Entry, Exit, and Plant-level Dynamics over the Business Cycle

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Question

- How does the pattern of entry and exit vary over the business cycle?
- How can we interpret the empirical findings using a dynamic general equilibrium model?

What we do

- Document the entry, exit, employment, and productivity dynamics of the U.S. manufacturing plants from Annual Survey of Manufactures (ASM): 1972–1997. In particular, we focus on behavior over the business cycle.
- Build a Hopenhayn and Rogerson (1993)-style dynamic general equilibrium model to explain the observation.

Plant-level data

- ASM (Annual Survey of Manufactures)
  - Confidential micro data files from the U.S. Census Bureau
  - Representative sample of U.S. manufacturing plants
  - Annual frequency $\rightarrow$ allows us to focus on the cyclical behavior
  - Previous studies (e.g., Dunne, Roberts, and Samuelson (1989)) used the Census of Manufactures (CM). CM is the universe of manufacturing plants but is collected every 5 years.

Business cycle evidence

- How does the pattern of entry and exit vary over the business cycle?
- We categorized years as good or bad, based on the growth rate of manufacturing output.
  - Good times: growth rate of output $\geq$ average growth rate (72, 73, 76, 77, 78, 83, 87, 88, 92, 93, 95, 96, 97).
  - Bad times: growth rate of output $<$ average growth rate (75, 80, 81, 82, 85, 86, 90, 91).

Business cycle evidence: entry and exit rates

Table : Entry and exit rates

	Good	Bad
Entry (birth)	8.1%	3.4%
Exit (death)	5.8%	5.1%

- Both entry and exit rates are higher in good times.
- Exit rates are comparable between good and bad times, but entry rates are very different.

Business cycle evidence: job creation and destruction

Table : Job Creation and Job Destruction

	Good	Bad
Job Creation from Startups	1.76	1.21
Job Creation from Continuers	8.20	6.48
Job Destruction from Shutdowns	2.52	2.27
Job Destruction from Continuers	6.72	8.74

- Job creation from startups and job destruction from shutdowns show a similar pattern:
  - Job creation from startups is much higher during booms.
  - Job destruction from shutdowns does not change much over the cycle.

Business cycle evidence: size (employment)

Table : Average employment of entering/exiting plants

	Good	Bad
Average size, continuing	85.4	89.5
Average size, entering	45.1	59.2
Average size, exiting	34.9	35.9
Relative size, entering	0.53	0.70
Relative size, exiting	0.50	0.46

- Entering and exiting plants are much smaller (compared to the 4-digit SIC industry average of continuing plants).
- Entering plants are smaller in good times. The average size of exiting plants is similar.

Business cycle evidence: relative productivity

Table : Productivity relative to continuing plants

	Good	Bad
Relative productivity, entering	0.69	0.85
Relative productivity, exiting	0.65	0.65

- The relative productivity: relative to the continuing plants in the same 4-digit industry.
- The productivity measure is based on the production function: $y_t = s_t n_t^{\theta_l}$.
- The plants entering in bad times are more productive than the plants entering in good times.

Summary of the observations

- The entry rate is more cyclical than the exit rate.
- Entrants are smaller and less productive (relative to the industry average) in booms compared to the entrants in recessions.
  $\rightarrow$There is a stronger selection of entrants in bad times.

Model

- Based on Hopenhayn and Rogerson (1993).
- Four modifications:
  - Aggregate shocks: production function $y_t = z_t s_t n_t^{\theta}$.
  - Positive (and stochastic) exit value.
  - Entry in "two steps" $\rightarrow$ Selection of entrants.
  - Employment adjustment cost.

Timing for incumbent

1. An incumbent plant starts a period with the state (s_{t-1}, n_{t-1}). First, everyone observes the aggregate state, z_t.
   - It observes its (stochastic) exit value, x_t.
   - Then it decides whether to stay or exit. If it exits, it pays the firing tax.
2. If it stays, it observes the idiosyncratic shock s_t.
3. Then it decides the employment in the current period, n_t, and produces.
   - If $n_t \neq n_{t-1}$, it pays adjustment costs (and firing tax, if $n_t < n_{t-1}$).

Timing for entrant

1. First, everyone observes the aggregate state, z_t.
2. To enter, the first step is to come up with an "idea." To come up with an idea, one has to pay c_q ("idea cost") and receive a random number q_t (quality of the idea). We call the people with an idea "potential entrants."
3. Given q_t, a potential entrant decides whether to enter. To enter, the entry cost c_e ("implementation cost," possibly including the sunk investment in equipment/structure) is paid.
4. From here, the decision is the same as the one for the incumbent. It observes s_t, it decides the employment n_t, pays the adjustment cost, and produces.

