Imported Capital Improves Firm Productivity

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Motivation

Motivation

- Large differences in output per worker (also, multi-factor productivity)
  - across firms in the same narrow industry (Syverson, 2011)
  - across countries (Hall and Jones, 1999; Caselli, 2005)
- One explanation: differences in *quality* of capital.
- This paper: trade liberalization makes high-quality capital cheaper.

Weaver productivity across countries and over time

"In 1910 one New England cotton textile operative performed as much work as 1.5 British, 2.3 German, and nearly 6 Greek, Japanese, Indian, or Chinese workers." (Clark, 1987)

"A typical weaver in the United States in 1902 produced over 50 times as many yards of cloth in an hour of weaving as did a weaver a century earlier producing a comparable cloth." (Bessen, 2012)

Not all of it is *quantity* of capital

"The weaver in 1902, however, achieved that output using eighteen power-driven looms while the weaver of 1802 used a single handloom." (Bessen, 2012)
"On technical performance, there was a small but significant quality gap in favour of the imported [rather than Indian] machine." (Sutton, 2001)

Imported machines are better in several dimensions (Koren, Csillag and Köllő, 2019)

Table 1: Differences between new and old machines—Regression estimates, 1991–1997

Dependent variable	Mean difference	Mean dep. var.	St. dev. dep. var.
Output (log)	0.820***	5.49	0.475
Potential output (log)	0.790***	5.94	0.449
Potential output/worker (log)	0.811***	3.52	0.845
Output/potential output (log)	0.031*	4.15	0.150
Percent downtime due to			
—scheduled maintenance	−3.20***	2.73	3.30
—troubleshooting	−1.68***	2.22	1.58
—change of warp	1.54**	8.33	5.97
—change of weft	0.940***	2.94	2.99
—other reasons	1.08	4.02	6.90
Total downtime	−0.961	20.38	9.74
Machine/worker	−2.64***	11.32	2.29
Interventions/hour	−1.64	45.26	9.46

Notes: Number of observations: 341 machine-months observed between May 1991 and August 1997. Estimation: OLS with robust standard errors. For an accounting of how the estimation sample was constructed see Appendix B. In each equation, the dependent variable is regressed on a dummy for

Production function

Production function

$$Q_{it} = \Omega_{it}(\lambda K_{it}^F + K_{it}^D)^\alpha L_{it}^\beta M_{it}^\gamma$$

with $\lambda > 1$

$$q_{it} \approx \omega_{it} + \alpha k_{it} + \beta l_{it} + \gamma m_{it} + \alpha(\lambda - 1)\frac{K_{it}^F}{K_{it}}$$

Patterns of capital imports

Data

- Hungarian Customs Statistics, 1992–2003
  - all *direct* exporter and importer
  - detailed by product (HS6): capital goods
  - and country of origin
- Balance Sheet and Earnings Statement
  - revenue, employment, material cost
  - capital: book value of equipment

Stocks and flows

- Imports are flows, equipment value is stock.
- Gross investment *flow*:

$$\hat{I}_{it} = K_{it} - (1 - \delta_{it})K_{i,t-1}$$

  with $\hat{I}_{it} = \hat{I}^D_{it} + I^F_{it}$
- Imported equipment *stock*:

$$\hat{K}^F_{it} = (1 - \hat{\delta}_{it})\hat{K}^F_{i,t-1} + I^F_{it}$$

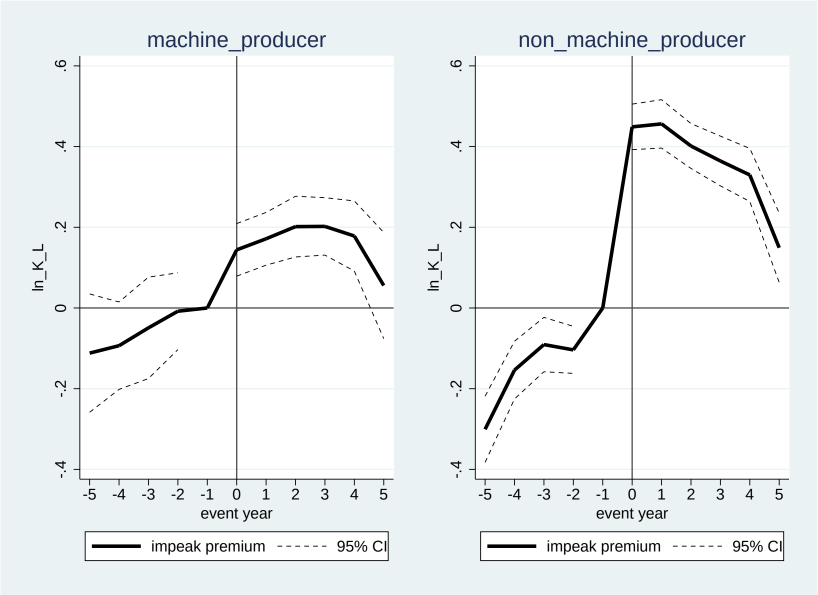
- Complications: what if $I^F_{it} > I_{it}$?

