The Slow Growth of New Plants: Learning about Demand?

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Introduction

Relevant Question

- Where do size gaps between young and old plants within industries come from?

Motivation

- New business tend to start small (Dunne, Roberts and Samuelson 1989, Caves 1998, Cabral and Matta 2003).
- Earlier literature: productivity/cost differences as an explanation (Bahk and Gort 1993; theory: Jovanovic 82, Hopenhayn 92, Melitz 03, Asplund & Nocke 07, among others).
- New evidence: selection is on profitability and not just on productivity (Foster Haltiwanger and Syverson 2008).

Introduction

This paper

- Extends the literature tying productivity to plant and firm survival (Bartelsman and Doms 2000) including other sources of heterogeneity.
- Given that new plants tend to be smaller than incumbents and the size gap closes slowly over time, they explore the sources of the D gap and its slow convergence.

The insight

Given the similarity in supply-side fundamentals⇒**idiosyncratic D factors** might explain plant size diff. (i.e. consumer base growth or building reputation: Caminal & Vives 99, Radner 03, Fishmand & Rob 03).

Introduction

Table 1. Evolution of Productivity and Demand across Plant Ages

	Plant Age Dummies			
Variable	Entrant	Young	Medium	Exiter
Physical TFP	0.013	0.005	-0.004	-0.019
	(0.005)	(0.006)	(0.006)	(0.005)
Demand Shock	-0.556	-0.406	-0.322	-0.342
	(0.026)	(0.026)	(0.026)	(0.022)

- Size pattern is not driven by productivity differences.
- Young plants have much lower idiosyncratic D measures (57%)
- D gaps close very slowly over time while supply side fundamentals show no such slow convergence

Model

Develop and estimate a model of dynamic demand process

Environment

- Each plant faces a contemporaneous D curve

$$q_t = \theta_t Age_t^{\phi} Z_t^{\gamma} p_t^{-\eta} \tag{2}$$

  - θ_t exogenous D shock (AR(1))
  - ϕ deterministic change in D
  - Z_t endogenous shifter, γ links current prod. with future expected demand level

$$Z_t = (1-\delta)Z_{t-1} + (1-\delta)R_{t-1}$$

- Production function and profits

$$\begin{aligned} q_t &= A_t x_t \\ \pi_t &= p_t A_t x_t - c_t x_t - f \end{aligned}$$

  - A_t TFP that evolves exogenously
  - x_t input choice

Model

- Value function: plant manager maximizes the present value of π

$$V(Z_t, A_t, Age_t, \theta_t) \quad = \quad \max\left\{0, \sup_x \theta_t^{\frac{1}{\eta}} Age_t^{\frac{\phi}{\eta}} Z_t^{\frac{\gamma}{\eta}} A_t^{1-\frac{1}{\eta}} x_t^{1-\frac{1}{\eta}} - c_t x_t - f \right.$$

$$\left. + \beta E[V(Z_{t+1}, A_{t+1}, Age_{t+1}, \theta_{t+1})]\right\}$$

  - states θ_t, Age, TFP evolves exogenously
  - state Z_t endogenously affected by plant's input choices

- Euler Equation

$$\frac{c_t}{(1-\delta)p_t A_t} - \frac{1}{(1-\delta)}\left(1-\frac{1}{\eta}\right)\theta_t^{\frac{1}{\eta}} Age_t^{\frac{\phi}{\eta}} Z_t^{\frac{\gamma}{\eta}} (A_t x_t)^{-\frac{1}{\eta}} p_t^{-1} =$$

$$\beta E\left\{\theta_{t+1}^{\frac{1}{\eta}} Age_{t+1}^{\frac{\phi}{\eta}} Z_{t+1}^{\frac{\gamma}{\eta}} (A_{t+1}x_{t+1})^{-\frac{1}{\eta}} p_{t+1}^{-1}\left[\frac{\gamma}{\eta}\frac{p_{t+1}A_{t+1}x_{t+1}}{Z_{t+1}}\left(1-\frac{1}{\eta}\right)\right] + \frac{c_{t+1}}{p_{t+1}A_{t+1}}\right\}$$

θ_t state variable observable to the plant manager but not by the economist⇒use the D curve, solve for θ_t and substitute it into here

Model: Euler Equation

$$\frac{c_t}{p_t A_t} - \left(1 - \frac{1}{\eta}\right) = \frac{\beta(1-\delta)\gamma}{\eta} \frac{1}{Z_{t+1}} E[R_{t+1}] + \beta(1-\delta) \left\{ E\left[\frac{c_{t+1}}{p_{t+1}A_{t+1}}\right] - \left(1 - \frac{1}{\eta}\right) \right\} \tag{7a}$$

- RHS=0 in the static problem
- As the plant ages, the ratio of its next period expected revenue to its D stock Z_{t+1} will fall$\Rightarrow$will drive the first RHS term toward 0$\Rightarrow$In the limit the plant to set its markup equal to the static rule (setting all terms in the EE equal to zero).
- Thus young plants have the smallest margins, and then it increases as the plant ages (how fast margins rise is in part a function of the depreciation rate of the plant's D stock)

Model: Estimation

- Estimation (D (2) function and EE(7a))
  - Use past revenues to construct the plant's demand stock Z_t as a function of past sales and the depreciation rate

$$Z_t = (1-\delta)^{\tau} Z_{t-\tau} + \sum_{i=1}^{\tau} (1-\delta)^i R_{t-i}$$

τ is the n^o periods the plant has operated

  - With initial D level for entrants (plant e):

$$Z_{0e} = (K_{0e})^{\lambda_1} \left(\frac{K_{0s(e)} + K_{0e}}{K_{0e}} \right)^{\lambda_2}$$

