Are supply curves convex? Implications for state-dependent responses to shocks

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- **Question:** Are responses to demand shocks state dependent?
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  - Robustness, e.g. Ramey and Zubairy (14), Santoro et al. (14)
  - Little to no structure
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- **Concerns:**
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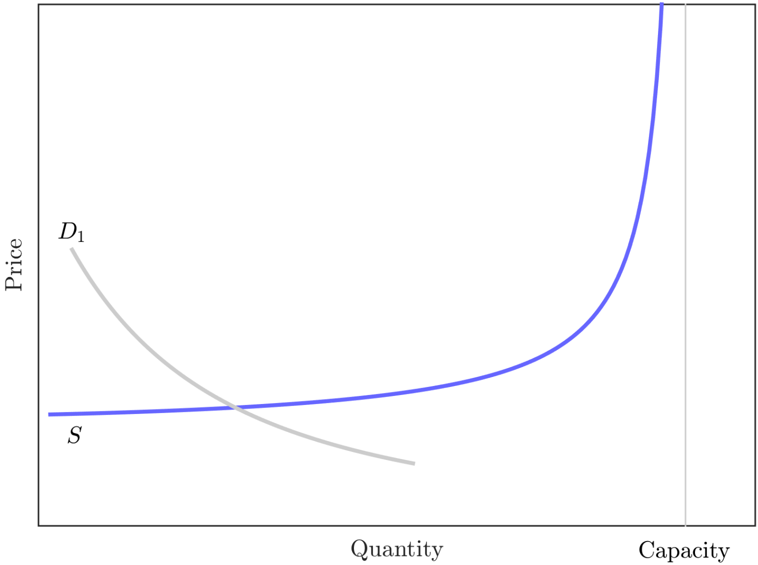
  - Little to no structure
  - Identification
- **Our approach:**
  - Commit to one mechanism: convex supply curves

Motivation



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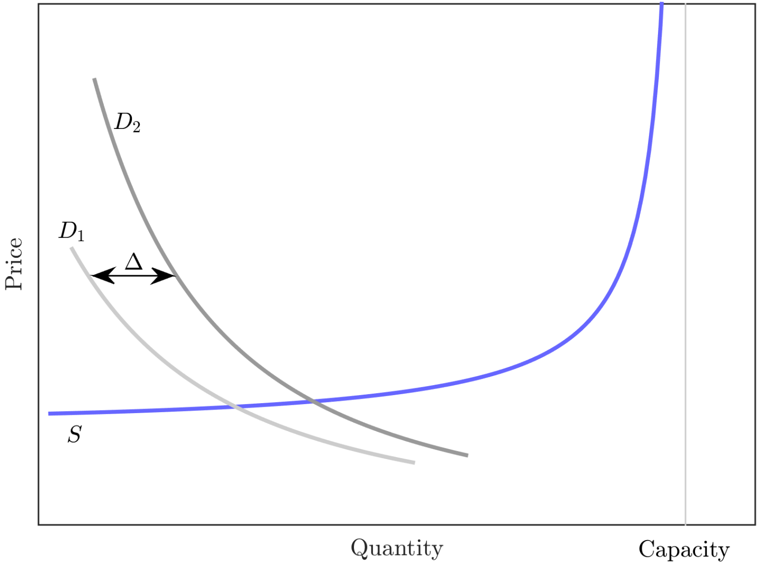

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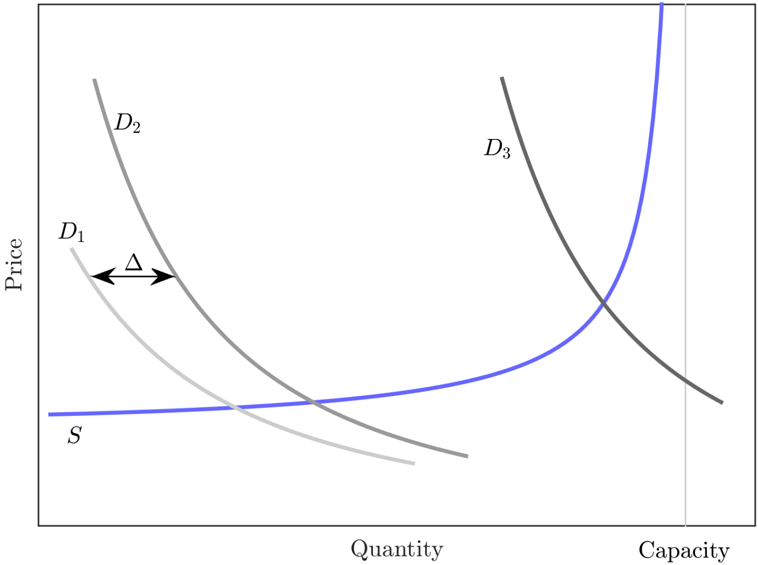

