Lentz & Mortensen (2005): "An Empirical Model of Growth Through Product Innovation"

Prof. Sargent's Reading Group

Matthias Kredler

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Facts on firm productivity

- Consensus in the literature (see survey by Bartelsmann & Doms, 2000):
  - Dispersion in productivity is large across firms
  - Productivity rank of any of these units in the distribution is highly persistent
- *No* consensus on how much of economy-wide productivity growth is due to worker re-allocation:
  - Bartelsmann & Doms (2000): roughly 25%
  - Foster, Haltiwanger & Krizan (2001): Almost none

Baily-Hulten-Campbell (1992)

Define over firms $i = 1, \ldots, L$

- firm's labor share: $s_{it} = N_{it}/N_t$
- firm productivity: $p_{it} = Y_{it}/N_{it}$
- economy-wide productivity: $P_t = \sum_i s_t^{(i)} p_t^{(i)}$

"BHC-decomposition" of productivity growth into five effects:

$$\Delta P_t = \sum_{i \text{ stays}} \Big[\underbrace{s_{t-1}^{(i)} \Delta p_t^{(i)}}_{\text{within-firm}} + \underbrace{\underbrace{p_{t-1}^{(i)} \Delta s_t^{(i)}}_{\text{between-firm}} + \underbrace{\Delta s_t^{(i)} \Delta p_t^{(i)}}_{\text{cross term}}}_{\text{"gross re-allocation"}} \Big] +$$

$$+ \underbrace{\sum_{i \text{ enters}} p_t^{(i)} s_t^{(i)}}_{\text{entry}} - \underbrace{\sum_{i \text{ exits}} p_{t-1}^{(i)} s_{t-1}^{(i)}}_{\text{exit}}$$

Goal of Lentz & Mortensen

- “Estimate the structure of an equilibrium model of growth” with heterogeneous firms
- “Identify and quantify the role of resource re-allocation in the growth process”
- “Show that the BHC-decomposition does not identify the contribution of resource re-allocation to growth” in a Klette-Kortum-type model.
- Structurally show how much of growth is due to worker re-allocation to firms of better innovation capacity.

Model: Overview

Built on Klette & Kortum (2004), which itself is based upon Grossman & Helpman (1991):

- Final good produced from continuum of intermediate goods by competetive firms
- Intermediates produced by monopolistic competitors using labor
- R&D leads to new blueprints for intermediates
- Firms
  - produce an integer number of intermediates
  - do R&D, but vary in their capability to do so

Representative household

- Continuous time
- Infinitely-lived
- Ranks consumption streams by

$$\int_0^\infty e^{-rt}\ln(C_t)dt$$

- Lending and borrowing unrestricted
- Endowed with measure l of labor each instant

Final good

Competitive producers use continuum of intermediate inputs:

$$C_t = \left(\int_0^1 Z(j) \left[A_t(j) x_t(j) \right]^{\frac{\sigma}{\sigma-1}} \right)^{\frac{\sigma-1}{\sigma}}$$

where

- $x_t(j)$: quantity of input j at time t
- $Z(j)$: reflects varying expenditure shares
- $A_t(j)$: productivity of input j at time t
- $\sigma > 0$: elasticity of substitution

Intermediate goods: Production

Leontief in capital and labor:

$$x_t(j) = \min\{L_t(j), K_t(j)\}$$

Productivity in final-goods production follows

$$A_t(j) = \prod_{i=1}^{J_t(j)} q_i(j),$$

where

- $J_t(j)$: number of past innovations for good j at t
- $q_i(j)$: quality of i'th innovation for good j
- Arrival of innovations stochastic: see R&D slide!

Intermediate goods: Pricing

Input prices:

- w: wage rate
- κ: rental rate of capital

Nash-Bertrand limit-pricing:

$$p(j) = m\left[q(j), \sigma\right](w + \kappa)$$

$$m(q,\sigma) = \begin{cases} \frac{\sigma}{\sigma-1} & \text{if } q > \frac{\sigma}{\sigma-1} \\ q & \text{otherwise} \end{cases}$$

Intermediate goods: R&D

Firm makes integer number of k different intermediate goods

- Enter market with $k = 1$
- New blue-prints arrive at rate γk, where γ is chosen
- R&D cost: $wkc(\gamma)$, where $c' > 0$ and $c'' < 0$
- R&D not directed:
  - Get random market $j \in [0, 1]$
  - Get productivity increase $q(j)$ drawn from distribution (next slide!)

