Estimating the Productivity Selection and Technology Spillover Effects from Imports

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Trade and productivity: two channels

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2. Firms engaging in international trade learn new technologies (products, processes, management techniques)

   => Industry productivity increases through within-firm productivity growth

Both channels may be important

- "Exposure to foreign competition often improves intra-plant efficiency"
  (Tybout, Abstract of 2003 survey)

- "In many cases, aggregate productivity improvements stem from the reshuffling of resources and output from less to more efficient producers"
  (Pavcnik, Abstract of 2002 ReStud paper)

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- Technology upgrading (Bustos, Verhoogen)
- Here we estimate learning externalities from international technology spillovers
  - Recent evidence for outward FDI (Griffith, Harrison, and van Reenen), inward FDI (Keller and Yeaple), and exports (de Loecker)

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    2. Negative: Inward FDI depresses the productivity of domestic firms because they are left with lower-quality inputs (Aitken and Harrison)
2. Together with the within-effect, when does import liberalization raise or lower industry productivity?

Results preview

1. In the long-run, the increased competition from import liberalization raises the number of domestic firms and *lowers* industry productivity
2. Imports generate also technology spillovers that *raise* domestic productivity
3. In high-tech sectors, technology spillovers outweigh the competition effect and industry productivity rises, and vice versa
4. The short-run impact of import liberalization is an increase in industry productivity
5. High entry barriers such as regulation dampen the domestic response to import liberalization

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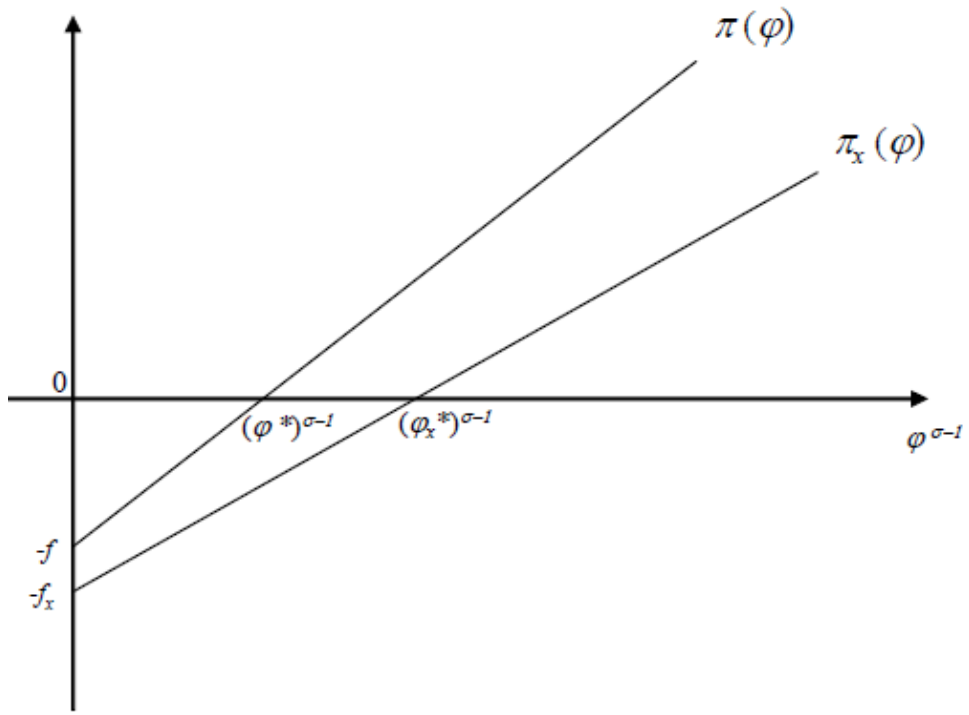