This allow a plant's initial D stock to be a function of the own physical size as well as the size of the firm that owns it

    - K_{0e} initial physical capital stock of plant e
    - $K_{0s(e)}$ sum of the physical capital stocks of plant e's siblings

Estimation

- When considering estimating the D eq. $q_t = \theta_t Age_t^{\phi} Z_t^{\gamma} p_t^{-\eta}$, $\exists$ endogeneity issue: RHS variables include
  - endogenous plant level prices, and
  - state variables Z_t and Age_t

  that, in the presence of serially correlated D shocks, are correlated with the unobserved D shock$\Rightarrow$to deal with these issues take logs and assume the unobserved D shock follows an AR(1) process:

$$\begin{aligned} \ln q_{t+1} &= \theta_{t+1} + \phi \ln Age_{t+1} + \gamma \ln Z_{t+1} - \eta \ln p_{t+1} \qquad (2a) \\ \theta_{t+1} &= \rho\theta_t + \nu_{t+1} \text{ where } \nu_{t+1} \text{ is } iid \end{aligned}$$

by taking quasi-differences

Estimation

$$\begin{aligned} \ln q_{t+1} &= \rho \ln q_t + \phi \ln Age_{t+1} - \rho\phi \ln Age_t \\ &+ \gamma \ln Z_{t+1} - \rho\gamma \ln Z_t \\ &- \eta \ln p_{t+1} + \rho\eta \ln p_t + \nu_{t+1} \end{aligned} \quad (2b)$$

- Now the residual ν_{t+1}, innovation to the unobserved D shock, is uncorrelated with
  - variables dated t and earlier and
  - with instruments dated in $t+1$ that are correlated with the RHS variables of (2b) but uncorrelated with the innovation to demand shocks (TFP as valid instrument for plant-level prices)

Estimation

- The EE (7a) is simplified by multiplying and dividing the cost-price ratio by the **plant's quantity**⇒the ratio becomes the plant's total variable costs as a share of revenue.

$$
\begin{aligned}
E\left[\varepsilon_{t+1}\right] &= \frac{C_t}{R_t} - \left(1 - \frac{1}{\eta}\right) - \frac{\beta(1-\delta)\gamma}{\eta}\frac{R_{t+1}}{Z_{t+1}} \\
&\quad -\beta(1-\delta)\left(\frac{C_{t+1}}{R_{t+1}} - \left(1 - \frac{1}{\eta}\right)\right) \\
&= 0
\end{aligned}
$$

  moment condition, (assuming that the expectation errors are additively separable, and that their mean is zero at the true parameter values).

- Estimate this MC by GMM. Instruments are variables dated t and earlier:
  - lagged cost-revenue ratios
  - lagged revenues, and
  - age dummies

Estimation: Jointly estimate EE and D by GMM

- Estimate 2 versions of the model:
  - One imposes $\delta = 0$ dep. rate of the D stock (D stock=cum. Rev)
  - The other estimates δ with the other parameters

Results: Concrete Sample

Parameter	[1]	[2]
γ	0.739	0.661
(elasticity of future demand to the demand stock)	(0.025)	(0.038)
η	-4.106	-4.384
(price elasticity of demand)	(0.376)	(0.448)
Young dummy	0.255	0.113
(demand shift for entering and young plants)	(0.071)	(0.088)
Medium age dummy	0.146	0.094
(demand shift for medium-aged plants)	(0.045)	(0.052)
ρ	0.522	0.576
(persistence of exogneous demand shocks θ)	(0.040)	(0.044)
λ_1	1.150	1.249
(elasticity of initial demand to plant's own K)	(0.037)	(0.004)
λ_2	0.326	0.328
(elasticity of initial demand to ratio of firm's K to plant's K)	(0.069)	(0.073)
Inverse Mills Ratio, Demand	-0.024	-0.025
(selection correction, demand equation)	(0.016)	(0.017)
Inverse Mills Ratio, EE	0.005	0.006
(selection correction, Euler equation)	(0.004)	(0.004)
δ		-0.074
(demand depreciation rate)		(0.023)
N	3446	3446

Results

Results: Entire Sample

Parameter	[1]	[2]
γ (elasticity of future demand to the demand stock)	0.758 (0.040)	0.656 (0.056)
η (price elasticity of demand)	-2.147 (0.157)	-2.066 (0.165)
Young dummy (demand shift for entering and young plants)	0.030 (0.051)	-0.079 (0.063)
Medium age dummy (demand shift for medium-aged plants)	0.065 (0.036)	0.012 (0.041)
ρ (persistence of exogneous demand shocks θ)	0.821 (0.065)	0.882 (0.070)
λ_1 (elasticity of initial demand to plant's own K)	1.315 (0.021)	1.419 (0.003)
λ_2 (elasticity of initial demand to ratio of firm's K to plant's K)	0.267 (0.063)	0.280 (0.087)
Inverse Mills Ratio, Demand (selection correction, demand equation)	-0.002 (0.012)	-0.054 (0.016)
Inverse Mills Ratio, EE (selection correction, Euler equation)	0.006 (0.003)	0.002 (0.013)
δ (demand depreciation rate)		0.005 (0.003)
N	5204	5204

Final Remarks

This paper develops and estimates a dynamic demand model to explore new sources of plants size growth and survival, and the slow convergence in size of new plants to established plants size.

Results indicate that

- Even in commodity-like product industries, entry is difficult and
- It takes a long time for a new business -even those of larger firms- to catch up more established competitors in terms of output.