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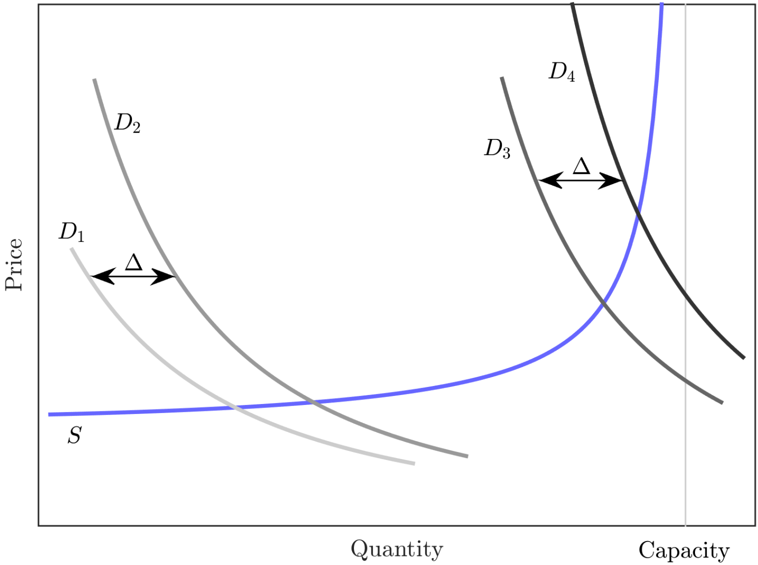

Related Literature

- **State-dependent effects of stabilization policy**
  Auerbach and Gorodnichenko (12, 13a, 13b), Michaillat (14), Owyang, Ramey, and Zubairy (13), Ramey and Zubairy (forthcoming), Santoro et al. (14), Tenreyro and Thwaites (16), Jorda, Schularick, and Taylor (17)

- **Capacity/capital utilization**
  - Theory: Greenwood, Hercovitz, and Huffman (88), Cooley, Hansen, and Prescott (95), Fagnart, Licandro, and Portier (97)
  - Empirics: Morin and Stevens (04), Bansak, Morin, and Starr (07), Lein and Koeberl (09, 11), Lein (10), Shapiro (89), Stock and Watson (99)

- **Exchange rate shocks**
  Gopinath and Rigobon (08), Amiti, Itskhoki and Konings (14)

Outline

1. Motivation
2. Model
3. Estimation
4. Direct evidence on rationing
5. Conclusion

Model

- Main assumption: Putty clay capacity limit $Q_{i,t}$ ▸ Evidence

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- Sufficient statistics estimating equation
- Object of analysis: Industry

Equilibrium

- Supply of industry i

$$\ln P_{i,t} = \Xi\left(u_{i,t}\right) + \ln \frac{w_{i,t} L_{i,t}}{X_{i,t}}$$

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- Demand from country n

$$X_{i,n,t} = \omega_{i,n,t}X_{n,t}\left[\frac{P^*_{i,n,t}}{\mathcal{P}^*_{n,t}}\right]^{-\sigma}$$

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- Exchange rate

$$P_{i,n,t} = \mathcal{E}_{n,t} P^*_{i,n,t}$$

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- Demand from country n

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- Exchange rate

$$P_{i,n,t} = \mathcal{E}_{n,t} P^*_{i,n,t}$$

- Market clearing

$$X_{i,t} = G_{i,t} + \sum_n X_{i,n,t}$$

Shocks

- Effective exchange rate depreciation of industry i

$$\Delta e_{i,t} := \sum_{n} s_{i,n,t-1} \Delta \ln \mathcal{E}_{n,t}$$

  - $s_{i,n,t}$: sales share to country n
  - $n = 0$ is the U.S. (with $\Delta \ln \mathcal{E}_{0,t} = 0$)