Value function (incumbent)

- An incumbent's value at the beginning of the period is described by the Bellman equation:

$$W(s_{t-1}, n_{t-1}) = \int \max\langle E_s[V^c(s_t, n_{t-1})|s_{t-1}], x_t - g(0, n_{t-1})\rangle d\xi(x_t).$$

  Here, $g(n_t, n_{t-1})$ is the firing tax and $\xi(x_t)$ is the distribution of the exit value x_t.
- $E_s[V^c(s_t, n_{t-1})|s_{t-1}]$ is the expected value of a continuing plant $V^c(s_t, n_{t-1})$, and is calculated as

$$E_s[V^c(s_t, n_{t-1})|s_{t-1}] = \int \max\langle V^a(s_t, n_{t-1}), V^n(s_t, n_{t-1})\rangle d\psi(s_t|s_{t-1}).$$

  $\psi(s_t|s_{t-1})$ is the conditional distribution of s_t given s_{t-1}.
  $V^a(s_t, n_{t-1})$ is the value function when it adjusts employment.
  $V^n(s_t, n_{t-1})$ is the value function when it does not adjust employment.

Value function (incumbent), cont'd.

- If the plant adjusts employment, the current period profit is

$$\pi^a(s_t, n_{t-1}, n_t) \equiv \lambda z f(n_t, s_t) - w_t n_t - g(n_t, n_{t-1}),$$

  where $\lambda < 1$ represents the "disruption cost" of adjustments, emphasized by Cooper, Haltiwanger, and Willis (2004).
- If the plant does not adjust employment, the current period profit is

$$\pi^n(s_t, n_{t-1}) \equiv z f(n_{t-1}, s_t) - w_t n_{t-1}.$$

- Therefore,

$$V^a(s_t, n_{t-1}) = \max_{n_t} \pi^a(s_t, n_{t-1}, n_t) + \beta W(s_t, n_t),$$

  and

$$V^n(s_t, n_{t-1}) = \pi^n(s_t, n_{t-1}) + \beta W(s_t, n_{t-1}).$$

Value function (entrant)

- The entrant's value function is

$$V^e(q_t) = \int V^c(s_t, 0) d\eta(s_t|q_t),$$

  where $\eta(s_t|q_t)$ is the distribution of s_t given q_t. There is a threshold value of q_t, q_t^*, which is determined by

$$V^e(q_t^*) = c_e.$$

- A potential entrant will enter if and only if $q_t \geq q_t^*$. From the data, we expect that q_t^* is larger in recessions than in booms.

Value function (entrant), cont'd.

- A potential entrant's value function is

$$V^p = \int \max\langle V^e(q_t) - c_e, 0\rangle d\nu(q_t),$$

where $\nu(q_t)$ is the distribution of quality of ideas. We impose a free-entry condition for becoming a potential entrant:

$$V^p = c_q.$$

Consumers

- The representative consumer maximizes the utility:

$$\mathbf{U} = E\left[\sum_{t=0}^{\infty} \beta^t [C_t + Av(1 - L_t)]\right],$$

  where $v(\cdot)$ is increasing and concave utility function for leisure, C_t is the consumption level, L_t is the employment level.
- Budget constraint in each period (no saving):

$$C_t = w_t L_t + \Pi_t + R_t,$$

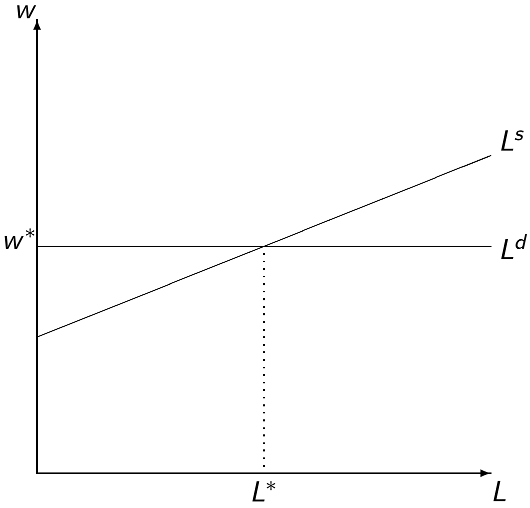
- First-order condition $\rightarrow$labor supply function:

$$Av'(1 - L_t) = w_t.$$

Equilibrium (steady-state)

- There are three equilibrium objects to look for:
  - the wage w_t
  - the threshold idea quality q_t^*
  - the mass of potential entrant N_t.
- For a given w_t, we calculate the value functions. From the entry decision, $V^e(q_t^*) = c_e$, we can find q_t^* corresponding to this w_t.
- Given w_t and q_t^*, we calculate V^p. Free entry condition for potential entrants, $V^p = c_q$, determines the wage w_t.
- Labor market equilibrium condition ($L^d = L^s$) determines N_t.