δ: displacement rate a product faces (is a consequence of all γ's in the economy)

Firm heterogeneity

Firms differ in quality of innovation:

- On entry ($k = 1$): Firm draws type τ from finite set
- Future innovations q are then drawn from $F_\tau(\cdot)$
- Stochastic dominance, ordered by τ:

$$F_{\tau_{i+1}}(q) \geq F_{\tau_i}(q) \qquad \text{for all } q, \text{for all } i$$

Free entry

Need innovation to enter with $k = 1$. Mass of potential entrants:

- Choose rate γ_0 of innovation
- R&D cost as for incumbents: $wc(\gamma_0)$
- Will learn their type τ after first innovation

Labor market

- Labor is homogenous
- Supply fixed at l
- Labor demanded in two markets:
  - R&D
  - Intermediate-good production

Equilibrium

A invariant measure over pairs (τ, k), prices (w, r), quantities $(l, C_t, x_t(j))$ and R&D decisions such that

- The following markets clear in each instant:
  - labor market
  - bond market
- Optimal decisions by final- and intermediate-good firms
- Firms and potential entrants choose optimal R&D intensity
- Measure over firms is invariant given R&D decisions

Note: Stationarity for productivity A_t not mentioned, but have to integrate over this!

Properties of equilibrium

- R&D is constant-returns-to-scale $\Rightarrow$ Innovation rate depends only on firm type τ
- More profitable/productive (i.e. high-τ) firms
  - grow faster
  - are more likely to survive
  - supply larger number of goods
- But: They need not hire more labor (higher productivity!)

Danish firm data

Annual panel of privately-owned firms: *Danish Business Statistics Register*

- 1992-1997
- Around 4,900 firms
- Restrict to those above 20 workers
- Variables:
  - Y: value added
  - W: total wage bill
  - N: full-time equivalent employment

Estimation

- Solve the model for set of parameters and simulate
- Compare outcomes to data moments on:
  - value added
  - wage bill
  - productivity
  - terms in BHC-decomposition
- Penalty function: GMM-type
- Only use firms that existed in 1992 (selection bias for entrants)

BHC-decomposition for Danish data

Within-firm	1.02
Between-firm	0.45
Cross term	-0.55
Exit	0.84

$$\Delta P_t = \sum_{i \text{ stays}} \Big[\underbrace{s_{t-1}^{(i)} \Delta p_t^{(i)}}_{\text{within-firm}} + \underbrace{\underbrace{p_{t-1}^{(i)} \Delta s_t^{(i)}}_{\text{between-firm}} + \underbrace{\Delta s_t^{(i)} \Delta p_t^{(i)}}_{\text{cross term}}}_{\text{"gross re-allocation"}} \Big] +$$

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Arguing against BHC-decomposition

"We show that models in which the distribution of resources across **firm types** is stationary imply that between- and cross-components [. . .] are zero in the absence of transitory noise."

- Of course: Types have constant shares in steady state $\Rightarrow$ no need for net worker flows between types
- **However:** Inside types there is churning $\Rightarrow$ Should call this re-allocation to more productive firms!
- Example: $k = 2$, $\delta = 0.07$, $g = 1.12$.
- Types τ and innovations g capture the underlying stochastic process for productivity: Why should "transitory" (14 years!) differentials not be important?

Structural adjustment of decomposition

- Counterfactual 1 (CF1): turn off measurement error
- CF2: CF1 + turn off demand shocks
- CF3: CF1 + CF2 + set productivity inside type τ to mean of that type

			Steady state with entry			
	Data	Point Estimate	Point Estimate	Counter-factual 1	Counter-factual 2	Counter-factual 3
Within	1.0149	0.9511	1.1216	0.8872	0.9303	0.8013
Between	0.4525	0.3417	0.2919	0.0734	0.1142	0.0000
Cross	−0.5514	−0.4047	−0.6087	−0.1548	−0.2390	0.0000
Exit	0.0839	0.1119	0.1331	0.1318	0.1314	0.1279
Entry	—	—	0.0621	0.0624	0.0631	0.0709
Survivor growth rate	0.0165	0.0165	0.0165	0.0164	0.0165	0.0165
Growth rate	—	—	0.0141	0.0141	0.0141	0.0141

New proposed decomposition

Authors suggest the following decomposition of productivity growth:

$$g = \underbrace{\sum_\tau E[\ln q_\tau]\phi_\tau}_{\text{residual}} + \underbrace{\sum_\tau \gamma_\tau E[\ln q_\tau](K_\tau - \phi_\tau)}_{\text{selection}} + \underbrace{\eta \sum_\tau E[\ln q_\tau]\phi_\tau}_{\text{entry/exit}}$$

where

- $g = \dot{C}/C$: consumption growth rate
- ϕ_τ: probability of becoming type τ upon entry
- K_τ: steady-state mass of type-τ firms
- η: entry rate

Results/Conclusions

- "Have shown that [. . .] between- and cross-terms are zero" in stationary models
- Structurally estimate creative-destruction model for firms
- Fit many features of the Danish data well
- New decomposition of growth:
  - 55%: selection effect
  - 20%: entry effect