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- Defense spending shock

$$\Delta g_{i,t} := \frac{G_{i,t} - G_{i,t-1}}{X_{i,t-1}}$$

  - Use Bartik-type instrument with aggregate defense spending

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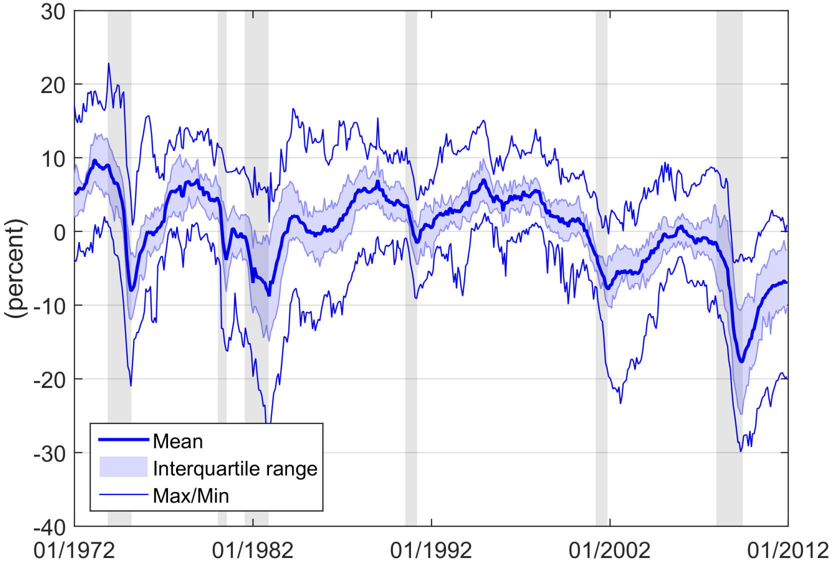
Demeaned utilization



Estimation

Baseline specification

$$\Delta \ln X_{i,t} = \beta_e \Delta e_{i,t} + \beta_{eu} \Delta e_{i,t} \cdot u_{i,t-1} + \beta_u u_{i,t-1}$$
$$+ \text{controls} + \omega^X_{i,t}$$

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- Controls include
  1. Market size and prices
  2. Unit costs
  3. Capacity
  4. Interactions with utilization

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- Controls include
  1. Market size and prices
  2. Unit costs
  3. Capacity
  4. Interactions with utilization
- Identification
  - β_u will in general be biased, β_{eu} won't
  - Next turn to $\Delta e_{i,t}$

Identification

Purification of $\Delta e_{i,t}$

1. Control for cost changes (Amiti et al., 14)

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Then

$$\Delta e_{i,t} = \underbrace{\Delta \ln \mathcal{E}_t^{com} \times (1 - s_{i,0,t-1})}_{\text{time FE} \times (1 - s_{i,0,t-1})}$$

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$$+ \underbrace{\sum_{n=1}^{N} (s_{i,n,t-1} - \bar{s}_{n,t-1}) \Delta \ln \mathcal{E}_{n,t}^{spec}}_{\text{our shock}}$$

Results: Quantities

Dependent variable $\Delta \ln X_{i,t}$

	(1)	(2)	(3)	(4)	(5)
$\Delta e_{i,t}$	2.79***				
	(0.75)				
$\Delta e_{i,t} \times u_{i,t-1}$	-22.30**				
	(9.43)				
$u_{i,t-1}$	-0.04				
	(0.09)				
Baseline controls	yes				
Observations	819				
R-squared	0.554				
Industry FE	no				
Time FE	no				
Time FE $\times (1 - s_{i,0,t-1})$	no				
Higher order controls	no				

Note: Driscoll-Kraay standard errors. Significance: *** p<0.01, ** p<0.05, * p<0.1.

Interpreting of the interaction term

Dependent Variable: $\Delta \ln X_{i,t}$

Percentile	Utilization rate	Elasticity w.r.t. $\Delta e_{i,t}$
10^{th}	-0.085	4.69
25^{th}	-0.032	3.50
50^{th}	0.012	2.52
75^{th}	0.046	1.76
90^{th}	0.075	1.12