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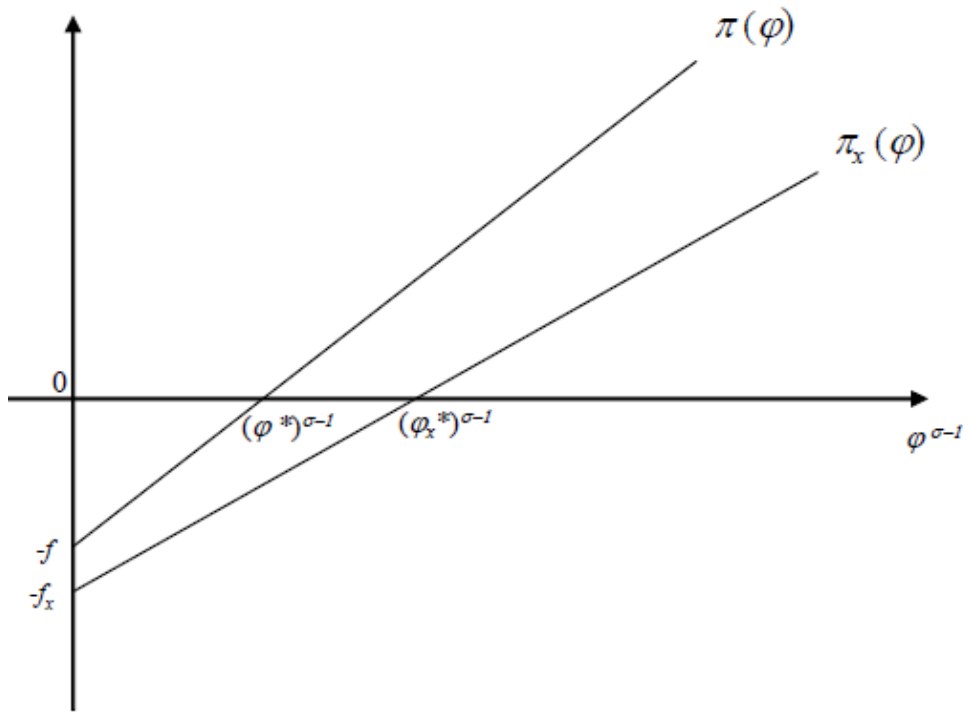
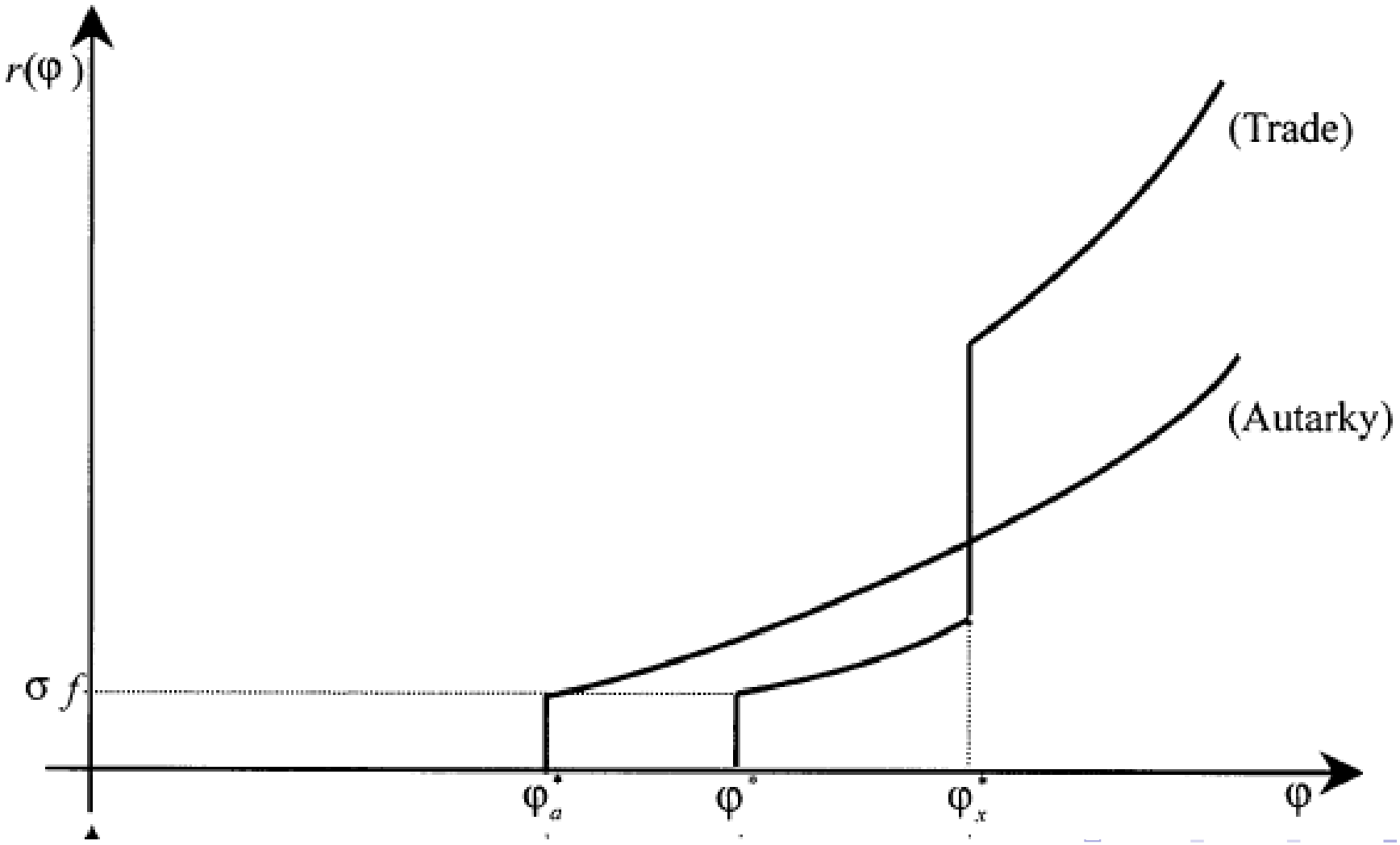


- The opportunity of exporting raises the profitability of high-productivity compared to low-productivity firms
  $\Rightarrow$ changes in firms' entry behavior and long-run industry productivity

New export opportunities result in market share gains for high-productivity firms



Import liberalization without new export opportunities

- Unilateral import liberalization raises only foreign productivity in this way
- Higher foreign productivity reduces the profitability of domestic exporters
  - That lowers their incentives to entry
- Lower entry from domestic high-productivity firms allows weak domestic firms to enter

$=>$ Domestic industry productivity falls

Two interpretations

- Unilateral import liberalization shifts market shares from domestic to foreign exporters
  - Recall results on profit shifting in imperfect competition trade models of the 80s
- A liberalized country facing highly protected foreign countries is not attractive as a base for operation

See Melitz, Melitz and Ottaviano

Empirical approach

- Using a modified production function approach, we ask:

  What is the impact of US R&D and US imports on productivity?

- This works because

1. Imports from US are significant
   1. in all countries, ranging from 3% (France) to 73% (Canada) of domestic value added in 1990s, and
   2. in industries such as computers and aircraft, U.S. imports are typically larger than domestic value added
2. The median share of U.S. in total R&D is close to 40%