Distribution of investment rates (following Khan and Thomas, 2008)

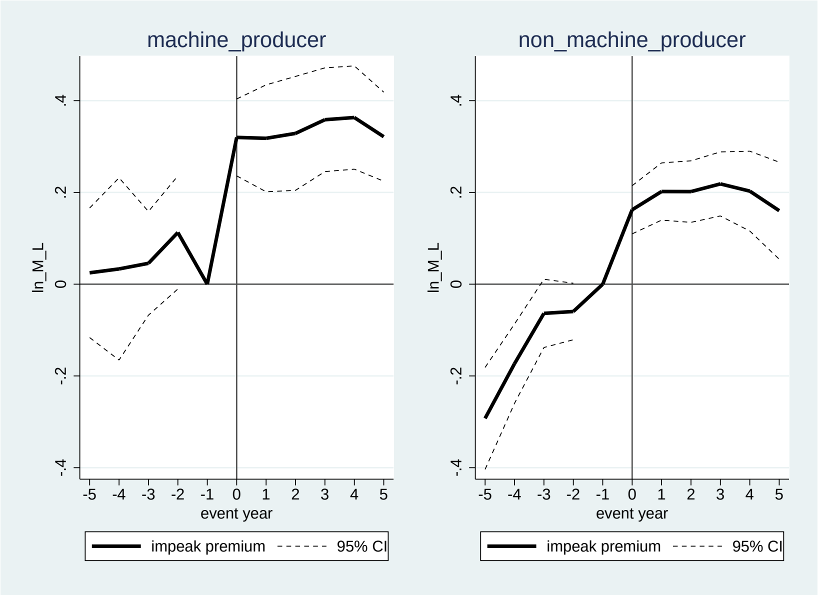
	Manufacturing 10+ employees	Non-machine manuf 10+ employees	Non-machine manuf all firm sizes
Average IR	0.321	0.270	-0.132
Average IR (winsor. 0.01)	0.378	0.335	0.338
Median IR	0.291	0.260	0.247
Inaction (%)	5.9	6.4	13.3
Positive investment (%)	85.9	85.0	77.0
Negative investment (%)	8.1	8.6	9.8
Positive spike (%)	59.9	56.9	54.1
Negative spike (%)	3.7	3.8	5.1
Observations	75,281	57,607	137,508

Notes: Inaction: abs(IR)$<$0.01, Positive spike: IR$>$0.2, Negative spike: IR$<$-0.2.
All samples exclude the first year of firms, where I_t equals K_t by construction.

