Firms and Industry Dynamics:
Literature and Perspective

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Hong Kong University
ZVI GRILICHES, 1930-1999
(Highly) Selected Contributions of Zvi Griliches

• Production Function Estimation
  • *Economies of Scale and the Form of the Production Function*, with Vidar Ringstad (1971) – Norwegian establishment micro data.
  • Measurement error, unobserved heterogeneity, endogeneity

• R&D and Innovation
  • “Hybrid Corn: An Exploration in the Economics of Technological Change” (1957), *Econometrica* – Diffusion process for innovation

• Price Measurement

See Heckman (2005) – Nobel prize nominating statement for Griliches
Producer Heterogeneity at the Micro Level

Within-industry - enormous differences across plants and firms.

- Observable Characteristics
  - Size (revenue, capital, employment)
  - Age
  - Wages paid
  - Skill level of workforce
  - Management practices or organization
  - Number of products/markets
  - Investment in R&D
  - Advertising

- Unobserved (less) Characteristics
  - Productivity/tech efficiency
  - Product Quality
  - Customer Base
  - Output Quantity and Price

- Performance Outcomes
  - Profitability/ Firm Value
  - Survival
  - Growth rates
  - Innovation rates
A Theory of Firm Growth and Exit

  - Single industry - firms are heterogenous in one dimension: $\omega_i$
  - Firm is born with exogenous draw of $\omega_i$, never changes
  - $c_i$ is unknown to the firm – observe a noisy signal $\Theta_{it} = \Theta(\omega_i + \varepsilon_t)$
  - Choose output based on $E(\Theta_{it})$ and update it based on observed profits

- Mechanism – firm gradually learns $\omega_i$, output level converges, and firm exits if expected future profits are too low.

- Predictions:
  - Probability of failure declines with firm size and age
  - Mean growth rate of survivors declines with size (given age)
  - Variance of survivor’s growth rate declines with age
Plant Growth and Exit – Empirical Evidence

- Panel data of U.S. Manufacturing plants, 5-year intervals, 1963-1982

### TABLE 1
**Plant Growth and Exit Rates**

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Size (number of employees)</th>
<th>5-19</th>
<th>20-49</th>
<th>50-99</th>
<th>100-249</th>
<th>&gt;250</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Mean employment growth rate of successful plants</td>
<td>1-5</td>
<td>0.606</td>
<td>0.299</td>
<td>0.187</td>
<td>0.132</td>
<td>0.067</td>
<td>0.446</td>
</tr>
<tr>
<td></td>
<td>6-10</td>
<td>0.338</td>
<td>0.136</td>
<td>0.066</td>
<td>0.011</td>
<td>-0.011</td>
<td>0.020</td>
</tr>
<tr>
<td></td>
<td>11-15</td>
<td>0.310</td>
<td>0.055</td>
<td>-0.006</td>
<td>-0.015</td>
<td>-0.018</td>
<td>0.153</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>0.519</td>
<td>0.226</td>
<td>0.130</td>
<td>0.077</td>
<td>0.026</td>
<td>0.353</td>
</tr>
<tr>
<td>b. Plant exit rates</td>
<td>1-5</td>
<td>0.412</td>
<td>0.396</td>
<td>0.390</td>
<td>0.327</td>
<td>0.229</td>
<td>0.397</td>
</tr>
<tr>
<td></td>
<td>6-10</td>
<td>0.347</td>
<td>0.288</td>
<td>0.281</td>
<td>0.245</td>
<td>0.158</td>
<td>0.303</td>
</tr>
<tr>
<td></td>
<td>11-15</td>
<td>0.304</td>
<td>0.206</td>
<td>0.234</td>
<td>0.212</td>
<td>0.131</td>
<td>0.255</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>0.391</td>
<td>0.347</td>
<td>0.346</td>
<td>0.291</td>
<td>0.191</td>
<td>0.363</td>
</tr>
<tr>
<td>c. Mean employment growth rate of all plants</td>
<td>1-5</td>
<td>-0.056</td>
<td>-0.216</td>
<td>-0.276</td>
<td>-0.238</td>
<td>-0.178</td>
<td>-0.129</td>
</tr>
<tr>
<td></td>
<td>6-10</td>
<td>-0.127</td>
<td>-0.169</td>
<td>-0.234</td>
<td>-0.236</td>
<td>-0.167</td>
<td>-0.162</td>
</tr>
<tr>
<td></td>
<td>11-15</td>
<td>-0.089</td>
<td>-0.163</td>
<td>-0.239</td>
<td>-0.224</td>
<td>-0.147</td>
<td>-0.141</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>-0.074</td>
<td>-0.199</td>
<td>-0.261</td>
<td>-0.236</td>
<td>-0.170</td>
<td>-0.138</td>
</tr>
<tr>
<td>d. Number of plant-year observations on successful plants/failing plants</td>
<td>1-5</td>
<td>75,959/53,325</td>
<td>29,938/19,649</td>
<td>13,758/5,794</td>
<td>3,972/4,601</td>
<td>3,281/977</td>
<td>132,408/87,346</td>
</tr>
<tr>
<td></td>
<td>6-10</td>
<td>27,409/14,569</td>
<td>15,268/5,584</td>
<td>7,577/2,961</td>
<td>5,829/1,889</td>
<td>2,630/494</td>
<td>58,713/25,947</td>
</tr>
<tr>
<td></td>
<td>11-15</td>
<td>7,773/3,400</td>
<td>4,671/1,216</td>
<td>2,198/673</td>
<td>1,568/421</td>
<td>911/137</td>
<td>17,125/5,847</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>111,141/71,294</td>
<td>49,881/26,449</td>
<td>23,533/12,428</td>
<td>16,869/6,911</td>
<td>6,822/1,608</td>
<td>208,246/118,690</td>
</tr>
</tbody>
</table>

