Growth through Innovation Bursts
by Berlingieri, De Ridder, Lashkari, and Rigo

Discussion by Nicolas Crouzet (Kellogg)

2024 Conference on the Economics of Innovation in Memory of Zvi Griliches
Overview

Creative destruction / QL models: continued *product improvement* is a key source of growth.
Overview

Creative destruction / QL models: continued product improvement is a key source of growth

This paper
What does the product improvement process look like in the data?
Overview

Creative destruction / QL models: continued **product improvement** is a key source of growth

This paper
What does the product improvement process look like **in the data**?

  Aggregate dynamics $\rightarrow$ firm dynamics $\rightarrow$ product dynamics
Overview

Creative destruction / QL models: continued **product improvement** is a key source of growth

**This paper**

What does the product improvement process look like in the data?

- Aggregate dynamics $\rightarrow$ firm dynamics $\rightarrow$ product dynamics

**Contribution**

Data on firms’ product portfolio
Overview

Creative destruction / QL models: continued product improvement is a key source of growth

This paper
What does the product improvement process look like in the data?

Aggregate dynamics → firm dynamics → product dynamics

Contribution
Data on firms’ product portfolio

Findings
Overview

Creative destruction / QL models: continued product improvement is a key source of growth

This paper

What does the product improvement process look like in the data?

− Aggregate dynamics → firm dynamics → product dynamics

Contribution

Data on firms’ product portfolio

Findings

The size distribution of product portfolios has “fat tails”
Overview

Creative destruction / QL models: continued **product improvement** is a key source of growth

This paper

What does the product improvement process look like **in the data**?

  Aggregate dynamics → firm dynamics → product dynamics

Contribution

Data on firms’ product portfolio

Findings

  The size distribution of product portfolios has ”fat tails”

  Firms add products to their portfolios in bursts that also have ”fat tails”
Overview

Creative destruction / QL models: continued **product improvement** is a key source of growth

This paper

What does the product improvement process look like in the data?

- Aggregate dynamics → firm dynamics → product dynamics

Contribution

Data on firms’ product portfolio

Findings

- The size distribution of product portfolios has “fat tails”
- Firms add products to their portfolios in bursts that also have “fat tails”
- Embedding this in QL model: effects of creative destruction on productivity growth ↑; concentration ↑
Roadmap

1. Data

2. Model
1. Data
Stylized facts

firm $j$, year $t$

$n_{j,t} = \# \text{ products}$

$\Delta^{(+)} n_{j,t} = \text{gross } \# \text{ products added from } t - 1 \text{ to } t$
Stylized facts

firm $j$, year $t$

\[ n_{j,t} = \text{# products} \]

\[ \Delta^{(+)} n_{j,t} = \text{gross # products added from } t - 1 \text{ to } t \]

1. $n_{j,t}$ follows a power law

2. $\Delta^{(+)} n_{j,t}$ follows a power law

3. "churn" in $n_{j,t}$ contributes substantially to aggregate revenue growth
Power law for $\Delta^{(+)n_{j,t}}$
Some basic "innovation accounting"

\[
\mathbb{E}\left[ \Delta^{(+)}n_{j,t} \mid n_{j,t} \right] = \mathbb{P}\left( \text{Innovation in } (t, t + \Delta t) \mid n_{j,t} \right) \\
\times \mathbb{E}\left[ \# \text{ new products} \mid \text{Innovation in } (t, t + \Delta t), n_{j,t} \right]
\]
Some basic "innovation accounting"

\[ \mathbb{E} \left[ \Delta^{(+)} n_{j,t} \mid n_{j,t} \right] = \mathbb{P} \left( \text{Innovation in } (t, t + \Delta t) \mid n_{j,t} \right) \times \mathbb{E} \left[ \text{# new products} \mid \text{Innovation in } (t, t + \Delta t) \right] \approx \lambda \text{[Innovation intensity]} \times \mathbb{E} \left[ \text{# new products} \mid \text{Innovation in } (t, t + \Delta t) \right] \]
Some basic "innovation accounting"

<table>
<thead>
<tr>
<th>Product Innovation Rate</th>
<th>All</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4-5</th>
<th>6-8</th>
<th>8+</th>
</tr>
</thead>
<tbody>
<tr>
<td>∆(+)n_{j,t}</td>
<td>.066</td>
<td>.066</td>
<td>.067</td>
<td>.068</td>
<td>.058</td>
<td>.056</td>
<td>.083</td>
</tr>
<tr>
<td># new products</td>
<td>(.001)</td>
<td>(.002)</td>
<td>(.001)</td>
<td>(.002)</td>
<td>(.002)</td>
<td>(.003)</td>
<td>(.004)</td>
</tr>
</tbody>
</table>

\[ E \left[ \Delta^{(+)} n_{j,t} \mid n_{j,t} \right] = P \left( \text{Innovation in } (t, t + \Delta t) \mid n_{j,t} \right) \]

\[ \times \ E \left[ \text{# new products} \mid \text{Innovation in } (t, t + \Delta t) \right] \]
Some basic “innovation accounting”

