Discussion of 'Lumpy investment in general equilibrium' by Bachman, Caballero, and Engel

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Overview

- micro evidence: Doms and Dunne (1998), Cooper & Haltiwanger (2006)
- existing partial equilibrium analyses
  - Caballero & Engel (1999), Caballero, Engel & Haltiwanger (1995)
  - nonconvex adjustment technologies yield aggregate nonlinearities

What is the aspect of the data that makes these models better than linear ones at explaining aggregate investment dynamics? ... it is the flexible cyclical elasticity of the increasing hazard model which allows it to better capture the high skewness and kurtosis imprinted on aggregate data by brisk investment recoveries. – Caballero (1999)

- aggregate nonlinearities eliminated in general equilibrium
  - Veracierto (2002), Thomas (2002), Khan & Thomas (2003, 2006)
- this paper contests size of adjustment frictions, given sectoral data
  - argues micro-frictions previously too weak versus GE forces (households)

Comparison to the Khan & Thomas analysis

- model differences

  1. additional independent shocks (sectoral interpretation)
     prompts calibration with large adjustment costs, no other implication.
  2. *required* maintenance investment (avoided on payment of fixed cost)
  3. households are essentially risk-neutral

- comparative strategy

  4. households are different (σ) in lumpy versus frictionless model

Items (2) and (3) are essential to the new findings in this paper relative to previous general equilibrium studies.

Model highlights

- production: $y = z\varepsilon k^{\theta} n^{\nu}$ where $\varepsilon = \varepsilon_S \varepsilon_I$ and $\rho_S = \rho_I$
- capital accumulation: $\gamma k' = (1 - \delta)k + i$
- profits: $\pi = p[y - \omega n - i - \tau(i)\omega\xi]$ (ξ: fixed cost draw, $\tau(i)$: indicator)

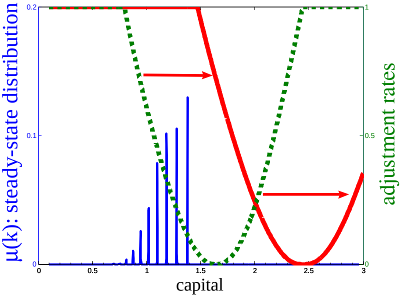
ξ-exempt investment:	$\tau(i) = 0$ IFF		
in traditional lumpy	$i = 0$		
in KT model	$i \in [ak, bk]$	with	$a \leq 0 \leq b$
in BCE model	$i = \chi[\gamma - (1 - \delta)]k$	with	$0 \leq \chi \leq 1$

- firm distribution μ with law of motion $\mu' = \Gamma(z, \mu)$
- target capital $k^*(\varepsilon; z, \mu)$ for "adjusting" firms
- adjustment hazards rising in $|k^*(\varepsilon; z, \mu) - k'(\varepsilon, k; z, \mu)_{\text{nonadjustment}}|$

Aggregate nonlinearities

mechanism

- aggregate shocks change target capital, $k^*(z, \varepsilon; \mu)$
  - movement in target shifts hazard



- large changes induce nonlinear extensive margin response
  - disproportionate investment response to large shocks (excess kurtosis)
  - asymmetric response to positive versus negative shocks (skewness)

Aggregate nonlinearities

partial versus general equilibrium in Khan and Thomas

- large aggregate nonlinearities in partial equilibrium

model	skewness	excess kurtosis
PE frictionless	0.358	0.140
PE lumpy investment	1.121	2.313
GE lumpy investment	0.067	- 0.074

- effects disappear in general equilibrium
  - movements in p, w dampen large changes in firms' $k^*(\varepsilon; z, \mu)$
  - dampen shifts in adjustment hazards, hence in numbers adjusting
  - results very close to corresponding frictionless model

Re-evaluating adjustment costs with sectoral data

- BCE argue equilibrium invariance arises from size of adjustment costs
- use sectoral data to calibrate $\bar{\xi}$

1. *introduce sectors into model via shocks, ε_s*
   - group of firms drawing ε_s together *defines* a sector
2. *assume sectoral shocks have no aggregate effects*
   - continuum of sectors, many firms in each
   - no input-output linkages between sectors
   - perfect substitutes (sectoral relative price fixed at 1)
3. *calibrate sectoral shocks using 3-digit manufacturing data*
   - sectoral relative prices not used to adjust TFP (ε_s not $p_s \varepsilon_s$)