Entry and exit are positively correlated across industries.

<table>
<thead>
<tr>
<th></th>
<th>Exit Rate</th>
<th>Entry Rate</th>
<th>Exit Rate</th>
<th>Entry Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exit Rate</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(No Correction for Fixed Industry Effects)</td>
<td>(Correction for Fixed Industry Effects)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exiter Market Share</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1963–1967</td>
<td>.741</td>
<td>.725</td>
<td>.743</td>
<td>.691</td>
</tr>
<tr>
<td>1967–1972</td>
<td>.722</td>
<td>.770</td>
<td>.759</td>
<td>.703</td>
</tr>
<tr>
<td>1972–1977</td>
<td>.681</td>
<td>.800</td>
<td>.788</td>
<td>.784</td>
</tr>
<tr>
<td>1977–1982</td>
<td>.571</td>
<td>.691</td>
<td>.758</td>
<td>.804</td>
</tr>
<tr>
<td></td>
<td>(No Correction for Fixed Industry Effects)</td>
<td>(Correction for Fixed Industry Effects)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Dunne, Roberts, and Samuelson (1988)
A Theory of Simultaneous Entry and Exit

“Entry, exit, and firm dynamics in long-run equilibrium,” Hopenhayn (1992)

- Firms are heterogeneous in one dimension, productivity $\omega_{it}$
- Productivity is known but evolves stochastically
  - Markov process $F(\omega_{it+1} \mid \omega_{it})$ that is strictly decreasing in $\omega_{it}$
- Entrants pay a sunk cost $C_e$ observe $\omega_{it}$
- Firms exit when $\omega_{it} < \omega$ that guarantees positive firm value

Implications:
- In equilibrium an industry has simultaneous entry and exit
- Magnitude of turnover is affected by $C_e$ (technology)
- High $C_e$ is a barrier to entry and exit. Inefficient firms can survive
Does Firm Turnover Improve Industry Productivity?

Compare productivity of entering, continuing, exiting firms.

Multilateral Tornqvist productivity index (Solow residual):

\[
\ln TFP_{ft} = (\ln Y_{ft} - \ln Y) - \sum_i \frac{1}{2} (S_{ift} + S_i)(\ln X_{ift} - \ln X_i)
\]

Production function estimation:  *Olley and Pakes (1996)*

\[
\ln Y_{ft} = \alpha_0 + \sum_i \alpha_i \ln X_{ift} + \ln TFP_{ft} + \varepsilon_{ft}
\]
Productivity Distributions – Taiwan 1981-91

How do firm movements contribute to the shift in the industry distribution?

