (0.40)
Import Penetration × Supplier Same SIC 4	0.89 (0.60)	-0.94 (0.60)	0.56 (0.95)	0.61 (0.72)				
R&D stock × Supplier Same SIC 4	-0.07 (0.07)	-0.01 (0.06)	0.02 (0.09)	-0.02 (0.04)				
Observations	24,285	24,974	24,752	23,514	21,858	22,514	22,303	21,136
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

back

Multi-segment firms

- Main SIC code = noisy measure of industry for multi-segment firms?
- Compustat Business Segments data
  - All industries that represent ≥10% of the firm's sales, employment or profits
  - 55% of firms report ≥2 segments
  - Construct segment-weighted import penetration

	Sales Growth	ROA	Capital Expenditures	Employment Growth
	(1)	(2)	(3)	(4)
Import penetration × R&D Stock	1.51***	1.73**	2.56***	1.18**
	(0.56)	(0.72)	(0.82)	(0.47)
Assets	0.03***	0.01	0.05***	0.07***
	(0.01)	(0.01)	(0.02)	(0.01)
Age	-0.22***	0.16***	-0.43***	-0.24***
	(0.02)	(0.02)	(0.03)	(0.02)
Import penetration × Age	-0.03	0.20	-0.04	-0.34
	(0.51)	(0.49)	(0.86)	(0.54)
R&D Stock	0.06**	-0.23***	0.02	0.13***
	(0.03)	(0.03)	(0.04)	(0.02)
Firm FE	Yes	Yes	Yes	Yes
Industry-Year FE	Yes	Yes	Yes	Yes
Observations	22,271	22,888	22,699	21,620

Excluding California

- 27% of firms do >50% of their R&D in California
- Exclude these firms:

	Sales Growth	ROA	Capital Expenditures	Employment Growth
	(1)	(2)	(3)	(4)
Import penetration × R&D Stock	1.21**	1.41**	2.77***	1.75***
	(0.58)	(0.62)	(0.89)	(0.54)
Assets	0.03***	0.01	0.05***	0.06***
	(0.01)	(0.01)	(0.02)	(0.01)
Age	-0.20***	0.13***	-0.38***	-0.23***
	(0.02)	(0.02)	(0.03)	(0.02)
R&D Stock	0.08**	-0.19***	0.00	0.11***
	(0.03)	(0.03)	(0.04)	(0.02)
Import penetration × Age	-0.48	-0.24	-0.13	-0.49
	(0.55)	(0.45)	(0.77)	(0.44)
Firm FE	Yes	Yes	Yes	Yes
Industry-Year FE	Yes	Yes	Yes	Yes
Observations	17,471	17,876	17,712	16,970
R2	.35	.73	.42	.37

back

Exogeneity of R&D policy?

	Change in State R&D Tax Credit ($t \to t+1$)		
	(1)	(2)	(3)
	$h=1$	$h=3$	$h=5$
Change in GDP ($t-h \to t$)	-.0022	.0013	.0053
	(.0068)	(.0052)	(.0057)
Change in R&D ($t-h \to t$)	.0016	-.00068	-.0033
	(.0057)	(.0022)	(.0031)
Change in Number of Doctorates ($t-h \to t$)	-.0023	.0012	.0011
	(.0029)	(.0028)	(.0025)
State FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Observations	1,224	1,224	1,224
Adj-R2	.92	.92	.92

- Our diff-in-diff approach actually requires weaker identifying assumption

  = Changes in R&D tax credit not correlated across states with the relative performance of import-competing vs. non-import-competing industries

R&D Tax Credit