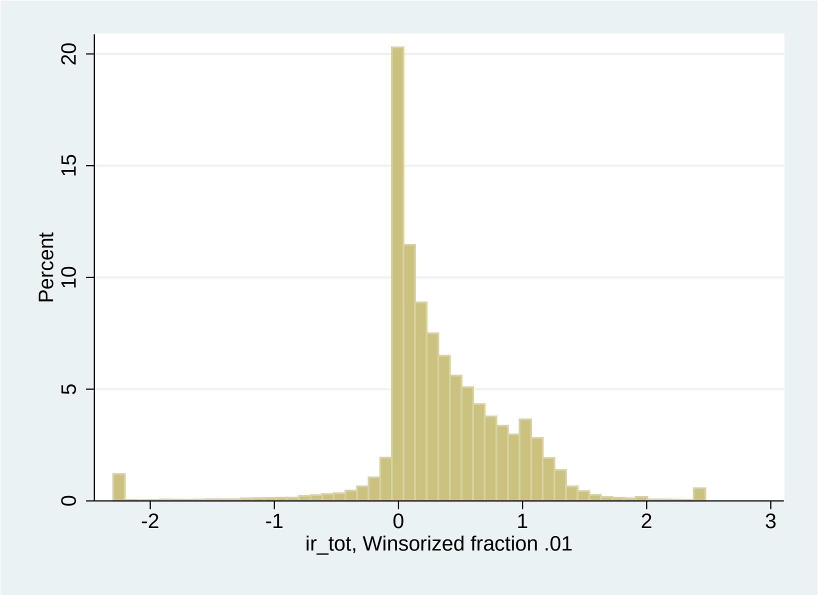
Capital intensity around import peaks



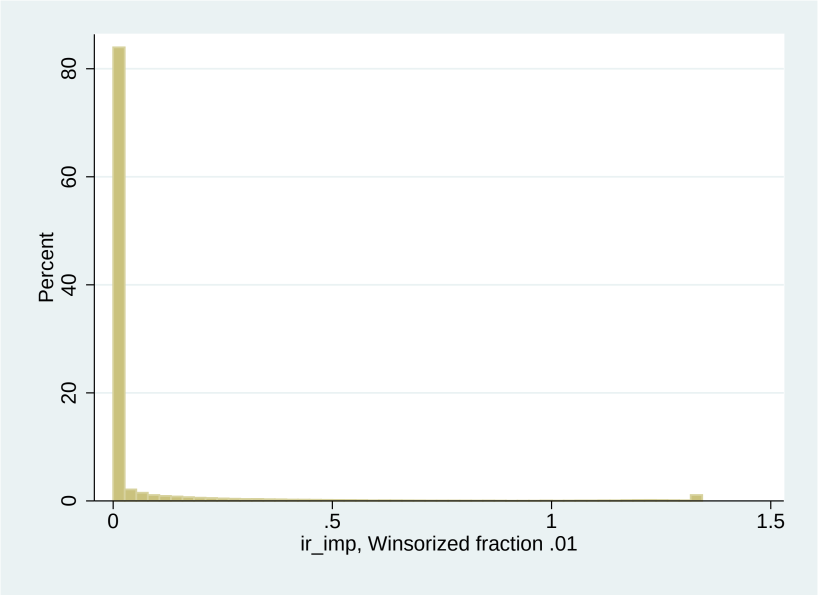
Material intensity around import peaks



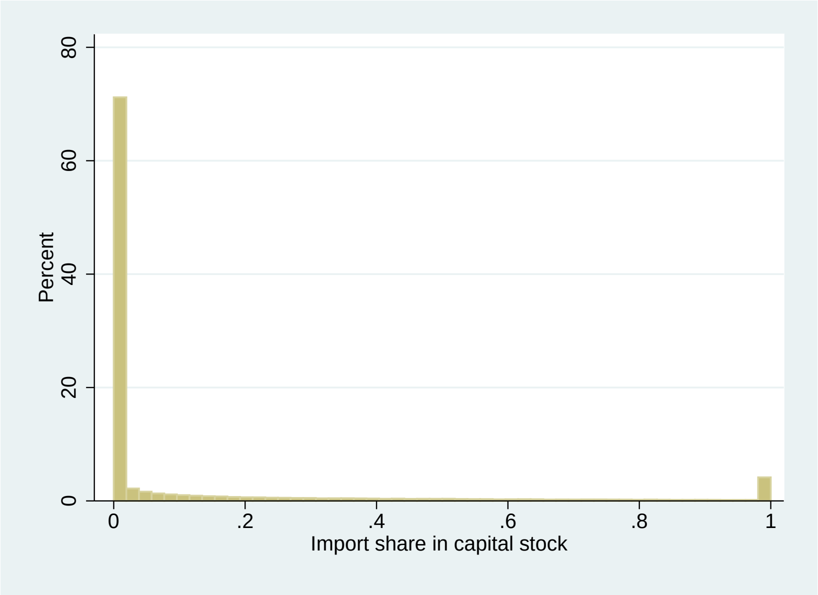
Investment rate distribution