Source: Aw, Chen, and Roberts (1991)
Decompose Industry Productivity Growth

Industry Productivity: \( \ln TFP_t = \sum_f \theta_f \ln TFP_{ft} \)

Firms are entering \((E_{t+1})\), exiting \((X_t)\) or continuing \((C_{t+1}, C_t)\)

Industry Productivity Growth:

\[
\ln TFP_{t+1} - \ln TFP_t = \frac{(\theta_{X_t} + \theta_{E_{t+1}})}{2}(\ln TFP_{E_{t+1}} - \ln TFP_{X_t}) \\
\frac{(\ln TFP_{X_t} + \ln TFP_{E_{t+1}})}{2}(\theta_{E_{t+1}} - \theta_{X_t}) \\
\sum_{f \in C} \frac{(\theta_{ft} + \theta_{ft+1})}{2}(\ln TFP_{ft+1} - \ln TFP_{ft}) \\
\sum_{f \in C} \frac{(\ln TFP_{ft} + \ln TFP_{ft+1})}{2}(\theta_{ft+1} - \theta_{ft})
\]

Entry - Exit

Continuing
### TFP Decomposition - Taiwan Manufacturing Plants

#### Table 8
Decomposition of industry productivity growth

<table>
<thead>
<tr>
<th>Industry (years)</th>
<th>Labor productivity growth</th>
<th>TFP growth</th>
<th>Decomposition of TFP growth</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Continuing firms</td>
</tr>
<tr>
<td>Textiles</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1981–1986</td>
<td>0.514</td>
<td>0.165</td>
<td>0.086</td>
</tr>
<tr>
<td>1986–1991</td>
<td>0.437</td>
<td>0.152</td>
<td>0.091</td>
</tr>
<tr>
<td>Clothing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1981–1986</td>
<td>0.157</td>
<td>-0.032</td>
<td>-0.023</td>
</tr>
<tr>
<td>1986–1991</td>
<td>0.332</td>
<td>0.110</td>
<td>0.056</td>
</tr>
<tr>
<td>Chemicals</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1981–1986</td>
<td>0.513</td>
<td>0.264</td>
<td>0.171</td>
</tr>
<tr>
<td>1986–1991</td>
<td>0.194</td>
<td>0.122</td>
<td>0.059</td>
</tr>
<tr>
<td>Plastics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1981–1986</td>
<td>0.268</td>
<td>0.120</td>
<td>0.071</td>
</tr>
<tr>
<td>1986–1991</td>
<td>0.420</td>
<td>0.118</td>
<td>0.080</td>
</tr>
<tr>
<td>Basic metals</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>1981–1986</td>
<td>0.369</td>
<td>0.121</td>
<td>0.087</td>
</tr>
<tr>
<td>1986–1991</td>
<td>0.299</td>
<td>0.164</td>
<td>0.127</td>
</tr>
<tr>
<td>Fabricated metals</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1981–1986</td>
<td>0.266</td>
<td>0.021</td>
<td>-0.008</td>
</tr>
<tr>
<td>1986–1991</td>
<td>0.371</td>
<td>0.083</td>
<td>0.042</td>
</tr>
<tr>
<td>Non-electrical machinery</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1981–1986</td>
<td>0.220</td>
<td>0.036</td>
<td>0.027</td>
</tr>
<tr>
<td>1986–1991</td>
<td>0.404</td>
<td>0.048</td>
<td>0.028</td>
</tr>
<tr>
<td>Electrical machinery</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1981–1986</td>
<td>0.368</td>
<td>0.053</td>
<td>0.028</td>
</tr>
<tr>
<td>1986–1991</td>
<td>0.743</td>
<td>0.293</td>
<td>0.180</td>
</tr>
<tr>
<td>Transportation equipment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1981–1986</td>
<td>-0.047</td>
<td>-0.133</td>
<td>-0.074</td>
</tr>
<tr>
<td>1986–1991</td>
<td>0.468</td>
<td>0.094</td>
<td>0.066</td>
</tr>
</tbody>
</table>
Table 1. Decomposition of TFP Growth, Selected Periods