Results: Quantities

Dependent variable $\Delta \ln X_{i,t}$

	(1)	(2)	(3)	(4)	(5)
$\Delta e_{i,t}$	2.79***	2.85***			
	(0.75)	(0.72)			
$\Delta e_{i,t} \times u_{i,t-1}$	-22.30**	-25.44***			
	(9.43)	(7.88)			
$u_{i,t-1}$	-0.04	-0.09			
	(0.09)	(0.08)			
Baseline controls	yes	yes			
Observations	819	819			
R-squared	0.554	0.569			
Industry FE	no	yes			
Time FE	no	no			
Time FE $\times (1 - s_{i,0,t-1})$	no	no			
Higher order controls	no	no			

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Results: Quantities

Dependent variable $\Delta \ln X_{i,t}$

	(1)	(2)	(3)	(4)	(5)
$\Delta e_{i,t}$	2.79***	2.85***	1.27		
	(0.75)	(0.72)	(0.90)		
$\Delta e_{i,t} \times u_{i,t-1}$	-22.30**	-25.44***	-24.40***		
	(9.43)	(7.88)	(7.38)		
$u_{i,t-1}$	-0.04	-0.09	-0.16		
	(0.09)	(0.08)	(0.10)		
Baseline controls	yes	yes	yes		
Observations	819	819	819		
R-squared	0.554	0.569	0.679		
Industry FE	no	yes	yes		
Time FE	no	no	yes		
Time FE $\times (1 - s_{i,0,t-1})$	no	no	no		
Higher order controls	no	no	no		

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Results: Quantities

Dependent variable $\Delta \ln X_{i,t}$

	(1)	(2)	(3)	(4)	(5)
$\Delta e_{i,t}$	2.79***	2.85***	1.27	2.02**	
	(0.75)	(0.72)	(0.90)	(0.85)	
$\Delta e_{i,t} \times u_{i,t-1}$	-22.30**	-25.44***	-24.40***	-31.35***	
	(9.43)	(7.88)	(7.38)	(6.34)	
$u_{i,t-1}$	-0.04	-0.09	-0.16	-0.18**	
	(0.09)	(0.08)	(0.10)	(0.09)	
Baseline controls	yes	yes	yes	yes	
Observations	819	819	819	819	
R-squared	0.554	0.569	0.679	0.714	
Industry FE	no	yes	yes	yes	
Time FE	no	no	yes	yes	
Time FE $\times (1 - s_{i,0,t-1})$	no	no	no	yes	
Higher order controls	no	no	no	no	

Note: Driscoll-Kraay standard errors. Significance: *** p<0.01, ** p<0.05, * p<0.1.

Results: Quantities

Dependent variable $\Delta \ln X_{i,t}$

	(1)	(2)	(3)	(4)	(5)
$\Delta e_{i,t}$	2.79***	2.85***	1.27	2.02**	1.87
	(0.75)	(0.72)	(0.90)	(0.85)	(2.07)
$\Delta e_{i,t} \times u_{i,t-1}$	-22.30**	-25.44***	-24.40***	-31.35***	-30.00***
	(9.43)	(7.88)	(7.38)	(6.34)	(7.19)
$u_{i,t-1}$	-0.04	-0.09	-0.16	-0.18**	-0.23**
	(0.09)	(0.08)	(0.10)	(0.09)	(0.08)
Baseline controls	yes	yes	yes	yes	yes
Observations	819	819	819	819	819
R-squared	0.554	0.569	0.679	0.714	0.735
Industry FE	no	yes	yes	yes	yes
Time FE	no	no	yes	yes	yes
Time FE $\times (1 - s_{i,0,t-1})$	no	no	no	yes	yes
Higher order controls	no	no	no	no	yes

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Results: Prices

Dependent variable $\Delta \ln P_{i,t}$

	(1)	(2)	(3)	(4)	(5)
$\Delta e_{i,t}$	-0.12				
	(0.24)				
$\Delta e_{i,t} \times u_{i,t-1}$	4.89**				
	(1.74)				
$u_{i,t-1}$	-0.06*				
	(0.03)				
Baseline controls	yes				
Observations	819				
R-squared	0.906				
Industry FE	no				
Time FE	no				
Time FE $\times (1 - s_{i,0,t-1})$	no				
Higher order controls	no				

Note: Driscoll-Kraay standard errors. Significance: *** p<0.01, ** p<0.05, * p<0.1.