Estimating selection and spillovers

- Consider

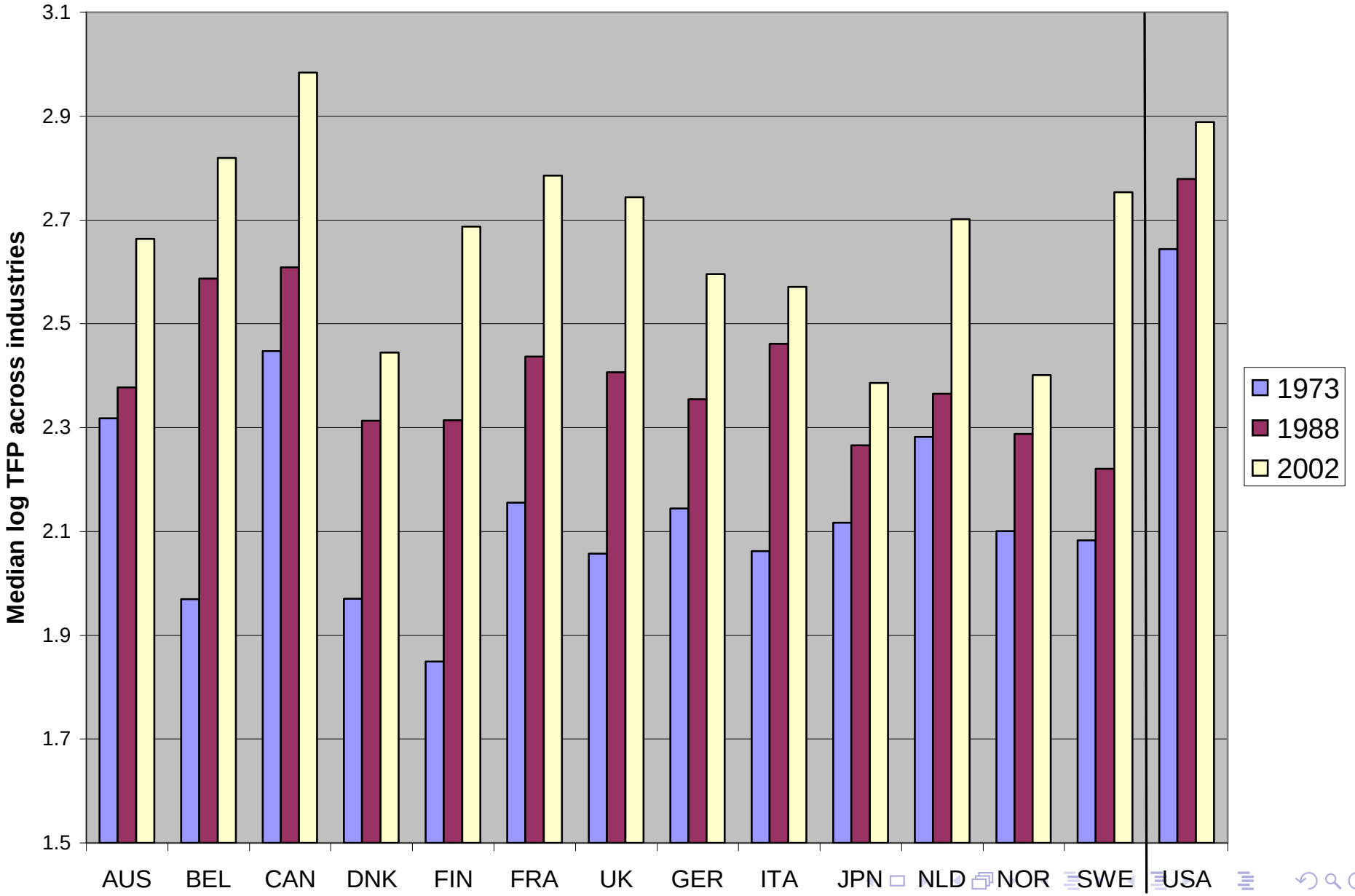
$$TFP_{cit} = \beta_1 [US\_R\&D_{it}] + \beta_2 [US\_IMP_{cit}] + \beta_3 [US\_R\&D_{it} \times US\_IMP_{cit}] + Controls + \varepsilon_{cit}$$

- Technology spillovers from the US: the marginal effect of US R&D ($US\_R\&D$) on productivity (TFP) is positive
- Productivity selection through US imports: the marginal effect of US imports (US_IMP) on productivity is non-zero
- Since we consider autonomous changes in US imports, due e.g. to unilateral changes in tariffs, selection effect of imports should be negative

Data on technology, trade, and productivity

- Industry data on value added, number of employees, and capital investment to compute TFP; source: Groningen Growth Database (1979-2002) extended with OECD STAN (1973-1978)
  - Assumption: Labor elasticity (β_l) of 0.72 (median labor share) and constant returns
  - Similar to the IV-Systems GMM estimates of $\beta_l = 0.71$, $\beta_k = 0.32$ in Acharya and Keller (2007)
- Industry data on R&D from OECD ANBERD, on bilateral imports from OECD BTD databases
- Firm data: number of firms from UNIDO industrial statistics
  - Obtain firm size measure: Average output per firm
  - 3-digit ISIC matched to 22 industry-classification
  - Years: 1981 to 2002