Percentage increase over the period

<table>
<thead>
<tr>
<th>Category</th>
<th>Total</th>
<th>Fixed shares</th>
<th>Share effect</th>
<th>Entry and exit</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1972−77</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All industries</td>
<td>7.17</td>
<td>5.04</td>
<td>2.12</td>
<td>0.01</td>
</tr>
<tr>
<td>Except 3573</td>
<td>4.62</td>
<td>2.80</td>
<td>1.92</td>
<td>−0.09</td>
</tr>
<tr>
<td>Except 3573 and 3711</td>
<td>0.89</td>
<td>−0.86</td>
<td>1.84</td>
<td>−0.09</td>
</tr>
<tr>
<td><strong>1977−82</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All industries</td>
<td>2.39</td>
<td>−1.09</td>
<td>2.53</td>
<td>0.95</td>
</tr>
<tr>
<td>Except 3573</td>
<td>−3.18</td>
<td>−6.08</td>
<td>2.49</td>
<td>0.41</td>
</tr>
<tr>
<td>Except 3573 and 3711</td>
<td>−4.80</td>
<td>−8.79</td>
<td>3.41</td>
<td>0.59</td>
</tr>
<tr>
<td><strong>1982−87</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All</td>
<td>15.63</td>
<td>13.52</td>
<td>3.15</td>
<td>−1.05</td>
</tr>
<tr>
<td>Except 3573</td>
<td>8.98</td>
<td>7.16</td>
<td>2.82</td>
<td>−1.00</td>
</tr>
<tr>
<td>Except 3573 and 3711</td>
<td>9.30</td>
<td>7.59</td>
<td>2.60</td>
<td>−0.89</td>
</tr>
</tbody>
</table>

Source: Authors' calculations.

Source: Bailey, Hulten, and Campbell (1982)
Multiple Sources of Firm Heterogeneity

• Single proxy for unobserved heterogeneity in profits

  • Revenue TFPR = \( \frac{P_i q_i}{x_i} \) where \( P_i q_i \) is deflated by aggregate price index.
  • Substantial differences across firms.
  • Very persistent over time at firm level.
  • Positively correlated with survival

• Multiple factors can contribute to persistent differences across firms

  • Cost-side factors
    • Input prices (materials deflated by industry deflator)
    • Technical efficiency \( TFPQ = \frac{q_i}{x_i} \)
  • Demand-side factors
    • Product Quality or appeal
    • Different demand elasticities
  • Imperfect Competition - markups

All impact firm price \( P_i \)
Production Function: \[ \ln Y_{ft} = e^{\omega_{ft}} h(X_{ft}) \]

\[ TFPQ_{ft} = \omega_{ft} = \ln Y_{ft} - \ln h(X_{ft}) \]

Output is replaced with revenue deflated with industry price index
Inputs are replaced with expenditures deflated by an price index

\[ TFP R_{ft} = \ln(R_{ft} - \ln \bar{P}_t) - \ln h(X_{ft}) \]

\[ \tilde{X}_{ft} = \frac{W_{ft}}{W_t} X_{ft} \]

Assume demand for each product depends on all product prices and quality index for each product \( \delta_{it} \) and Bertrand competition
Interpreting TFPR – Katayama, Lu, Tybout (2009)

\[ TFPQ_{ft} = \ln \left( \frac{X_{ft}}{h(X_{ft})} \right) + \ln \left( \frac{\eta_{ft}}{\gamma_{ft}(\eta_{ft} - 1)} \right) + \ln \left( \frac{W_{ft}}{\bar{P}_t} \right) \]

- High factor prices can be passed through to output price and TFPR
- High markups do the same, inelastic demand raises TFPR
- High product appeal \( \delta_{it} \) can create inelastic demand
- Rich empirical model (Colombian data)– nested logit demand and cost function
  - MC is negatively correlated with TFPR because of high markups
  - TFPR has very low correlation with demand/quality factors.
Empirical Studies – TFPQ vs TFPR