Results: Prices

Dependent variable $\Delta \ln P_{i,t}$

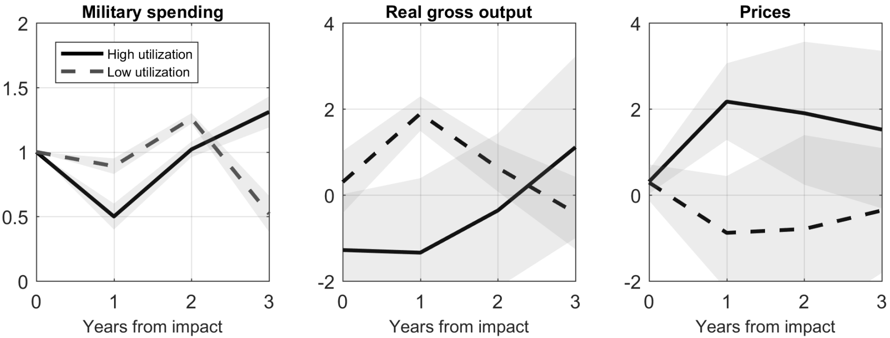
	(1)	(2)	(3)	(4)	(5)
$\Delta e_{i,t}$	-0.12	-0.13	-0.13	0.25	-1.69*
	(0.24)	(0.23)	(0.21)	(0.74)	(0.93)
$\Delta e_{i,t} \times u_{i,t-1}$	4.89**	4.53**	5.99***	5.66***	5.10**
	(1.74)	(1.78)	(1.97)	(1.66)	(1.93)
$u_{i,t-1}$	-0.06*	-0.07**	-0.04	-0.04	-0.01
	(0.03)	(0.03)	(0.04)	(0.04)	(0.04)
Baseline controls	yes	yes	yes	yes	yes
Observations	819	819	819	819	819
R-squared	0.906	0.908	0.921	0.927	0.932
Industry FE	no	yes	yes	yes	yes
Time FE	no	no	yes	yes	yes
Time FE $\times (1 - s_{i,0,t-1})$	no	no	no	yes	yes
Higher order controls	no	no	no	no	yes

Note: Driscoll-Kraay standard errors. Significance: *** p<0.01, ** p<0.05, * p<0.1.

Outline

1. Motivation
2. Model
3. Data and Estimation: Extension to defense spending
4. Conclusion

Results



Note: Shaded areas are one standard error bands, clustered by industry

Conclusion

- Structural model with capacity constraints

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- Sufficient statistics approach to estimation
- **Responses to demand shocks are highly state dependent**
- Evidence consistent with convex supply curves
- Implications for stabilization policy?

Survey Form

Item 2	VALUE OF PRODUCTION		$Bil.	Mil.	Thou.

A. Report market value of **actual production** for the quarter.

ACTUAL PRODUCTION . . . .

$Bil.	Mil.	Thou.

B. Estimate the market value of production of this plant as if it had been operating at **full production capability** for the quarter.

Assume:

- only machinery and equipment **in place and ready to operate**.
- normal downtime.
- labor, materials, utilities, etc. **ARE FULLY AVAILABLE**.
- the number of shifts, hours of operation and overtime pay that can be **sustained** under **normal** conditions and a **realistic** work schedule in the long run.
- the **same product mix** as the actual production.

FULL PRODUCTION CAPABILITY . . . .

$Bil.	Mil.	Thou.

C. Divide your **actual production** estimate by your **full production estimate**. Multiply this ratio by 100 to get a percentage. . . . .

Capacity Utilization

%

Is this a reasonable estimate of your utilization rate for this quarter? ☐ Yes ☐ No — *Review item 2A and 2B*

SUBMIT

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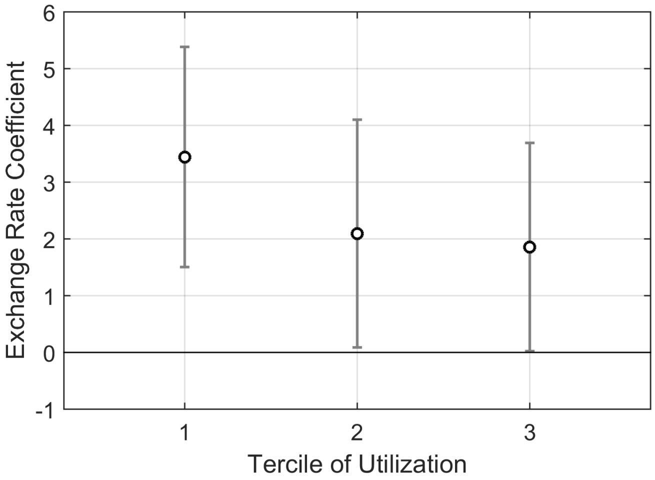
Nonparametric Estimation: Quantities