Imported investment rate distribution

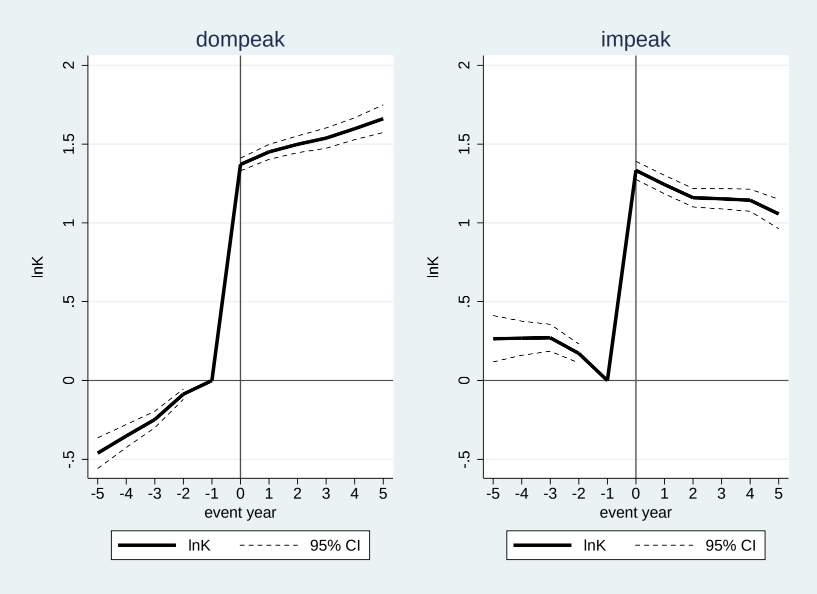


Import share in capital sock

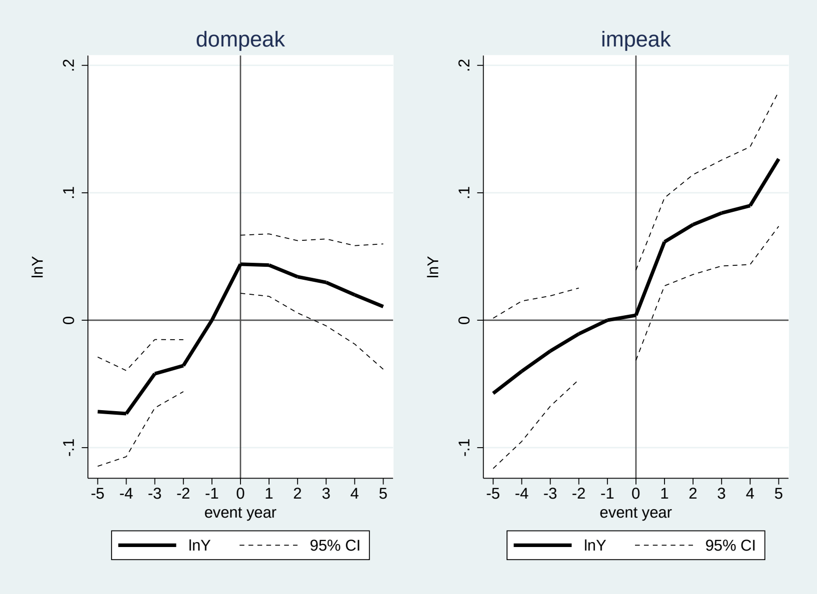


Event studies

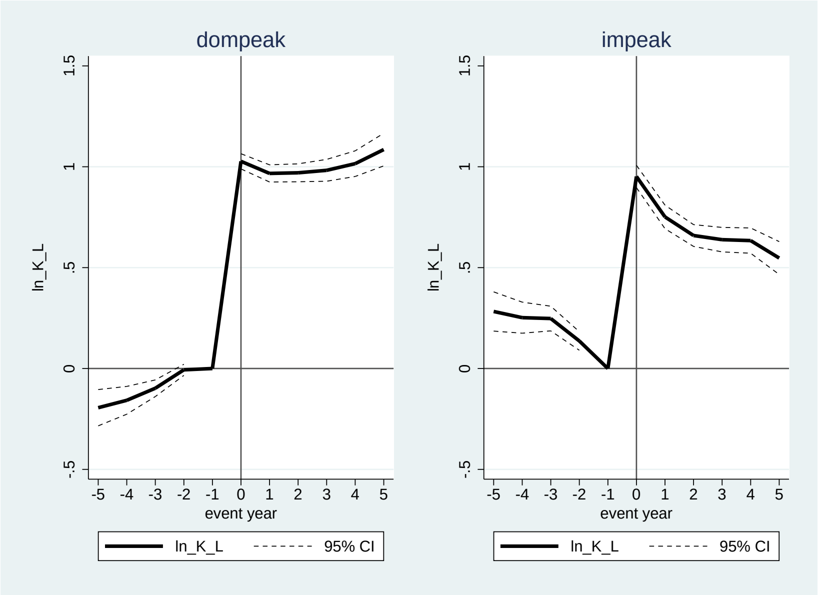
Capital stock around investment peaks (dom vs imp)