Productivity across countries, 1973 - 2002



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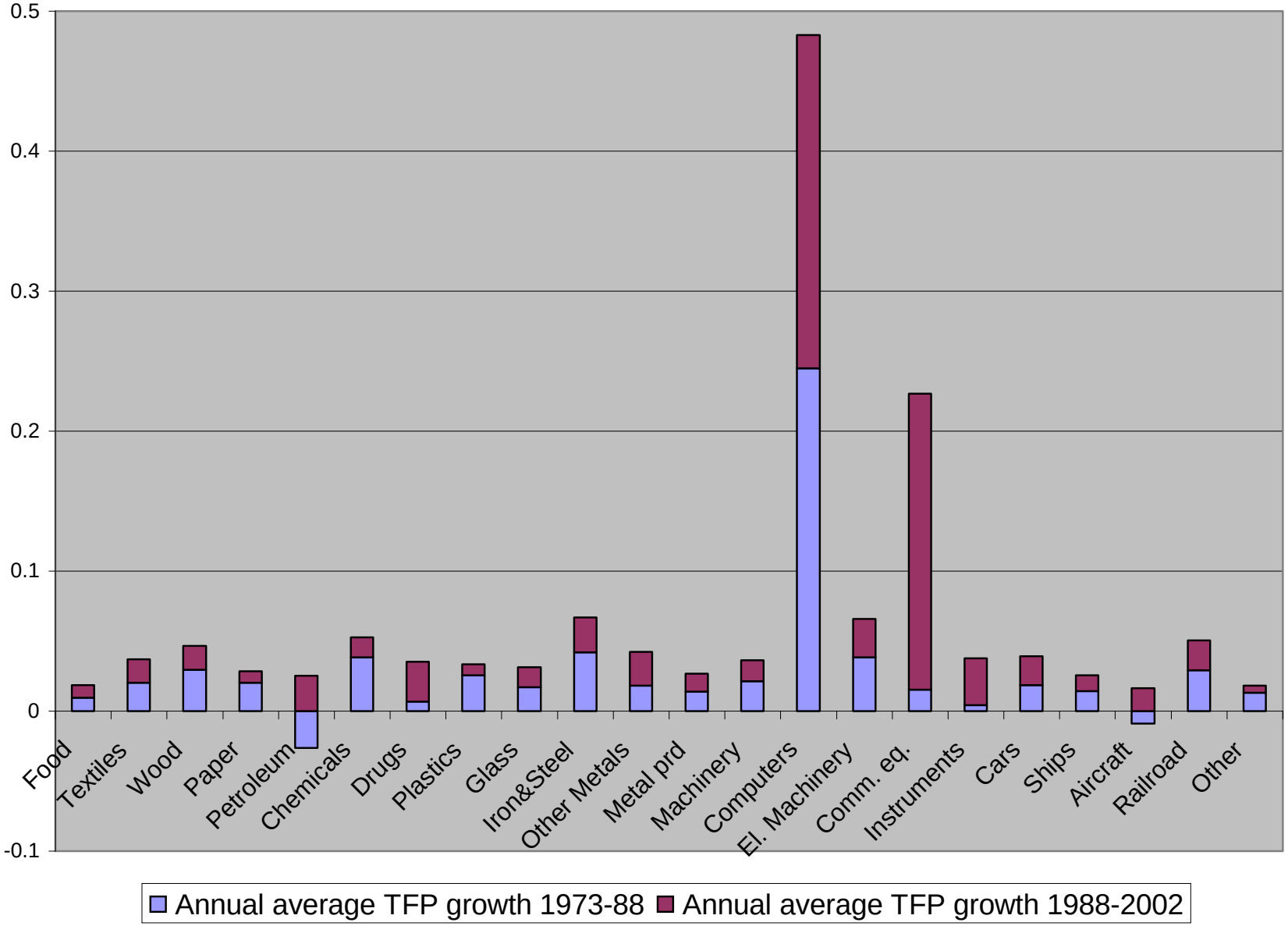

Data on entry regulation and firms' entry and exit behavior

1. Entry regulation: Number of procedures to start a business
   - varies by country; source: Djankov et al. (2002)

2. Gross turnover (= firm entry + firm exit) in U.S. industries, captures mainly natural (non-policy induced) barriers
   - varies by industry; source: Dunne, Roberts, and Samuelson (1997) and Fisman and Sarria-Allende (2004)

3. Gross turnover in the industries of nine countries
   - varies by industry and country; source: Bartelsmann, Haltiwanger, and Scarpetta (2007)