Equilibrium in the labor market



Business cycle model

- We extend the model to incorporate aggregate shocks.
- The distribution of incumbents changes over time, and depends on the distribution of plants in the previous period.

$$L_t^d = L_{it}^d + N_t L_{et}^d.$$

Note: w_t and q_t^* are functions of only z_t.

Calibration

Calibration is done so that the average statistics match the cross-sectional data.

- We assume

$$\ln(s') = a_s + \rho_s \ln(s) + \varepsilon_s,$$

where $\varepsilon_s \sim N(0, \sigma_s^2)$.

Table : Benchmark parameters

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β	θ	a_s	ρ_s	σ_s	λ	c_e	c_q
0.94	0.7	0.040	0.97	0.112	0.983	941.2	14.1

Comparison of the model to the data: average numbers

Table : Data and model statistics in the steady-state

	Data	Model
Average size of continuing plants	87.5	87.5
Average size of entering plants	50.3	47.4
Average size of exiting plants	35.0	35.3
Entry rate	6.2%	5.5%
Exit rate	5.5%	5.5%
AR(1) coefficient ρ for employment	0.97	0.97
Variance of growth rate for n	0.14	0.14
Job reallocation rate	19.4%	27.4%

Results with aggregate productivity shocks only

- $z = 1.01$ with good times and $z = 0.99$ with bad times.
- Results:

	Good	Bad
Wage	1.014	0.986
q^*	0.5000	0.5000
Entry rate	6.7%	4.0%
Exit rate	5.3%	5.4%
Average size of all plants	84.6	86.5
Relative size of entrants	0.57	0.57
Relative size of exit plants	0.41	0.41
Relative productivity of entrants	0.85	0.85
Relative productivity of exit plants	0.84	0.84

- Successful in generating procyclical entry rate and acyclical exit rate.
  - Not many "marginal plants" for the exiting decision.
  - Quantity is adjusted at the entry margin.

Problems (aggregate productivity shocks only)

- Wage responds too much to the productivity shock. The standard deviation of the wage is 1.5 times the standard deviation of the shock.
- $\rightarrow$ There is no variation in q^*:
  - higher productivity in booms makes entry more attractive, but...
  - ...this is almost completely offset by the increase in wages (general equilibrium effect).

Problems (aggregate productivity shocks only)

To solve these problems, we assume that c_q is procyclical and c_e is countercyclical.

- Procyclical c_q reduces the response of wages.
  - Idea creation (invention) is a human-capital intensive process. The cost of hiring a good inventor is higher in booms.
  - In booms, there are more entry and idea creation may suffer from decreasing returns ("fishing-out" effect). In this case, the model should be modified to make $c_q(N)$. (Much harder to solve.)
- Countercyclical c_e strengthens the selection in recessions.
  - c_e can be interpreted as the sunk investment on equipment/structure at the entry. The price of investment goods tend to be lower in booms (Fisher, 2006).
  - c_e may include the financial cost for borrowing when enter. This cost may be lower in booms.

Procyclical c_q and countercyclical c_e

- c_q is 3.2% lower in recessions 3.8% higher in booms.
- c_e is 0.7% higher in recessions 0.7% lower in booms.

Table : The case of a countercyclical c_e and procyclical c_q

	Good	Bad
Wage	1.010	0.990
q^*	0.3216	0.6259
Entry rate	7.1%	3.9%
Exit rate	5.5%	5.5%
Average size of all plants	80.5	83.4
Relative size of entrants	0.47	0.65
Relative size of exiting plants	0.40	0.40
Relative productivity of entrants	0.78	0.93
Relative productivity of exiting plants	0.84	0.84

- Successful in *quantitatively* replicating the entry/exit rate and the size/productivity facts.

Conclusion

What did we learn?

- From the data:
  - The entry rate is more cyclical than the exit rate.
  - Entering plants are larger and more productive in recessions.
  - Exiting plants are similar over the business cycle.
- From the model:
  - Positive productivity shock makes entry more attractive, but it is counteracted by the change in wages.
  - Procyclical idea cost and countercyclical implementation cost seems important to understanding the process of entry over the business cycle.