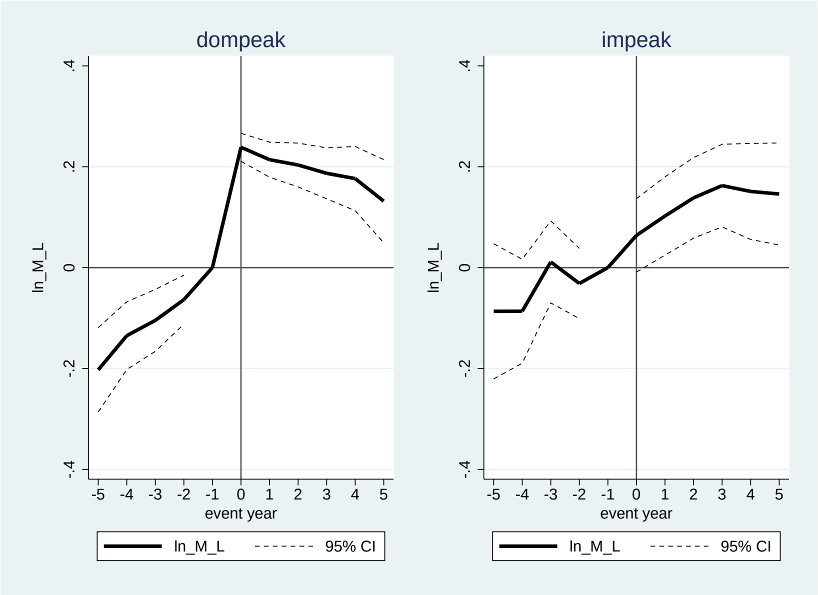
TFP around investment peaks (dom vs imp)



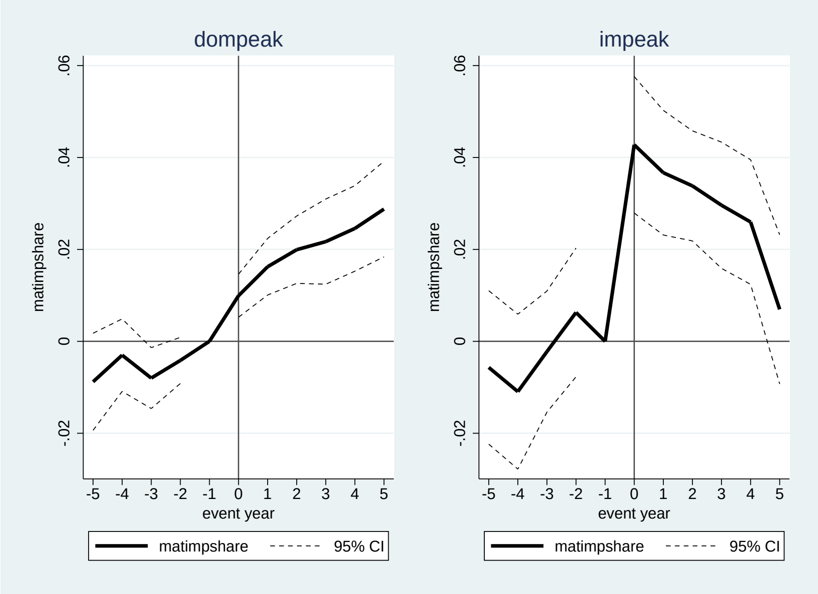
Capital intensity around investment peaks (dom vs imp)