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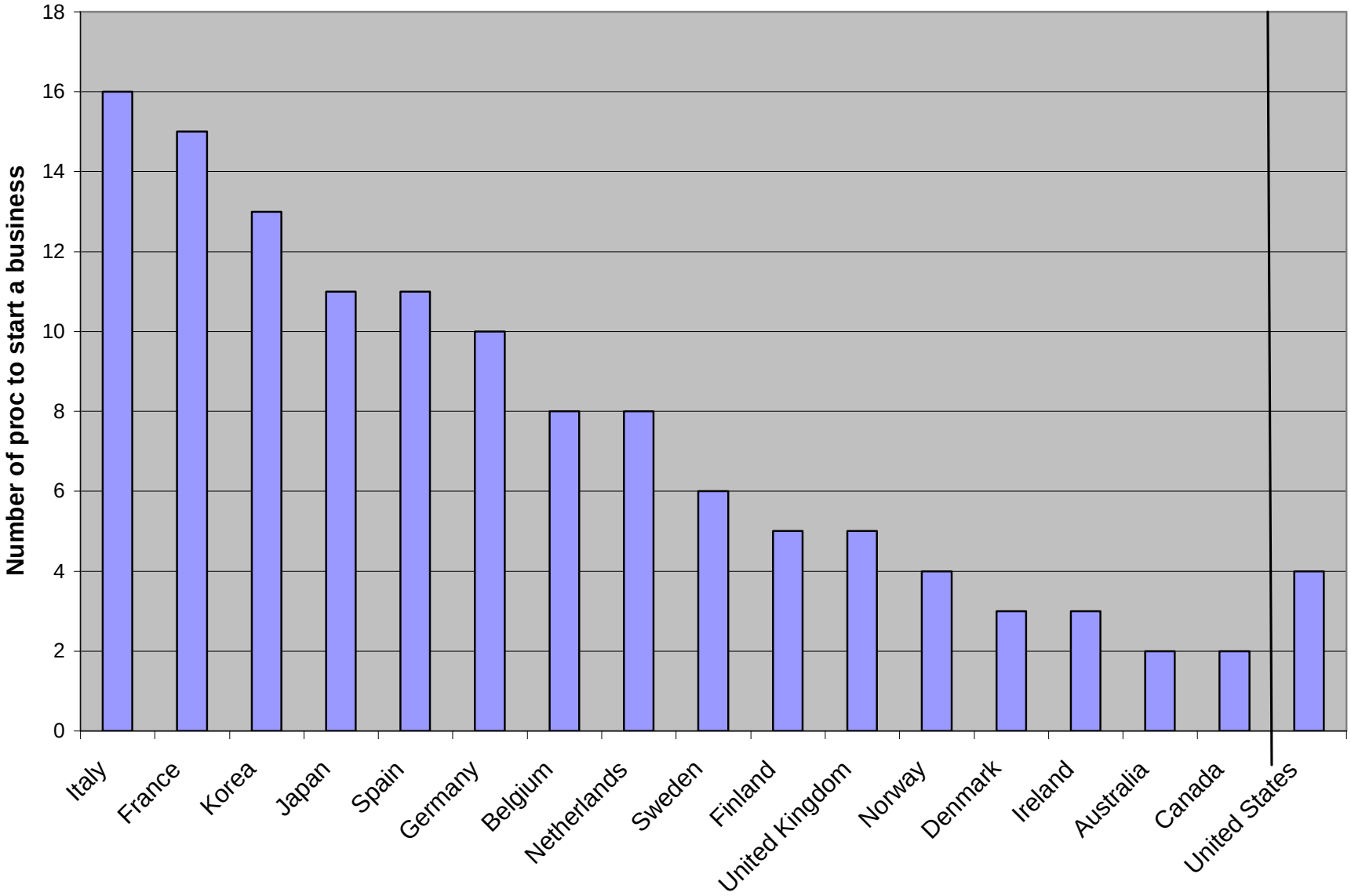
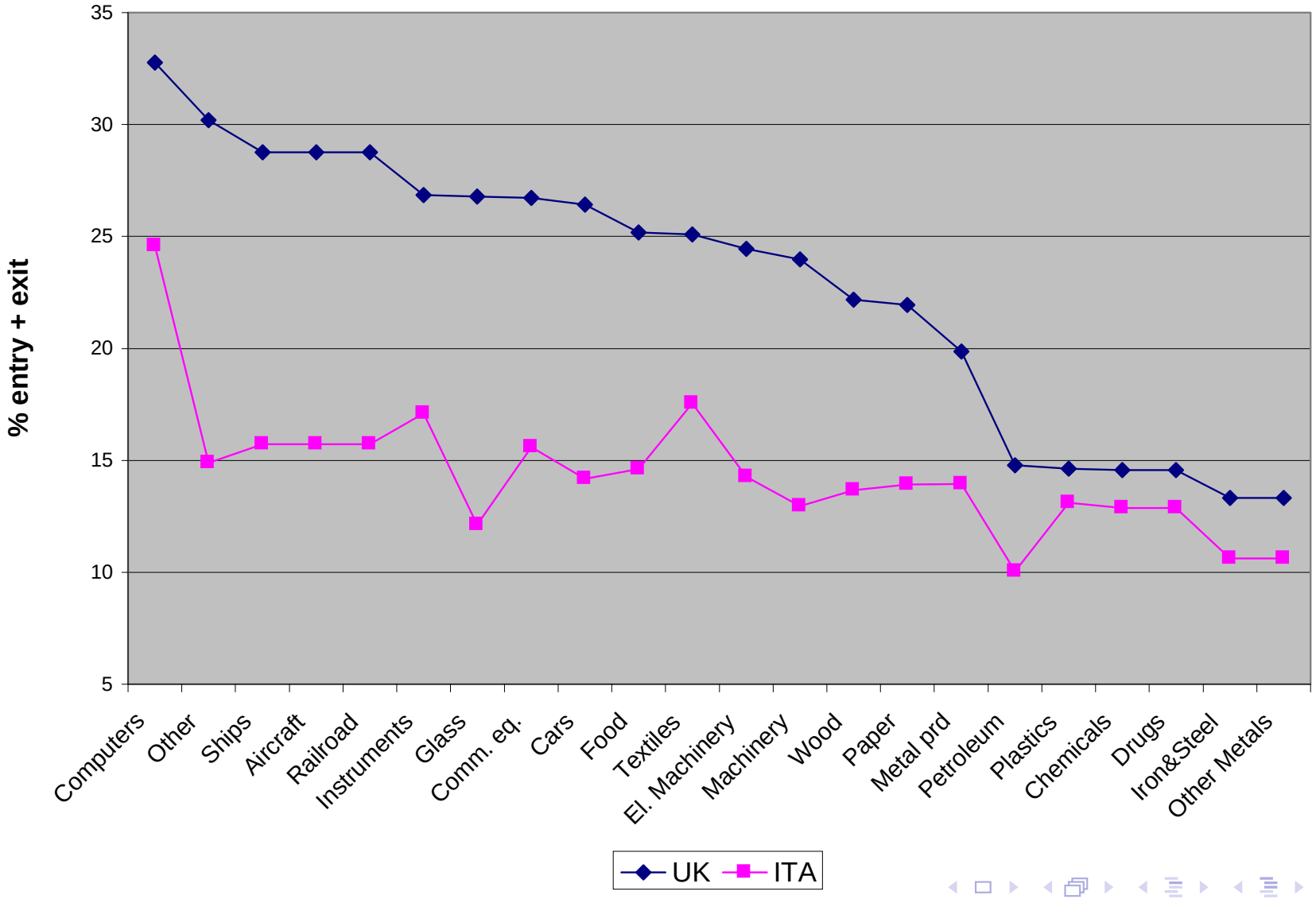


Gross turnover as measure of regulation and natural barriers



Estimation equation

- TFP on domestic R&D (r_{cit}), US R&D (r_{it}^{US}), and bilateral imports from the US (m_{cit}^{US}), all in logs

$$tfp_{cit} = \beta_1 r_{cit} + \beta_2 r_{it}^{us} + \beta_3 m_{cit}^{us} + \beta_4 \left(r_{it}^{US} \times m_{cit}^{US} \right) + \varepsilon_{cit}$$

- Two alternative error specifications
  - Fixed effects or within estimator

$$\varepsilon_{cit} = \gamma X' + \mu_{ci} + \eta_t + u_{cit}$$

  - IV Systems GMM, treating domestic R&D and imports as endogenous

$$\begin{aligned} \varepsilon_{cit} &= \gamma X' + \lambda_c + \varsigma_i + \eta_t + \nu_{cit} \\ \nu_{cit} &= \rho \nu_{cit-1} + u_{cit} \end{aligned}$$

