# Of Shrimps and Men: Innovation, Competition and Product Diversity

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# A classic view of innovation

- Innovation gives a **temporary advantage** to the innovator, until laggards eventually **catch up** (Aghion et al., 2005)
- Intuition: innovation is a way to temporarily **escape competition**
- Led to a large literature on Innovation Vs Competition (see recent review by Griffith and Van Reenen, 2021)

## This paper

**What if the "catch up" phase is more competitive than before the innovation?**

- First paper to show that innovation can be detrimental to the innovator's profit due to the choice of product variety
- We illustrate the theory by using the US shrimp industry case

# How Innovation Killed the American Shrimp: before innovation

Large-scale shrimp aquaculture began developing in 1970 based on local species: L. Vannamei (US) Vs P. Monodon (Asia)

Figure 1: United States

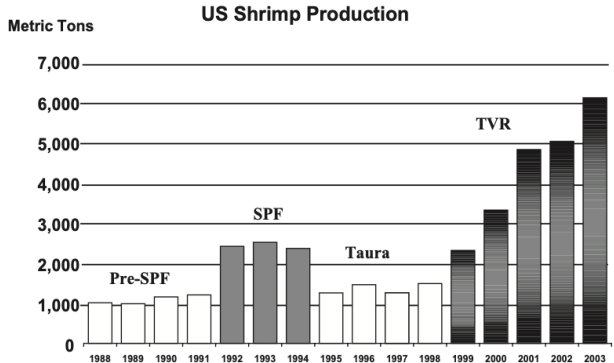

Figure 2: Asia

# The US innovation

- Different varieties, same problem: mass mortality due to periodical outbreaks
- High volatility in production
- **INNOVATION:** in 1998, the US developed a technology able to protect Vannamei shrimps against the major diseases (TVR)

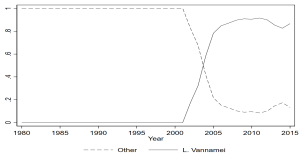
# The gains from innovation

Figure 3: US Shrimps production (source: Wyban, 2009)

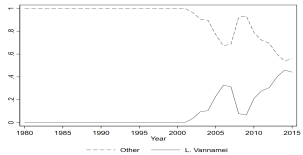


# The innovation catch-up

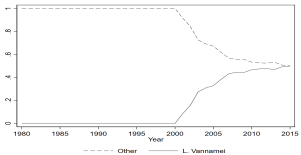
- Increasing availability of TVR broodstocks of *L. Vannamei*: Asian countries switch their production to the US variety



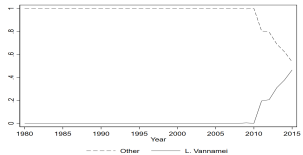

(a) Thailand




(b) Vietnam




(c) China




(d) India

# How Innovation Killed the American Shrimp: after innovation

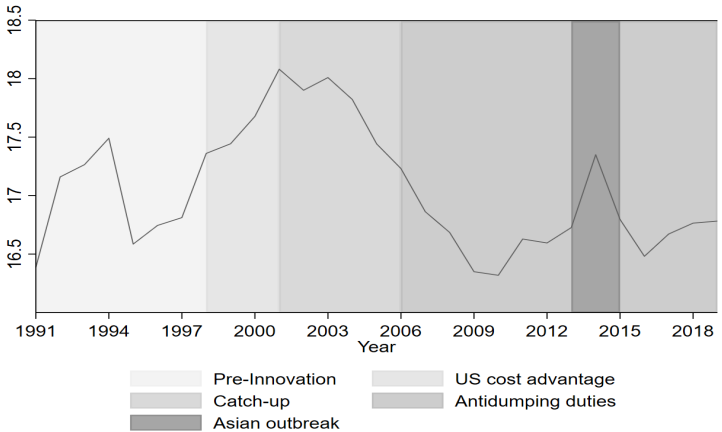
Figure 4: United States

Figure 5: Asia

....but cheaper

# What about the US profits?

Figure 6: Aggregate US industry profit (1991-2019)



## Goal of the theory

1. Show that in a market in which producers compete in quantity (Cournot) and can choose a variety...
2. an innovation (cost reduction) can lead to lower product diversity ...
3. ... and lower profit in the catch up phase

## Some related results

- Innovator is in a "pesky little brother" relationship with laggard (Besen and Farrell, 1994)
- Vives (2008): more substitutability leads to more efforts to innovate
- Cournot Paradox (Seade, 1985; Amir et al., 2017)
- Braess Paradox (Braess, 1968; Braess et al., 2005)