<table>
<thead>
<tr>
<th>Product Innovation Rate</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4-5</th>
<th>6-8</th>
<th>8+</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>.066</td>
<td>.066</td>
<td>.067</td>
<td>.068</td>
<td>.058</td>
<td>.056</td>
</tr>
<tr>
<td>E</td>
<td>(.001)</td>
<td>(.002)</td>
<td>(.001)</td>
<td>(.002)</td>
<td>(.002)</td>
<td>(.003)</td>
</tr>
</tbody>
</table>

\[
\mathbb{E} \left[ \Delta^{(+)} n_{j,t} \mid n_{j,t} \right] = \mathbb{P} \left( \text{Innovation in } (t, t + \Delta t) \mid n_{j,t} \right) \\
\times \mathbb{E} \left[ \# \text{ new products } \mid \text{Innovation in } (t, t + \Delta t), n_{j,t} \right]
\]

\[
\mathbb{E} \left[ \frac{\Delta^{(+)} n_{j,t}}{n_{j,t}} \mid n_{j,t} \right]
\]
Some basic “innovation accounting”

<table>
<thead>
<tr>
<th>Product Innovation Rate</th>
<th>All</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4-5</th>
<th>6-8</th>
<th>8+</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>.066</td>
<td>.066</td>
<td>.067</td>
<td>.068</td>
<td>.058</td>
<td>.056</td>
<td>.083</td>
</tr>
<tr>
<td></td>
<td>(.001)</td>
<td>(.002)</td>
<td>(.001)</td>
<td>(.002)</td>
<td>(.002)</td>
<td>(.003)</td>
<td>(.004)</td>
</tr>
</tbody>
</table>

\[
E \left[ \Delta^{(+)} n_{j,t} \mid n_{j,t} \right] = P \left( \text{Innovation in } (t, t + \Delta t) \mid n_{j,t} \right) \\
\times E \left[ \text{# new products} \mid \text{Innovation in } (t, t + \Delta t) \right]
\]

\[
E \left[ \frac{\Delta^{(+)} n_{j,t}}{n_{j,t}} \mid n_{j,t} \right] = \frac{P \left( \text{Innovation in } (t, t + \Delta t) \mid n_{j,t} \right)}{n_{j,t}} \\
\times E \left[ \text{# new products} \mid \text{Innovation in } (t, t + \Delta t) \right]
\]
Some basic “innovation accounting”

<table>
<thead>
<tr>
<th></th>
<th>All</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4-5</th>
<th>6-8</th>
<th>8+</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta n_{j,t}$</td>
<td>.066</td>
<td>.066</td>
<td>.067</td>
<td>.068</td>
<td>.058</td>
<td>.056</td>
<td>.083</td>
</tr>
<tr>
<td>$P$</td>
<td>(.001)</td>
<td>(.002)</td>
<td>(.001)</td>
<td>(.002)</td>
<td>(.002)</td>
<td>(.003)</td>
<td>(.004)</td>
</tr>
</tbody>
</table>

$$
E \left[ \Delta^{(+)} n_{j,t} \mid n_{j,t} \right] = P \left( \text{ Innovation in } (t, t + \Delta t) \mid n_{j,t} \right)
\times E \left[ \text{ # new products} \mid \text{ Innovation in } (t, t + \Delta t) \right]
$$

$$
E \left[ \frac{\Delta^{(+)} n_{j,t}}{n_{j,t}} \mid n_{j,t} \right] = \frac{P \left( \text{ Innovation in } (t, t + \Delta t) \mid n_{j,t} \right)}{n_{j,t}}
\times E \left[ \text{ # new products} \mid \text{ Innovation in } (t, t + \Delta t) \right]
$$

$$
\approx \lambda
$$

[Innovation intensity]

$$
\times E \left[ \text{ # new products} \mid \text{ Innovation in } (t, t + \Delta t) \right]
$$

[Innovation scope]
### What is a product?