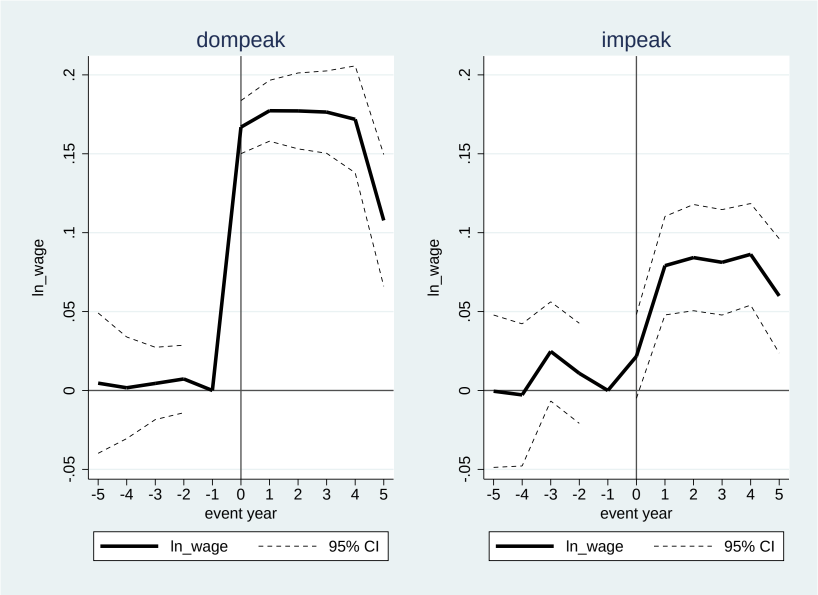
Material intensity around investment peaks (dom vs imp)



Material import intensity around investment peaks (dom vs imp)

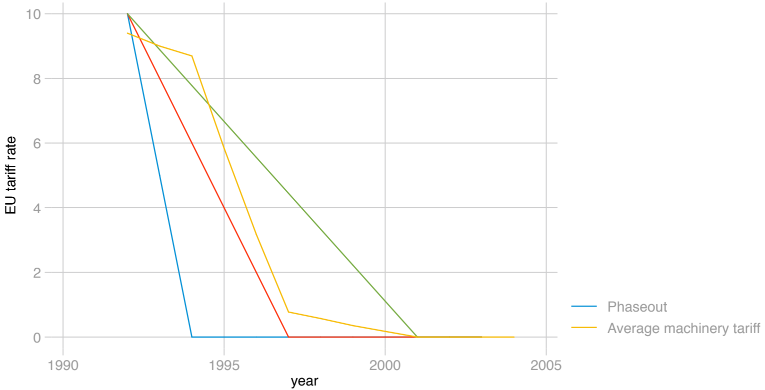


Average wage around investment peaks (dom vs imp)

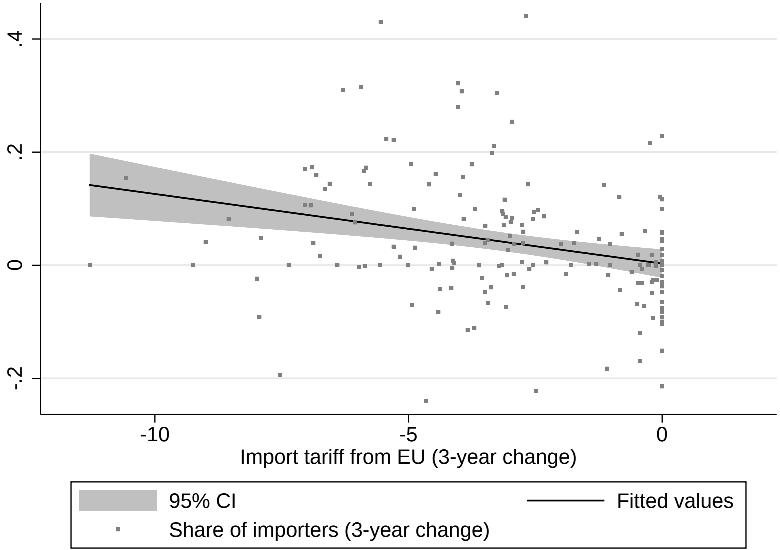


Identification

Interim Agreement with EEA (1991) phased out tariffs



Faster phaseout results in faster imports (Koren, Csillag and Köllő, 2019)



When do firms import?