- result: large $\bar{\xi}$ required to restrain highly volatile capital flows

Calibration steps

1. fix required maintenance parameter
2. select maximum fixed cost such that variance of simulated sectoral investment rates matches 3-digit data
3. adjust relative risk aversion such that GE model reproduces variance of aggregate investment rate

- *baseline:* $\chi = 0.5$, $\overline{\xi} = 0.239$, $\sigma = \frac{1}{9}$
  - matches sectoral and aggregate investment rate volatility by design
  - low σ also raises volatility in consumption and labor

Fit to Cooper and Haltiwanger (2006) evidence

investment category	obs. among establishments in **LRD**	obs. among establishments in **baseline BCE**
inactive: $\lvert$ invest. rate $\rvert$ < .01	**8** percent	**0** percent
positive: invest. rate > + .01	**82** percent	**100** percent
negative: invest. rate < - .01	**10** percent	**0** percent
positive spike: invest. rate > + .20	**19** percent	**6** percent
negative spike: invest. rate < - .20	**02** percent	**0** percent

- BCE argue discrepancies with establishment data are easily corrected
  - establishment is many units with imperfectly correlated productivities
  - investment decisions at each unit
  - add *sales/purchase shock* to allocation of capital

$$(\mathrm{i/k})_{e,t}^{\text{recorded}} = (1+\tau_{e,t})(\mathrm{i/k})_{e,t}^{\text{actual}} + \tau_{e,t}(1-\delta)$$

$\tau_{e,t}$ *uncorrelated with* ε_e*,* ε_u*, and* ξ (large measurement error)

Calibrated parameters

- wide range of possible parameter sets from table 3:

χ	$\bar{\xi}$	σ
0	1.551	$\frac{1}{6.94}$
$\frac{1}{4}$	0.680	$\frac{1}{7.69}$
$\frac{1}{2}$	0.239	$\frac{1}{9.09}$
$\frac{3}{4}$	0.068	$\frac{1}{10.99}$
1	0.046	$\frac{1}{32.25}$

- authors select $\chi = \frac{1}{2}$ parameter set
- compare to frictionless model with $\chi = \bar{\xi} = 0$ and $\sigma = 1$

Results 1

comparison of aggregate investment rate dynamics

model	persistence	standard deviation	skewness	excess kurtosis
Khan-Thomas lumpy	0.662	0.010	0.067	- 0.074
baseline BCE: χ=1/2, ξ=0.24, σ=1/9	0.705	0.007	0.315	0.033

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baseline BCE: χ=1/2, ξ=0.24, σ=1/9	0.705	0.007	0.315	0.033
alternative BCE: χ=0, ξ=1.55, σ=1/7	0.703	0.007	0.141	- 0.089

- large fixed costs insufficient for aggregate nonlinearities
- degree of mandatory maintenance is important

effect of *allowing* fixed-cost-exempt maintenance

alteration to Khan-Thomas model	persistence	standard deviation	skewness	excess kurtosis
- no fixed costs for i $\in [0,\delta k]$	0.665	0.010	0.070	- 0.057

Results 2

- role of required maintenance and low sigma in baseline BCE results

model	persistence	standard deviation	skewness	excess kurtosis
baseline BCE: (χ=0.50, σ=1/9)	0.705	0.007	0.315	0.033
- alteration 1: σ=1, χ=0.50	0.702	0.005	0.151	- 0.062
- alteration 2: σ=1, χ=0	0.662	0.006	0.071	- 0.075

Results 2

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- but do we really need a nonlinear model?

	persistence	standard deviation	skewness	excess kurtosis
postwar U.S. investment rate	0.706	0.008	- 0.182	- 0.743

Conclusion

- authors use sectoral data to infer large adjustment frictions
  - illustrate general equilibrium invariance result can be overcome
- tensions in model's ability to hit three levels of aggregation
  - sectoral versus aggregate *(needs σ very low)*
  - sectoral versus establishment-level *(needs sales/purchase shocks)*
  - *would these persist in a richer sectoral model with imperfectly substitutable outputs and/or input-output linkages?*
- required maintenance assumption seems essential to the nonlinearities
  - *possible to arrive at similar results with standard partial irreversibility?*