• Foster, Haltiwanger, and Syverson (AER, 2008)
  • Use U.S. manufacturing plants in 11 homogenous goods industries
  • Can measure physical $Y_{ft}$ and construct output prices as $P_{ft} = R_{ft} / Y_{ft}$
  • Findings:
    • $\text{Corr}(\text{TFPQ}, \text{TFPR}) = 0.75$, $\text{Corr}(\text{TFPQ}, \text{P}) = -0.54$, $\text{Corr}(\text{TFPR}, \text{P}) = 0.16$
    • Higher TFPQ plants (lower MC) have lower prices.
  • Add a demand model-
    \[ \ln Y_{ft} = \alpha_0 + \alpha_1 \ln P_{ft} + \alpha_z + \delta_{ft} \]
  • Findings:
    • $\text{Corr}(\text{TFPR}, \delta) = 0.28$, $\text{Corr}(\text{TFPQ}, \delta) = 0.01$
    • High persistence over time in all measures
    • All measures are negatively correlated with exit
    • Heterogeneity in demand shock is more important than heterogeneity in TFPQ
    • Productivity decomposition: TFPR underestimates contribution of net entry (entrants have low prices)
Empirical Studies – Efficiency or Demand

- Pozzi and Schivardi (Rand, 2016)
  - Data on output price for Italian manufacturing firms in three industries
  - Add CES demand (constant markup) and monopolistic competition.
  - Profit max predicts Y increase with ω and δ, P rises with δ and falls with ω

<table>
<thead>
<tr>
<th>TABLE 5</th>
<th>Quantity Sold and Output Growth</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Output Sold</td>
</tr>
<tr>
<td></td>
<td>(1) Revenues (2) Quantity</td>
</tr>
<tr>
<td>ΔTFP</td>
<td>0.66*** (0.019)</td>
</tr>
<tr>
<td>Δξ</td>
<td>0.44*** (0.007)</td>
</tr>
<tr>
<td>Observations</td>
<td>6566 (6566)</td>
</tr>
<tr>
<td>R²</td>
<td>0.70 (0.50)</td>
</tr>
</tbody>
</table>

- Revenue is more responsive to demand, less responsive to productivity than quantity (price effect)
- Demand shocks are more important than productivity shocks in explaining firm size.
Empirical Studies – Efficiency, Demand, Wedges

• Eslava, Haltiwanger and Urdaneta (Restud, 2023)
  • (Related to Hsieh and Klenow (2009) and Hottman, Redding, Weistein (2016)
• Exploit plant data that includes *input and output prices and quantities*
• Across plants differences in size can arise from:
  • Output quality differences
  • Markups (Cournot competition)
  • Marginal cost – technical efficiency (TFPQ) and quality differences in input
  • Residual – deviations between theory-predicted size and observed size.
• Theory: Derive optimal plant sales with CD production, CES demand, Cournot competition.
• Empirical: Estimate production and demand allowing plant-level variation in $\omega$ and $\delta$
Empirical Studies – Efficiency, Demand, Wedges

Contribution to the Var(log sales): TFPQ and Demand have positive contribution. Demand is largest. Wages, markup, residual make negative contribution to size dispersion.

<table>
<thead>
<tr>
<th></th>
<th>Levels decomposition</th>
<th>Growth decomposition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Weighted avg. ages</td>
<td>Age 3</td>
</tr>
<tr>
<td>Panel A: Unweighted</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TFPQ-HK</td>
<td>1.139</td>
<td>1.184</td>
</tr>
<tr>
<td>TFPQ</td>
<td>0.081</td>
<td>0.131</td>
</tr>
<tr>
<td>Demand</td>
<td>1.058</td>
<td>1.053</td>
</tr>
<tr>
<td>Composite (HK) wedge</td>
<td>-0.139</td>
<td>-0.184</td>
</tr>
<tr>
<td>Material prices</td>
<td>0.003</td>
<td>0.009</td>
</tr>
<tr>
<td>Wages</td>
<td>-0.073</td>
<td>-0.072</td>
</tr>
<tr>
<td>Markup</td>
<td>-0.019</td>
<td>-0.011</td>
</tr>
<tr>
<td>Residual wedge</td>
<td>-0.049</td>
<td>-0.110</td>
</tr>
<tr>
<td>Marginal cost HRW</td>
<td>-0.039</td>
<td>-0.042</td>
</tr>
</tbody>
</table>
Entry Decision

- Efficiency, demand, markups affect firm size, growth, and exit.
- Entry costs are another source of unobserved heterogeneity