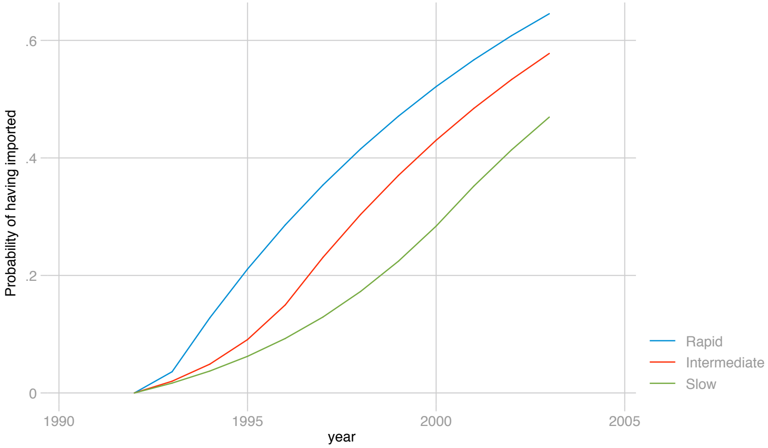
- Lumpy imported investment suggests fixed cost of importing (also see Halpern, Koren and Szeidl, 2015)
- Import if $p_t^F / p_t^D < f(L_{it})$.
- Hazard of *starting to import* (flow):

$$\Pr(K_{it}^F > 0 | K_{i,t-1}^F = 0) = \mu_{st} - \xi \Delta\tau_{st} L_{it}$$

- Probability of *having imported* in the past (stock):

$$\Pr(K_{it}^F > 0) \approx \tilde{\mu}_{st} - \xi L_{it-\text{age}_{it}} \sum_{a=0}^{\text{age}_{it}} \Delta\tau_{st-a}$$

Example of cumulated import hazards



Results

First stage

Depvar: having imported (dummy)	Pooled	Firm FE
cdtariffeu X size 0-10	-0.017***	0.009*
	(0.001)	(0.005)
cdtariffeu X size 10-50	-0.026***	-0.001
	(0.001)	(0.005)
cdtariffeu X size 50+	-0.046***	-0.019***
	(0.002)	(0.005)
lnK	0.048***	0.027***
	(0.002)	(0.001)
lnM	0.018***	0.007***
	(0.001)	(0.001)
lnL	0.008**	0.018***
	(0.003)	(0.003)
foreign (dummy)	0.321***	0.149***
	(0.011)	(0.022)
size dummies	yes	yes
age dummies	yes	yes
industry x year effects	yes	
year effects		yes
Observations	102,516	102,516
R-squared	0.296	0.211
Number of id		17,736
F-test	239.1	91.74

Notes: Robust standard errors (clustered by industry) are in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Productivity

Depvar: lnY	Pooled		Firm FE	
	OLS	IV	OLS	IV
having imported (dummy)	0.199***	0.263***	0.086***	0.781***
	(0.015)	(0.075)	(0.012)	(0.112)
lnK	0.132***	0.129***	0.092***	0.073***
	(0.005)	(0.006)	(0.004)	(0.005)
lnM	0.413***	0.412***	0.297***	0.292***
	(0.009)	(0.010)	(0.010)	(0.010)
lnL	0.299***	0.299***	0.364***	0.353***
	(0.010)	(0.010)	(0.010)	(0.010)
foreign (dummy)	0.161***	0.140***	0.091**	-0.033
	(0.023)	(0.034)	(0.043)	(0.047)
size dummies	yes	yes	yes	yes
age dummies	yes	yes	yes	yes
industry x year effects	yes	yes		
year effects			yes	yes
Observations	102,516	102,516	102,516	102,516
R-squared	0.771	0.771	0.545	0.503
Number of id			17,736	17,736

Notes: Robust standard errors (clustered by industry) are in parentheses.
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Complementarity

Complementarity

- Are imported machines complementarity with other inputs?
- If so, can explain
  - large gaps
  - divergence
- Two ways to measure complementarity (Brynjolfsson and Milgrom, 2013):
  - performance: $f_{xy} > 0$
  - behavior: $\partial x / \partial y > 0$

Positive cross derivative of output (Koren, Csillag and Köllő, 2019)