#### NACE 22.22 : Manufacture of plastic packing goods

<table>
<thead>
<tr>
<th>CPA 22.22.11</th>
<th>Sacks and bags (including cones), of polymers of ethylene</th>
</tr>
</thead>
<tbody>
<tr>
<td>22.22.11.00</td>
<td>Sacks and bags of polymers of ethylene (including cones)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CPA 22.22.12</th>
<th>Sacks and bags (including cones), of other plastics than polymers of ethylene</th>
</tr>
</thead>
<tbody>
<tr>
<td>22.22.12.00</td>
<td>Plastic sacks and bags (including cones) (excluding of polymers of ethylene)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CPA 22.22.13</th>
<th>Boxes, cases, crates and similar articles of plastics</th>
</tr>
</thead>
<tbody>
<tr>
<td>22.22.13.00</td>
<td>Plastic boxes, cases, crates and similar articles for the conveyance or packing of goods</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CPA 22.22.14</th>
<th>Carboys, bottles, flasks and similar articles of plastics</th>
</tr>
</thead>
<tbody>
<tr>
<td>22.22.14.50</td>
<td>Plastic carboys, bottles, flasks and similar articles for the conveyance or packing of goods, of a capacity ≤ 2 litres</td>
</tr>
<tr>
<td>22.22.14.70</td>
<td>Plastic carboys, bottles, flasks and similar articles for the conveyance or packing of goods, of a capacity &gt; 2 litres</td>
</tr>
</tbody>
</table>
**What is a product?**

**NACE 22.22 : Manufacture of plastic packing goods**

<table>
<thead>
<tr>
<th>CPA 22.22.11 : Sacks and bags (including cones), of polymers of ethylene</th>
</tr>
</thead>
<tbody>
<tr>
<td>22.22.11.00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CPA 22.22.12 : Sacks and bags (including cones), of other plastics than polymers of ethylene</th>
</tr>
</thead>
<tbody>
<tr>
<td>22.22.12.00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CPA 22.22.13 : Boxes, cases, crates and similar articles of plastics</th>
</tr>
</thead>
<tbody>
<tr>
<td>22.22.13.00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CPA 22.22.14 : Carboys, bottles, flasks and similar articles of plastics</th>
</tr>
</thead>
<tbody>
<tr>
<td>22.22.14.50</td>
</tr>
</tbody>
</table>

| 22.22.14.70 | Plastic carboys, bottles, flasks and similar articles for the conveyance or packing of goods, of a capacity > 2 litres | 3923 30 90 |
This is a carboy (in case you were wondering)
| CPA 22.22.11 : Sacks and bags (including cones), of polymers of ethylene |
|------------------------|--------------------------------|------------------|
| 22.22.11.00 | Sacks and bags of polymers of ethylene (including cones) | 3923 21 |

| CPA 22.22.12 : Sacks and bags (including cones), of other plastics than polymers of ethylene |
|------------------------|--------------------------------|------------------|
| 22.22.12.00 | Plastic sacks and bags (including cones) (excluding of polymers of ethylene) | 3923[.29(.10 + .90)] |

| CPA 22.22.13 : Boxes, cases, crates and similar articles of plastics |
|------------------------|--------------------------------|------------------|
| 22.22.13.00 | Plastic boxes, cases, crates and similar articles for the conveyance or packing of goods | 3923[.10(.10 + .90)] |

| CPA 22.22.14 : Carboys, bottles, flasks and similar articles of plastics |
|------------------------|--------------------------------|------------------|
| 22.22.14.50 | Plastic carboys, bottles, flasks and similar articles for the conveyance or packing of goods, of a capacity ≤ 2 litres | 3923 30 10 |
| 22.22.14.70 | Plastic carboys, bottles, flasks and similar articles for the conveyance or packing of goods, of a capacity > 2 litres | 3923 30 90 |
What is a product?

<table>
<thead>
<tr>
<th>NACE 22.22 : Manufacture of plastic packing goods</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPA 22.22.11 : Sacks and bags (including cones), or polymers of ethylene</td>
</tr>
<tr>
<td>22.22.11.00</td>
</tr>
<tr>
<td>CPA 22.22.12 : Sacks and bags (including cones), or other plastics than polymers of ethylene</td>
</tr>
<tr>
<td>22.22.12.00</td>
</tr>
<tr>
<td>CPA 22.22.13 : Boxes, cases, crates and similar articles of plastics</td>
</tr>
<tr>
<td>22.22.13.00</td>
</tr>
<tr>
<td>CPA 22.22.14 : Carboys, bottles, flasks and similar articles of plastics</td>
</tr>
<tr>
<td>22.22.14.50</td>
</tr>
<tr>
<td>22.22.14.70</td>
</tr>
</tbody>
</table>
Some questions for the data

1. When a firm adds a product to its portfolio, does it also improve its quality?
Some questions for the data

1. When a firm adds a product to its portfolio, does it also improve its quality?
Some questions for the data

1. When a firm adds a product to its portfolio, does it also improve its quality?

   Similar to quality-adjusting patent counts
Some questions for the data

1. When a firm adds a product to its portfolio, does it also improve its quality?

   Similar to quality-adjusting patent counts

   What share of the market does the firm gain?
Some questions for the data

1. When a firm adds a product to its portfolio, does it also improve its quality?

   Similar to quality-adjusting patent counts

   What share of the market does the firm gain?