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Results: Quantities

	Dependent Variable: $\Delta \ln X_{i,t}$			
RHS Variable	(1)	(2)	(3)	(4)
$\sum_n s_{i,n,t-1} \Delta \ln \mathcal{E}_{n,t}$	2.22***	0.48	0.83	2.20***
	(0.60)	(0.80)	(0.80)	(0.57)
$\sum_n s_{i,n,t-1} \Delta \ln \mathcal{E}_{n,t} \cdot u_{i,t-1}$	-16.32***	-32.12***	-30.08***	-17.32***
	(5.48)	(5.70)	(5.40)	(5.43)
$\Delta \ln q_{i,t}$	0.98***			0.99***
	(0.04)			(0.05)
$\Delta \ln q_{i,t} \cdot u_{i,t-1}$	-0.54			-0.38
	(0.57)			(0.55)
$\Delta \ln mc_{i,t}$	-0.03		-0.17***	
	(0.04)		(0.05)	
$\Delta \ln mc_{i,t} \cdot u_{i,t-1}$	-0.55		-0.64	
	(0.56)		(0.86)	
Other variables	yes	yes	yes	yes
Observations	819	819	819	819
R-squared	0.62	0.37	0.39	0.62
Industry FE	no	no	no	no
Time FE	no	no	no	no

Driscoll-Kraay standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1. back

Results: Quantities

	Dependent Variable: $\Delta \ln X_{i,t}$			
RHS Variable	(1)	(2)	(3)	(4)
$\sum_n s_{i,n,t-1} \Delta \ln \mathcal{E}_{n,t}$	0.85	-0.16	-0.15	0.89
	(0.81)	(0.81)	(0.78)	(0.83)
$\sum_n s_{i,n,t-1} \Delta \ln \mathcal{E}_{n,t} \cdot u_{i,t-1}$	-16.62***	-22.33***	-21.21***	-16.97***
	(4.36)	(6.86)	(6.78)	(4.43)
$\Delta \ln q_{i,t}$	0.96***			0.97***
	(0.11)			(0.11)
$\Delta \ln q_{i,t} \cdot u_{i,t-1}$	-0.57			-0.48
	(0.71)			(0.66)
$\Delta \ln mc_{i,t}$	-0.06**		-0.11**	
	(0.03)		(0.04)	
$\Delta \ln mc_{i,t} \cdot u_{i,t-1}$	-0.36		-0.63	
	(0.45)		(0.64)	
Other variables	yes	yes	yes	yes
Observations	819	819	819	819
R-squared	0.70	0.61	0.61	0.70
Industry FE	yes	yes	yes	yes
Time FE	yes	yes	yes	yes

Driscoll-Kraay standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1.

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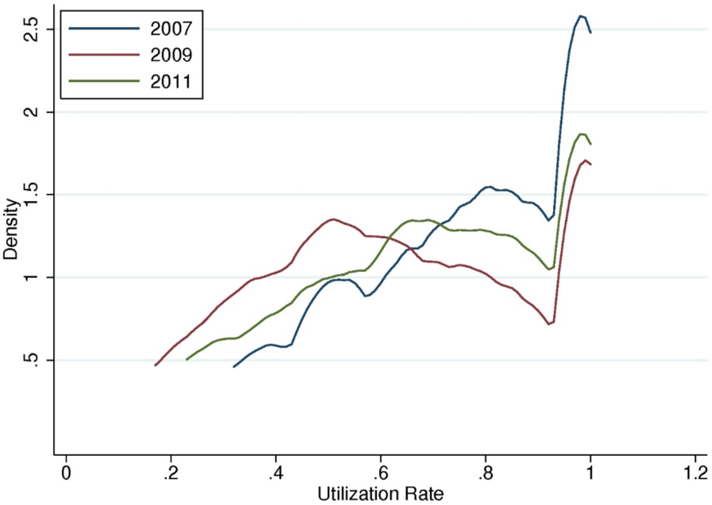
Cross-sectional distribution of utilization



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Data

- Sample
  - Manufacturing 3-digit NAICS industries (21)
  - Old OECD countries
  - 1972 - 2011

Data

- Sample
  - Manufacturing 3-digit NAICS industries (21)
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- Peter Schott's website: exports

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