- Industry Level - Hopenhayn (1992), high entry costs are a barrier to entry and exit and allow inefficient firms to survive.
- Firm Level – entry costs create hysteresis in firm entry and exit.
  Entrant faces a sunk entry cost $CE_i$. $E(V_i)$ is expected firm value if in
  Incumbent faces a fixed cost $CF_i < CE_i$

  New firms enters if $E(V_i) > CE_i$ but Incumbent remains in if $E(V_i) > CF_i$

- Implication – Entry and fixed costs impact firm and industry dynamics
Empirical Models of Entry – Estimate Sunk Costs

• Dynamic oligopoly game - $E(V_i)$ depends on number of firms
  • Collard-Wexler (Econometrica, 2013) – concrete plants
  • Ryan (Econometrica, 2912) – cement plants
  • Aguirregabiria and Mira (Econometrica, 2007) – retail establishments
  • Dunne, Klimek, Roberts, and Xu (Rand, 2013) – dentists and chiropractors

• Entry into Exporting - Single agent decision
  • Das, Roberts and Tybout (Econometrica, 2007)
  • Alessandria, Arkolakis and Ruhl (2021) – review article

• Investment in R&D – Single agent decision
  • Aw, Roberts, and Xu (AER, 2011)
  • Peters, Roberts, Vuong, Fryges (Rand, 2017)
  • Maican, Orth, Roberts, Vuong (JEEA, 2023)
Combining Demand, Cost, Entry Heterogeneity

• Roberts, Xu, Fan, Zhang (Restud, 2018)
• Model of firm export demand, pricing, and destination markets
• Chinese footwear producers 2002-2006.
• Firm price and quantity of exports by destination market
• Empirical Model
  • Demand equation depends on unobserved firm quality $\xi_f$
  • Pricing equation depends on unobserved firm cost efficiency $c_f$
  • Market participation equation depends on unobserved firm fixed cost $\eta_f$
Empirical Model of Export Participation

- \( f \) – firm, \( d \) – destination region (7), \( k \) – product (textile, rubber, leather)
- Demand – market share

\[
\ln(s_{kf}^{dt}) = \ln(s_{0f}^{dt}) = \xi_f + \xi_k - \alpha_d \ln(p_{kf}^{dt}) + \tau_{dt} + u_{kf}^{dt},
\]

- Pricing

\[
\ln(p_{kf}^{dt}) = \gamma_{dt} + \gamma_k + \gamma_w \ln(w_f^t) + c_f + v_{kf}^{dt},
\]

- Destination Profit

\[
\ln \pi^{dt}(\xi_f, c_f; w_f^t, K_f) = \ln \left[ \frac{1}{\alpha_d} \right] + \ln \Omega^{dt} + \ln \left[ \sum_{k \in K_f} r_k^d \right] + \ln r^{dt}(\xi_f, c_f)
\]

- Export Destination Choice

\[
I_f^{dt} = 1 \text{ if } X_f^{dt} \psi + \delta I_f^{dt-1} + \eta_f \geq \varepsilon_f^{dt}
\]

\[
= 0 \text{ otherwise.}
\]
Empirical Model of Export Participation

• Three-dimensional firm heterogeneity \((\xi_f, c_f, \eta_f) \sim N(0, \Sigma_f)\)

• Results:

<table>
<thead>
<tr>
<th>TABLE 10</th>
<th>Posterior distribution of (\Sigma_f)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
</tr>
<tr>
<td>Var((\xi_f))</td>
<td>3.687</td>
</tr>
<tr>
<td>Var((c_f))</td>
<td>0.341</td>
</tr>
<tr>
<td>Var((\eta_f))</td>
<td>0.136</td>
</tr>
<tr>
<td>Cov((\xi_f, c_f))</td>
<td>0.795</td>
</tr>
<tr>
<td>Cov((\xi_f, \eta_f))</td>
<td>0.099</td>
</tr>
<tr>
<td>Cov((c_f, \eta_f))</td>
<td>0.012</td>
</tr>
</tbody>
</table>

• Demand heterogeneity (market shares) much larger than cost heterogeneity
• Covariance demand and cost implies high-cost firms have high price (quality)
• Heterogeneity in fixed cost - main determinant of number of destinations
Endogenous Heterogeneity – Firm Investment

