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 → 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.
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

<table>
<thead>
<tr>
<th></th>
<th>Good</th>
<th>Bad</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entry (birth)</td>
<td>8.1%</td>
<td>3.4%</td>
</tr>
<tr>
<td>Exit (death)</td>
<td>5.8%</td>
<td>5.1%</td>
</tr>
</tbody>
</table>

- 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>
<thead>
<tr>
<th>Table: Job Creation and Job Destruction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Job Creation from Startups</td>
</tr>
<tr>
<td>Job Creation from Continuers</td>
</tr>
<tr>
<td>Job Destruction from Shutdowns</td>
</tr>
<tr>
<td>Job Destruction from Continuers</td>
</tr>
</tbody>
</table>

- 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.
### Table: Average employment of entering/exiting plants

<table>
<thead>
<tr>
<th></th>
<th>Good</th>
<th>Bad</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average size, continuing</td>
<td>85.4</td>
<td>89.5</td>
</tr>
<tr>
<td>Average size, entering</td>
<td>45.1</td>
<td>59.2</td>
</tr>
<tr>
<td>Average size, exiting</td>
<td>34.9</td>
<td>35.9</td>
</tr>
<tr>
<td>Relative size, entering</td>
<td>0.53</td>
<td>0.70</td>
</tr>
<tr>
<td>Relative size, exiting</td>
<td>0.50</td>
<td>0.46</td>
</tr>
</tbody>
</table>

- 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>
<thead>
<tr>
<th></th>
<th>Good</th>
<th>Bad</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative productivity, entering</td>
<td>0.69</td>
<td>0.85</td>
</tr>
<tr>
<td>Relative productivity, exiting</td>
<td>0.65</td>
<td>0.65</td>
</tr>
</tbody>
</table>

- The relative productivity: relative to the continuing plants in the same 4-digit industry.
- The productivity measure is based on the production function: $y_t = s_t n_t^{\theta_I}$.
- 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.
  → 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” → 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.
An incumbent’s value at the beginning of the period is described by the Bellman equation:

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

Here, \( g(n_t, n_{t-1}) \) is the firing tax and \( \xi(x_t) \) is the distribution of the exit value \( x_t \).

\( E_s[V^c(s, n_{t-1})|s_{t-1}] \) is the expected value of a continuing plant \( V^c(s, n_{t-1}) \), and is calculated as

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

\( \psi(s_t|s_{t-1}) \) is the conditional distribution of \( s_t \) given \( s_{t-1} \).
\( V^a(s, n_{t-1}) \) is the value function when it adjusts employment.
\( V^n(s, n_{t-1}) \) 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
  \[ \pi^a(s_t, n_{t-1}, n_t) \equiv \lambda zf(n_t, s_t) - w_t n_t - g(n_t, n_{t-1}), \]
  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
  \[ \pi^n(s_t, n_{t-1}) \equiv zf(n_{t-1}, s_t) - w_t n_{t-1}. \]

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

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

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:

\[
Av'(1 - L_t) = w_t.
\]
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

\[ L^d \]

\[ L^s \]

\[ W^* \]
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.

\[
L^d_t = L^d_{it} + N_t L^d_{et}.
\]

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>
<thead>
<tr>
<th>( \beta )</th>
<th>( \theta )</th>
<th>( a_s )</th>
<th>( \rho_s )</th>
<th>( \sigma_s )</th>
<th>( \lambda )</th>
<th>( c_e )</th>
<th>( c_q )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.94</td>
<td>0.7</td>
<td>0.040</td>
<td>0.97</td>
<td>0.112</td>
<td>0.983</td>
<td>941.2</td>
<td>14.1</td>
</tr>
</tbody>
</table>
Comparison of the model to the data: average numbers

Table: Data and model statistics in the steady-state

<table>
<thead>
<tr>
<th></th>
<th>Data</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average size of continuing plants</td>
<td>87.5</td>
<td>87.5</td>
</tr>
<tr>
<td>Average size of entering plants</td>
<td>50.3</td>
<td>47.4</td>
</tr>
<tr>
<td>Average size of exiting plants</td>
<td>35.0</td>
<td>35.3</td>
</tr>
<tr>
<td>Entry rate</td>
<td>6.2%</td>
<td>5.5%</td>
</tr>
<tr>
<td>Exit rate</td>
<td>5.5%</td>
<td>5.5%</td>
</tr>
<tr>
<td>AR(1) coefficient $\rho$ for employment</td>
<td>0.97</td>
<td>0.97</td>
</tr>
<tr>
<td>Variance of growth rate for $n$</td>
<td>0.14</td>
<td>0.14</td>
</tr>
<tr>
<td>Job reallocation rate</td>
<td>19.4%</td>
<td>27.4%</td>
</tr>
</tbody>
</table>
Results with aggregate productivity shocks only

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

<table>
<thead>
<tr>
<th></th>
<th>Good</th>
<th>Bad</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wage</td>
<td>1.014</td>
<td>0.986</td>
</tr>
<tr>
<td>$q^*$</td>
<td>0.5000</td>
<td>0.5000</td>
</tr>
<tr>
<td>Entry rate</td>
<td>6.7%</td>
<td>4.0%</td>
</tr>
<tr>
<td>Exit rate</td>
<td>5.3%</td>
<td>5.4%</td>
</tr>
<tr>
<td>Average size of all plants</td>
<td>84.6</td>
<td>86.5</td>
</tr>
<tr>
<td>Relative size of entrants</td>
<td>0.57</td>
<td>0.57</td>
</tr>
<tr>
<td>Relative size of exit plants</td>
<td>0.41</td>
<td>0.41</td>
</tr>
<tr>
<td>Relative productivity of entrants</td>
<td>0.85</td>
<td>0.85</td>
</tr>
<tr>
<td>Relative productivity of exit plants</td>
<td>0.84</td>
<td>0.84</td>
</tr>
</tbody>
</table>

- 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.

- 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 $c_q$

<table>
<thead>
<tr>
<th></th>
<th>Good</th>
<th>Bad</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wage</td>
<td>1.010</td>
<td>0.990</td>
</tr>
<tr>
<td>$q^*$</td>
<td>0.3216</td>
<td>0.6259</td>
</tr>
<tr>
<td>Entry rate</td>
<td>7.1%</td>
<td>3.9%</td>
</tr>
<tr>
<td>Exit rate</td>
<td>5.5%</td>
<td>5.5%</td>
</tr>
<tr>
<td>Average size of all plants</td>
<td>80.5</td>
<td>83.4</td>
</tr>
<tr>
<td>Relative size of entrants</td>
<td>0.47</td>
<td>0.65</td>
</tr>
<tr>
<td>Relative size of exiting plants</td>
<td>0.40</td>
<td>0.40</td>
</tr>
<tr>
<td>Relative productivity of entrants</td>
<td>0.78</td>
<td>0.93</td>
</tr>
<tr>
<td>Relative productivity of exiting plants</td>
<td>0.84</td>
<td>0.84</td>
</tr>
</tbody>
</table>

- 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.