2. What else can we learn about "product innovation strategies"?
Some questions for the data

1. When a firm adds a product to its portfolio, does it also improve its quality?

   Similar to quality-adjusting patent counts

   What share of the market does the firm gain?

2. What else can we learn about “product innovation strategies”?

   Are newly added products close to the portfolio?
Some questions for the data

1. When a firm adds a product to its portfolio, does it also improve its quality?

   Similar to quality-adjusting patent counts

   What share of the market does the firm gain?

2. What else can we learn about “product innovation strategies”?

   Are newly added products close to the portfolio?

   Are there firms that growth without continuous product churn?
2. Model
Model

Klette and Kortum (2004)
Model

Klette and Kortum (2004)  +  "innovation bursts"
Model

Klette and Kortum (2004) + "innovation bursts"

\[ P(\Delta^{(+)} n_{j,t} = k) = \frac{k^{-\theta}}{\zeta(\theta)} \quad \theta \geq 2 \]

\[ P(\Delta^{(+)} n_{j,t} = 1) = 1 \quad \theta \to +\infty \quad [\text{Klette and Kortum}] \]
Model

Klette and Kortum (2004) + "innovation bursts"

\[ P(\Delta^{(+)n_{j,t}} = k) = \frac{k^{-\theta}}{\zeta(\theta)} \quad \theta \geq 2 \]

\[ P(\Delta^{(+)n_{j,t}} = 1) = 1 \quad \theta \to +\infty \quad [\text{Klette and Kortum}] \]

\[ v: \text{value of incumbent (per variety)} \]

\[ (r + \tau) v = \max_{\lambda} \pi - \left(\frac{\alpha}{\psi} \lambda \psi\right) w + \lambda v \]
Model

Klette and Kortum (2004) + "innovation bursts"

\[ P(\Delta^{(+)} n_{j,t} = k) = \frac{k^{-\theta}}{\zeta(\theta)} \quad \theta \geq 2 \]

\[ P(\Delta^{(+)} n_{j,t} = 1) = 1 \quad \theta \rightarrow +\infty \quad [\text{Klette and Kortum}] \]

\( v \): value of incumbent (per variety)

\[(r + \tau)v = \max_{\lambda} \pi - \left(\frac{\alpha}{\psi}\lambda^\psi\right)w + \frac{\zeta(\theta - 1)}{\zeta(\theta)} \lambda v \quad > 1\]
Model

Klette and Kortum (2004) + "innovation bursts"

\[ \mathbb{P}(\Delta^{(+)} n_{j,t} = k) = \frac{k^{-\theta}}{\zeta(\theta)} \quad \theta \geq 2 \]

\[ \mathbb{P}(\Delta^{(+)} n_{j,t} = 1) = 1 \quad \theta \to +\infty \quad [\text{Klette and Kortum}] \]

\(v\): value of incumbent (per variety)

\[ (r + \tau) v = \max_{\lambda} \pi - \left(\frac{\alpha}{\psi} \lambda^\psi\right) w + \frac{\zeta(\theta - 1)}{\zeta(\theta)} \lambda v \]

\(\therefore "\text{marginal } q\text" \text{ of innovation } (\lambda) \text{ is higher than in KK}\)
Model


\[
P(\Delta^{(+)n_{j,t} = k}) = \frac{k^{-\theta}}{\zeta(\theta)} \quad \theta \geq 2
\]

\[
P(\Delta^{(+)n_{j,t} = 1}) = 1 \quad \theta \to +\infty \quad [\text{Klette and Kortum}]
\]

\(v\): value of incumbent (per variety)

\[(r + \tau)v = \max_{\lambda} \pi - \left(\frac{\alpha}{\psi} \lambda^\psi\right) w + \frac{\zeta(\theta - 1)}{\zeta(\theta)} \lambda v
\]

\[\therefore "\text{marginal } q\text{" of innovation (}\lambda\text{) is higher than in KK}\]

\[\alpha \lambda^{\psi - 1} w = \frac{\zeta(\theta - 1)}{\zeta(\theta)} v
\]
Entry and growth