Systems GMM IV

- Simplest production function with i cross-sectional, t time dimension:

$$y_{it} = \beta_k k_{it} + \beta_l l_{it} + \epsilon_{it}; \qquad \epsilon_{it} = \eta_i + \nu_{it} + \tilde{\tau}_t$$

where η_i : fixed group effect, τ_t : fixed time effect, and

$$\nu_{it} = \rho \nu_{it-1} + \varepsilon_{it}$$

- Re-write as dynamic panel model with serially uncorrelated errors

$$y_{it} = \pi_1 y_{it-1} + \pi_2 k_{it} + \pi_3 k_{it-1} + \pi_4 l_{it} + \pi_5 l_{it-1} + \eta_i^* + \tilde{\tau}_t^* + \varepsilon_{it}$$

with

$$\pi_1 = \rho \qquad \pi_2 = \beta_k \qquad \pi_3 = -\rho\beta_k \qquad \pi_4 = \beta_l$$
$$\pi_5 = -\rho\beta_l \quad \eta_i^* = (1-\rho)\eta_i \quad \tilde{\tau}_t^* = \tilde{\tau}_t - \rho\tilde{\tau}_{t-1}$$

Moment conditions to exploit

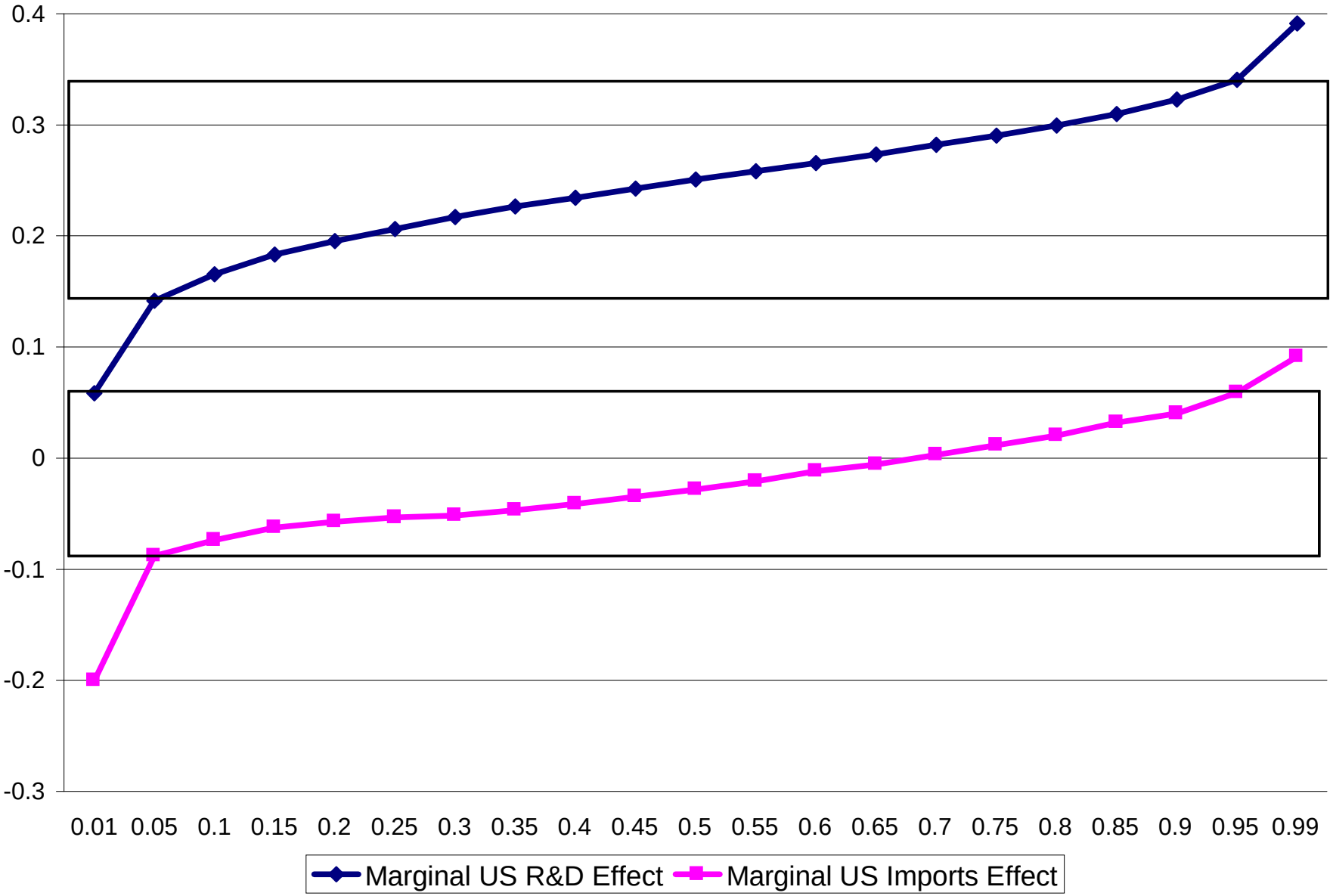
$$E\left(y_{it-s}\Delta\varepsilon_{it}\right) = 0 \text{ for } s \geq 2 \qquad E\left(\Delta k_{it-s}\left(\varepsilon_{it} + \eta_i^*\right)\right) = 0 \text{ for } s \geq 1$$
$$E\left(k_{it-s}\Delta\varepsilon_{it}\right) = 0 \text{ for } s \geq 2 \qquad E\left(\Delta l_{it-s}\left(\varepsilon_{it} + \eta_i^*\right)\right) = 0 \text{ for } s \geq 1$$
$$E\left(l_{it-s}\Delta\varepsilon_{it}\right) = 0 \text{ for } s \geq 2$$

Fixed effects results

	(1)	(2)	(3)	(4)
US R&D	0.239 (0.015)		0.247 (0.017)	**−0.116** (0.035)
US Imports		−0.023 (0.008)	−0.037 (0.008)	**−0.303** (0.028)
US R&D x US Imports				**0.031** (0.003)
Domestic R&D	0.110 (0.011)	0.190 (0.013)	0.113 (0.011)	**0.101** (0.010)
JPN R&D	0.209 (0.017)	0.263 (0.015)	0.203 (0.017)	**0.178** (0.016)
GER R&D	0.067 (0.011)	0.140 (0.013)	0.066 (0.011)	**0.097** (0.011)
# of obs.	7,902	8,169	7,902	7,902