Table 4: The effect of machine type and worker quality on log output per machine

	(1) Production function
Log number of weavers	0.109***
	(0.029)
New machine	-0.858**
	(0.335)
Log residual wage (as of 1989) of workers at the machine type	-9.91**
	(4.62)
New machine × log residual wage	38.53***
	(7.55)
Number of observations	261
R^2	0.733
Effect of the new machine at 25th percentile of the 1989 residual wage	-0.747
Effect of the new machine at 50th percentile of the 1989 residual wage	1.20
Effect of the new machine at 75th percentile of the 1989 residual wage	1.47

Notes: Dependent variable: log output per machine. Sample: machine-months for five types of loom. Estimation: OLS. The average residual wage was measured by regressing individual log annual earnings (based on payment by results) in 1989 on age, age squared and type of machine fixed effects, and averaging the residual for workers employed at the given type of machine in the given month. Output is measured in million

Assortative assignment (Koren, Csillag and Köllő, 2019)

Table 2: The effect of worker quality on the probability that a worker was matched to a new machine

	(1) Machine-worker assignment
Log residual wage in 1989	2.63***
	(0.645)
Age	0.231**
	(0.100)
Age squared	-0.004***
	(0.001)
Tenure (years)	0.051***
	(0.015)
Number of observations	519
Pseudo-R^2	0.233
Standard deviation of the residual wage	0.128
Mean dependent variable	0.299

Notes: Dependent variable: 1 if the worker is assigned to a new machine, and 0 otherwise. Sample: person-years for continuing workers employed in the plant in 1989. Estimation: Probit. The residual wage was measured by regressing log payments by results in 1989 on age, age squared and type of machine fixed effects. Standard errors (in parentheses) are calculated from a 200-repetition bootstrap. Coefficients significantly different from zero at 1, 5 and 10 percent are marked by

Imported machines are more material intensive

Depvar: ln M/L	Pooled		Firm FE	
	OLS	IV	OLS	IV
having imported (dummy)	0.542***	0.706***	0.206***	1.218***
	(0.021)	(0.119)	(0.020)	(0.185)
foreign (dummy)	-0.032	-0.091*	0.109	-0.072
	(0.037)	(0.055)	(0.073)	(0.078)
size dummies	yes	yes	yes	yes
age dummies	yes	yes	yes	yes
industry x year effects	yes	yes		
year effects			yes	yes
Observations	102,516	102,516	102,516	102,516
R-squared	0.161	0.159	0.056	0.007
Number of id			17,736	17,736

Notes: Robust standard errors (clustered by industry) are in parentheses.
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Imported machines are more *imported* material intensive

Depvar: matimpshare	Pooled		Firm FE	
	OLS	IV	OLS	IV
having imported (dummy)	0.127***	0.110***	0.042***	0.148***
	(0.005)	(0.026)	(0.004)	(0.034)
foreign (dummy)	0.138***	0.144***	0.032**	0.014
	(0.009)	(0.013)	(0.014)	(0.015)
size dummies	yes	yes	yes	yes
age dummies	yes	yes	yes	yes
industry x year effects	yes	yes		
year effects			yes	yes
Observations	102,516	102,516	102,516	102,516
R-squared	0.186	0.186	0.010	-0.023
Number of id			17,736	17,736

Notes: Robust standard errors (clustered by industry) are in parentheses.
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Imported machines use higher quality labor

Depvar: ln wage	Pooled		Firm FE	
	OLS	IV	OLS	IV
having imported (dummy)	0.151***	0.586***	0.089***	0.796***
	(0.009)	(0.049)	(0.009)	(0.090)
foreign (dummy)	0.280***	0.125***	0.089**	-0.037
	(0.017)	(0.024)	(0.036)	(0.041)
size dummies	yes	yes	yes	yes
age dummies	yes	yes	yes	yes
industry x year effects	yes	yes		
year effects			yes	yes
Observations	102,516	102,516	102,516	102,516
R-squared	0.463	0.417	0.587	0.523
Number of id			17,736	17,736

Notes: Robust standard errors (clustered by industry) are in parentheses.
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Conclusion

Conclusion

- Reduced-form evidence from tariff changes and more direct meausures suggest machines imported 1992–2003 in Hungary is better quality than domestic machine of same book value.
- Imported machines improve productivity and are complementary with material, particularly imported material, also with skilled labor.

Next steps

- Dynamic model of importing.
- Quantitative assessment.