• Common element in all this literature – heterogeneity in productivity, demand, entry cost is exogenous to the firm

• Firms make investments to affect their performance
  • Demand – invest to build customer base
    • develop new products, improve quality
    • Advertise, marketing expenses
    • Improve service quality
  • Production
    • Invest in innovation – lower production costs, develop new products.
    • Integrate new technology
    • Learning by doing

• Implication – Firm characteristics (observed and unobserved) evolve endogenously as firm’s make investments. Fundamentally a dynamic process.
Dynamic Investment – Learning about Demand

• Foster, Haltiwanger, Syverson (Economica, 2016)
• Use 11 homogenous manufacturing products
  • new firms are smaller than older firms
  • no differences in (average) TFPQ.
• Two new components
  • Modify the demand curve to depend on age and past sales (and current price)
  • Specify the choice of output to maximize present value of the firm.

Implication – output expansion raises demand and profits in future
Empirical model: demand curve, Euler equation for output choice.
Finding: Significant effect of past sales, no effect for age
Conclusion: “Demand Accumulation by Doing” is present.
Dynamic Investment – R&D

• R&D investment – current expenditure, future impact on profits
  • Developing new products (demand)
  • Improving technical efficiency (supply)
• Addition to the model - productivity evolution, decision rule for R&D

\[
\omega_{it+1} = g(\omega_{it}, r_{d_{it}}, \epsilon_{it}) + \varepsilon_{it+1}
\]

Doraszelski and Jaumandreu (Restud, 2013)

\[
\omega_{it+1} = g(\omega_{it}, r_{d_{it}}) + \varepsilon_{it+1}
\]

Peters, Roberts, Vuong, and Fryges (Rand Journal, 2017)

\[
\omega_{it+1} = g(\omega_{it}, \omega_{i_{t+1}}, \varepsilon_{it+1}) + \varepsilon_{it+1}
\]

Maican, Orth, Roberts, Vuong (JEEA, 2023)

\[
\omega_{it+1} = g^m(\omega_{it}, r_{d_{it}}) + \varepsilon_{it+1}
\]

Captures persistence in productivity, contribution of R&D/innovation, uncertainty of future \( \omega \)
Dynamic Returns to R&D – Change in Firm Value

- Firm’s value function with state \( s_{jt} = (k_{jt}, \omega_{jt}, \mu_{jt}) \):

\[
V(s_{jt}) = \pi(s_{jt}) + \max \{ E_t V(s_{jt+1} | s_{jt}, rd_{jt} = 0), \max_{rd > 0} [E_t V(s_{jt+1} | s_{jt}, rd_{jt}) - C_I(rd_{jt}, v_{jt}, I(rd_{jt-1}))] \} \]

Expected future firm value conditional on R&D choice:

\[
E_t V(s_{jt+1}) = \beta \int_\zeta \int_\nu V(k, g^\omega(\omega, rd, \zeta), g^\mu(\mu, rd, \nu)) d\zeta d\nu
\]
Expected Payoff to R&D Investment

- The expected benefit of investing in R&D is
  \[ \Delta EV(s_{jt}) = E_t V(s_{jt+1}|s_{jt}, rd_{jt}) - E_t V(s_{jt+1}|s_{jt}, rd_{jt} = 0) \]

- Extensive margin: Firm chooses \( rd > 0 \) if:
  \[ \Delta EV(s_{jt}) \geq C_I(rd_{jt}, v_{jt}, I(rd_{jt-1})) \]

- Intensive margin: The optimal amount of R&D spending satisfies:
  \[ \frac{\partial V(s_{jt})}{\partial rd_{jt}} = 0 \]
Figure 4: Rate of Return to R&D – Domestic Firms

Figure 5: Rate of Return to R&D – Exporting Firms

Source: Peters, Roberts, Vuong, Research Policy 2022
Concluding Thoughts

• Data driven research area
  • Access to comprehensive firm/plant surveys or censuses – whole size distribution, dynamic patterns of entry, growth, exit

• Heterogeneity in firm performance (within industry) does reflect a diverse set of underlying factors – technology, demand, market power.

Areas for future thought

• Relative importance of these sources differs by industry, country, time. Why?


• Firm Investments – advertising, R&D, capital – are endogenous choices that affect firm performance and dynamics.