Dependent variable: log Total factor productivity; robust s.e. in parentheses

Productivity effects of US R&D and US Imports



IV System GMM results

	(1)	(2)
US R&D	0.323 (0.058)	0.058 (0.098)
US Imports	−0.014 (0.023)	**−0.206** (0.065)
US R&D x US Imports		**0.022** (0.007)
AR(1) test [p-value]	−1.78 [0.08]	−2.01 [0.04]
AR(2) test [p-value]	1.47 [0.14]	1.39 [0.17]
OverID [p-value]	4.16 [0.66]	3.56 [0.74]
# of obs.	6,915	6,915

Dep. var.: TFP; robust s.e. and p-values in parentheses; included: Domestic, JPN, GER R&D (coeff's not shown)

Results compared

		FE Within	IV GMM
US R&D	5%	0.14	0.19
	Mean	0.25	0.26
	95%	0.34	0.33
US IMP	5%	−0.09	−0.20
	Mean	−0.02	−0.01
	95%	0.06	0.06

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- On average, the impact of imports on productivity is small or zero. But if imports
  - embody little technology, the selection effect dominates and they lower productivity
  - are highly technology-intensive, the spillover effect dominates and they raise productivity

Robustness

	FOR = JPN	FOR = GER	FOR = US TFP w/ ind. factor shares
FOR R&D	0.177 (0.035)	−0.040 (0.025)	−0.118 (0.034)
FOR IMP	−0.135 (0.017)	−0.108 (0.020)	−0.255 (0.027)
FOR R&D x FOR IMP	0.015 (0.002)	0.013 (0.003)	0.027 (0.003)
R&D marg. eff. mean [5%, 95%]	0.33 [0.26, 0.39]	0.12 [0.08, 0.15]	0.20 [0.11, 0.28]
IMP marg. eff. mean [5%, 95%]	−0.01 [−0.05, 0.02]	−0.01 [−0.05, 0.02]	−0.01 [−0.07, 0.06]

Fixed effects (within) regressions; dep. var.: TFP; domestic, US (1,2) JPN (2,3), GER (1,3) R&D included; robust s.e. in parentheses

Productivity, firm size, and the number of firms

	Dep. var. TFP	Dep. var. ∅ firm size	Dep. var. # of firms
US R&D	−0.346 (0.046)	−0.308 (0.079)	0.138 (0.067)
US IMP	−0.416 (0.035)	−0.167 (0.052)	0.227 (0.049)
US R&D x US IMP	0.046 (0.004)	0.026 (0.006)	−0.026 (0.005)
# of obs.	6,403	4,833	4,855

Fixed effects regressions; years 1982 to 2002; domestic, JPN, GER R&D included; robust s.e. in parentheses

- Industry productivity and average firm size move together, as predicted by heterogeneous-firm models

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- Industry productivity and average firm size move together, as predicted by heterogeneous-firm models
- In the long-run, surging imports unaccompanied by spillovers lead to net entry of additional domestic firms

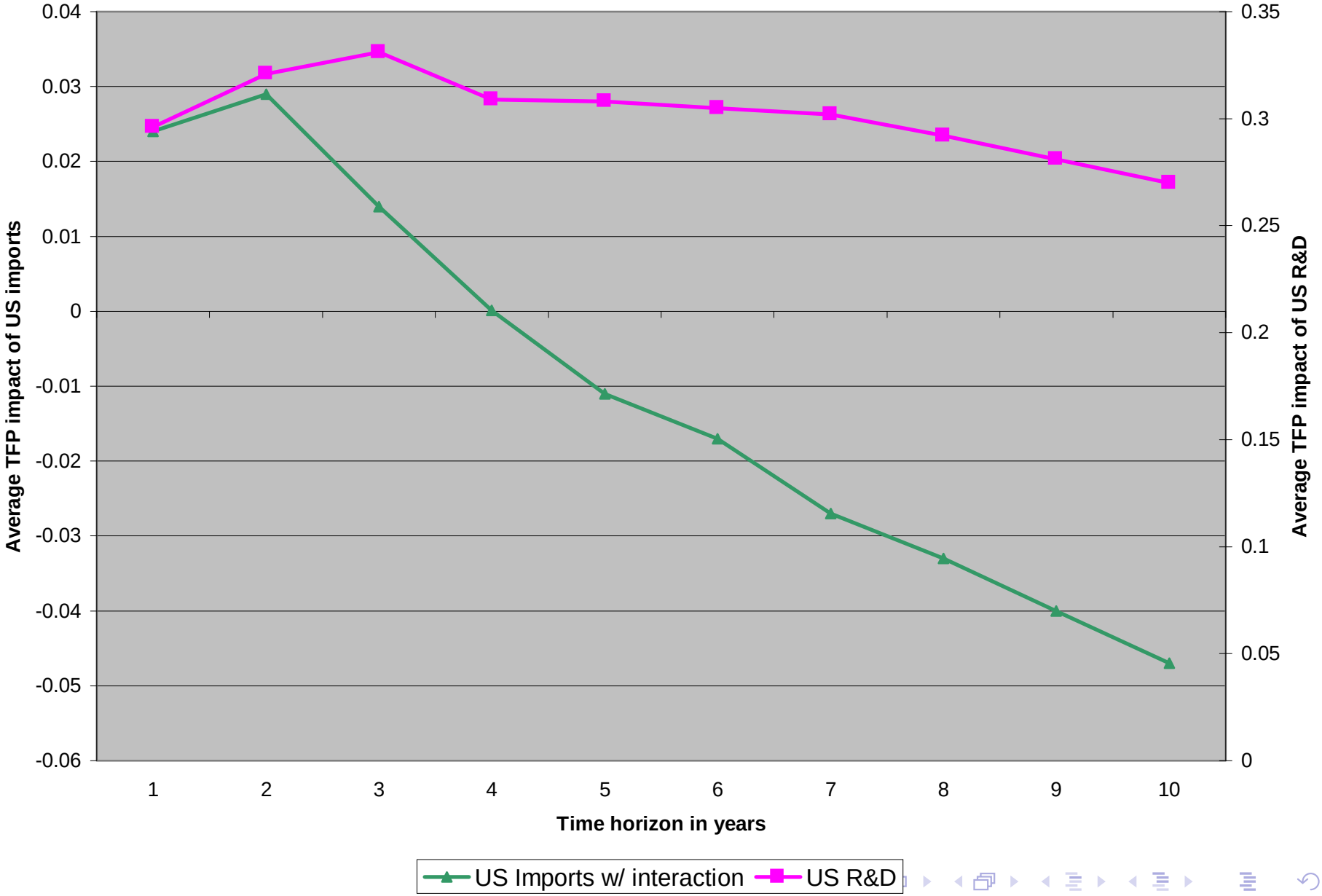
Productivity selection: short-run versus long-run