$w l_s$: cost of setting up a new firm
Entry and growth

\( w l_s \): cost of setting up a new firm

\[
\begin{align*}
w l_s &= v
\end{align*}
\]
Entry and growth

$w l_s$: cost of setting up a new firm

$$w l_s = \frac{\zeta(\theta - 1)}{\zeta(\theta)} v$$
Entry and growth

\( w l_s \): cost of setting up a new firm

\[

w l_s = \frac{\zeta(\theta - 1)}{\zeta(\theta)} v
\]

Aggregate growth = \( \tau \log(q) \), with \( \tau = \) rate of creative destruction
Entry and growth

\( w l_s \): cost of setting up a new firm

\[
w l_s = \frac{\zeta(\theta - 1)}{\zeta(\theta)} v
\]

Aggregate growth = \( \tau \log(q) \), with \( \tau = \text{rate of creative destruction} \)

\[
\tau = \left(1 - \frac{1}{\psi}\right) \left(\frac{L}{l_s}\right) \frac{1}{\psi - 1} + \frac{L}{l_s} \left(1 - \frac{1}{q}\right) - \frac{\rho}{q}
\]
Entry and growth

$w_l = \text{cost of setting up a new firm}$

$$w_l = \frac{\zeta(\theta - 1)}{\zeta(\theta)} v$$

Aggregate growth = $\tau \log(q)$, with $\tau = \text{rate of creative destruction}$

$$\tau = \frac{\zeta(\theta - 1)}{\zeta(\theta)} \left( 1 - \frac{1}{\psi} \right) \frac{L}{\alpha} \left( \frac{l_s}{\psi - 1} \right) + \frac{\zeta(\theta - 1)}{\zeta(\theta)} \frac{L}{l_s} \left( 1 - \frac{1}{q} \right) - \frac{\rho}{q}$$
Entry and growth

\( w l_s \): cost of setting up a new firm

\[
w l_s = \frac{\zeta(\theta - 1)}{\zeta(\theta)} v
\]

Aggregate growth = \( \tau \log(q) \), with \( \tau = \text{rate of creative destruction} \)

\[
\tau = \frac{\zeta(\theta - 1)}{\zeta(\theta)} \left(1 - \frac{1}{\psi}\right) \left(\frac{l_s}{\alpha}\right)^{\frac{1}{\psi-1}} + \frac{\zeta(\theta - 1)}{\zeta(\theta)} \frac{L}{l_s} \left(1 - \frac{1}{q}\right) - \frac{\rho}{q}
\]

"Rescaled" KK, with:

\[
\tilde{l}_s = \left\{ \frac{\zeta(\theta)}{\zeta(\theta - 1)} l_s \right\}^{<1} \quad \text{[lower entry costs]}
\]

\[
\tilde{\alpha} = \left(\frac{\zeta(\theta)}{\zeta(\theta - 1)}\right)^{\psi} \alpha \quad \text{[lower flow innovation costs]}
\]
KK + "only" innovation bursts

Do innovation bursts change the quantitative predictions of KK?
KK + "only" innovation bursts

Do innovation bursts change the quantitative predictions of KK?

✓ Concentration: longer tails than KK

✗ Aggregate growth
KK + “only” innovation bursts

Do innovation bursts change the quantitative predictions of KK?

✔ Concentration: longer tails than KK

✗ Aggregate growth
KK + "only" innovation bursts

Do innovation bursts change the quantitative predictions of KK?

✔ Concentration: longer tails than KK

✗ Aggregate growth

(Feature, not bug!)
KK + "only" innovation bursts

Do innovation bursts change the quantitative predictions of KK?

✔ Concentration: longer tails than KK

✗ Aggregate growth

(Feature, not bug!)

What else is there in the full model?

Process innovation
KK + "only" innovation bursts

Do innovation bursts change the quantitative predictions of KK?

✓ Concentration: longer tails than KK

✗ Aggregate growth

(Feature, not bug!)

What else is there in the full model?

Process innovation

But also, other small things: preferences ≠ Cobb-Douglas; entrants cannot introduce multiple varieties; non-homogeneous investment cost functions
KK + "only" innovation bursts

Do innovation bursts change the quantitative predictions of KK?

✓ Concentration: longer tails than KK

✗ Aggregate growth

(Feature, not bug!)

What else is there in the full model?

Process innovation

But also, other small things: preferences ≠ Cobb-Douglas; entrants cannot introduce multiple varieties; non-homogeneous investment cost functions

Suggestion: KK + innovation bursts + "only" process innovation
Conclusion

Exciting set of stylized facts + nice articulation with model

- additions to product portfolio ↔ quality improvements in QL models?
- what else can we learn about product innovation strategies of firms?

A paper people should read!