- Natural entry barriers and entry regulation should have its strongest impact in the short-run, when it is very costly to overcome these barriers
- In general, the short-run response of industry productivity to import competition might be quite different from the long-run response
  - The Melitz and Ottaviano (2008) prediction for unilateral import liberalization is
    - ★ positive for the short-run
    - ★ negative for the long-run
- We estimate time-differenced regressions

$$\Delta^q ltfp_{cit} = \gamma_1 \Delta^q m_{cit}^{US} + \gamma_2 \Delta^q r_{it}^{US} + \gamma_3 \left(\Delta^q m_{cit}^{US} \times \Delta^q r_{it}^{US} \right) + \gamma X' + e_{cit},$$

where $q = 1, ..., 10$ are one-year to ten-year (long) differences

Positive short-run and negative long-run imports selection



Selection and firm turnover

	(1)	(2)	(3)	(4)
Domestic R&D	0.113	0.114	0.105	**0.109**
	(0.011)	(0.012)	(0.012)	(0.012)
US R&D	0.247	0.247	0.265	**0.265**
	(0.015)	(0.015)	(0.017)	(0.017)
US IMP	−0.037	−0.037	−0.036	**−0.048**
	(0.008)	(0.008)	(0.008)	(0.009)
Domestic R&D x low turnover		−0.004	0.042	0.024
		(0.013)	(0.016)	(0.017)
US R&D x low turnover			−0.094	**−0.108**
			(0.025)	(0.027)
US IMP x low turnover				**0.048**
				(0.013)

Fixed effects regressions; dependent variable: TFP; 7,902 obs; robust s.e. in parentheses

- Low turnover reduces technology spillovers and it reduces selection

Selection and firm turnover: by-country vs US data

	Country-specific turnover data	US turnover data
Domestic R&D	**0.109**	**0.099**
	(0.012)	(0.012)
US R&D	**0.265**	**0.264**
	(0.017)	(0.016)
US IMP	**−0.048**	**−0.047**
	(0.009)	(0.009)
Domestic R&D x low turnover	0.024	**0.073**
	(0.017)	(0.023)
US R&D x low turnover	**−0.108**	**−0.146**
	(0.027)	(0.031)
US IMP x low turnover	**0.048**	**0.049**
	(0.013)	(0.016)

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- Selection and spillovers findings unaffected by possible endogeneity

Selection and entry regulation

	(1)	(2)	(3)	(4)
Domestic R&D	0.113	0.107	0.110	**0.114**
	(0.011)	(0.011)	(0.011)	(0.011)
US R&D	0.247	0.246	0.240	**0.241**
	(0.015)	(0.015)	(0.015)	(0.015)
US IMP	−0.037	−0.036	−0.036	**−0.047**
	(0.008)	(0.008)	(0.008)	(0.009)
Domestic R&D x high regulation		0.015	0.004	−0.009
		(0.016)	(0.018)	(0.019)
US R&D x high regulation			0.018	0.015
			(0.026)	(0.026)
US IMP x high regulation				**0.037**
				(0.014)

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- Entry regulation reduces selection without lowering spillovers

Selection and entry regulation

	(1)	(2)
US R&D	0.247 (0.015)	**0.259** (0.012)
US R&D x low turnover		**−0.142** (0.030)
US R&D x high regulation		0.008 (0.026)
US Imports	−0.037 (0.008)	**−0.057** (0.010)
US Imports x low turnover		**0.049** (0.015)
US Imports x high regulation		**0.038** (0.014)

Fixed effects regressions; dependent variable: TFP; domestic, JPN, GER R&D included; 7,902 obs; robust s.e. in parentheses

- Productivity selection from imports is muted by both natural and policy entry barriers

Conclusions

1. There is strong evidence for imports, due e.g. to tariff liberalization, generating both productivity selection and technology spillovers
   - Supports models with heterogeneous firms and technology spillovers
2. An increase in imports *lowers* domestic industry productivity in the long-run through negative selection
3. Imports also lead to technology spillovers that *raise* domestic productivity
4. For firms in high-technology sectors, the spillovers outweigh productivity selection and imports raise productivity, while for firms in a low-tech environment, selection through strong product market competition dominates and imports lead to lower productivity
5. The selection mechanism is muted when entry barriers are high: through regulation, natural barriers, or in the short-run
   - Consistent with some recent heterogeneous firms models

Policy implications

- A case against unilateral trade liberalization, given that it leads to negative selection, lowering domestic productivity and welfare?

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  - Short-run selection effect is positive

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  - Short-run selection effect is positive
  - Do we expect that unilateral trade liberalization always raises productivity and welfare?
- A case for entry barriers and regulation, given that this moderates negative selection?
  - Entry barriers not only reduce selection but also technological spillovers: one net, what is larger?

Future research

- Selection and spillovers from FDI and exports
- Employ a framework in which domestic firms
  - can face new foreign competition (=> selection)
  - may potentially benefit from foreign technology (=> spillovers)
  - make their own technological upgrading decision (=> investment)

Papers by Bustos, Verhoogen, and Bloom, Draca, van Reenen

- Iacovono-Keller (2009)