## Setup

- Two representative firms, Home ($h$) and Foreign ($f$), produce shrimps
- Two kind of shrimps available, the white legs shrimps "Vannamei" ($v$) and the tiger shrimps "Monodon" ($m$)
- Each of the firms can produce only one variety, and chooses a quantity
- If $h$ and $f$ produce the same variety: Cournot competition
- If they choose different varieties: differentiated Cournot competition (Singh, 1984)

## Setup

Inverse demand for firm $i \in \{h, f\}$ is given by

$$p_i^k = A - q_i^k - g(k,l)q_j^l, \tag{1}$$

- with $k, l \in \{v, m\}$ the chosen variety of each firm
- For $k \neq l$, $g = \gamma \in (0, 1)$ characterizes the level of substitution between both types of shrimps à la Singh (1984)
- For $k = l$, $g = 1$ (standard Cournot)

## The three phases of innovation

1. **Pre-innovation:** both firms produce at constant marginal cost $c_i^k = c > 0$ for all $k \in \{v, m\}$
2. **Innovation:** innovator $h$ can produce variety $v$ at marginal cost $c_h^v = 0$ (other costs remain $c$)
3. **Catch up:** both firms can produce variety $v$ at marginal cost $c_i^v = 0$ for all $i \in \{h, f\}$ (cost for the other variety $m$ remains $c$)

**Interpretation:** $c$ is a measure of how important the innovation is

# Pre-innovation phase profit

**Lemma**

*The Pre-innovation phase has two Nash equilibria in pure strategy, in which both firms choose different varieties.*

| | | Foreign: $v$ | Foreign: $m$ |
|---|---|---|---|
| Home | $v$ | $\frac{(A-c)^2}{9}, \frac{(A-c)^2}{9}$ | $\frac{(A-c)^2}{(2+\gamma)^2}, \frac{(A-c)^2}{(2+\gamma)^2}$ |
| | $m$ | $\frac{(A-c)^2}{(2+\gamma)^2}, \frac{(A-c)^2}{(2+\gamma)^2}$ | $\frac{(A-c)^2}{9}, \frac{(A-c)^2}{9}$ |

# Innovation phase profit

## Lemma

*The innovation phase has either one or two Nash equilibria in pure strategy. For* $c \leq \frac{A(1-\gamma)}{\gamma+5} = \tilde{c}$*, the two equilibria are similar to the pre-innovation phase, both firms choose different varieties. For* $c > \tilde{c}$*, in the unique equilibrium the innovator* $h$ *produces the variety* $v$ *in which it has a cost advantage, the other firm* $f$ *produces the other variety* $m$*.*

| | | Foreign | |
|---|---|---|---|
| | | $v$ | $m$ |
| Home | $v$ | $\frac{(A+c)^2}{9}, \frac{(A-2c)^2}{9}$ | $\frac{(A(2-\gamma)+\gamma c)^2}{(4-\gamma^2)^2}, \frac{(A(2-\gamma)-2c)^2}{(4-\gamma^2)^2}$ |
| | $m$ | $\frac{(A-c)^2}{(2+\gamma)^2}, \frac{(A-c)^2}{(2+\gamma)^2}$ | $\frac{(A-c)^2}{9}, \frac{(A-c)^2}{9}$ |

# Catch-up phase profit

## Lemma

*The catch up phase has either one or two Nash equilibria in pure strategy. For* $c \leq \frac{1}{6}A(2-\gamma)(1-\gamma) = \bar{c}$*, the two equilibria are similar to the pre-innovation phase, both firms choose different varieties. For* $c > \bar{c}$*, in the unique equilibrium both firms produce variety* $v$*.*

| | | Foreign: $v$ | Foreign: $m$ |
|---|---|---|---|
| Home | $v$ | $\frac{A^2}{9}, \frac{A^2}{9}$ | $\frac{(A(2-\gamma)+\gamma c)^2}{(4-\gamma^2)^2}, \frac{(A(2-\gamma)-2c)^2}{(4-\gamma^2)^2}$ |
| | $m$ | $\frac{(A(2-\gamma)-2c)^2}{(4-\gamma^2)^2}, \frac{(A(2-\gamma)+\gamma c)^2}{(4-\gamma^2)^2}$ | $\frac{(A-c)^2}{9}, \frac{(A-c)^2}{9}$ |

## Proposition: The innovation curse

1. For $c > \bar{c}$, both firms produce variety $v$ in the catch-up phase, while both produce different varieties in the pre-innovation phase
2. For $c < \frac{1}{3}A(1-\gamma) = c^*$, the catch-up phase profit when both firms produce variety $v$ is strictly lower than the pre-innovation profit when both produce different varieties, for both firms
3. As $\tilde{c} < \bar{c} < c^*$ there always exists a $c \in (\bar{c}, c^*)$ such that innovation leads to lower profit in the catch up phase than pre-innovation

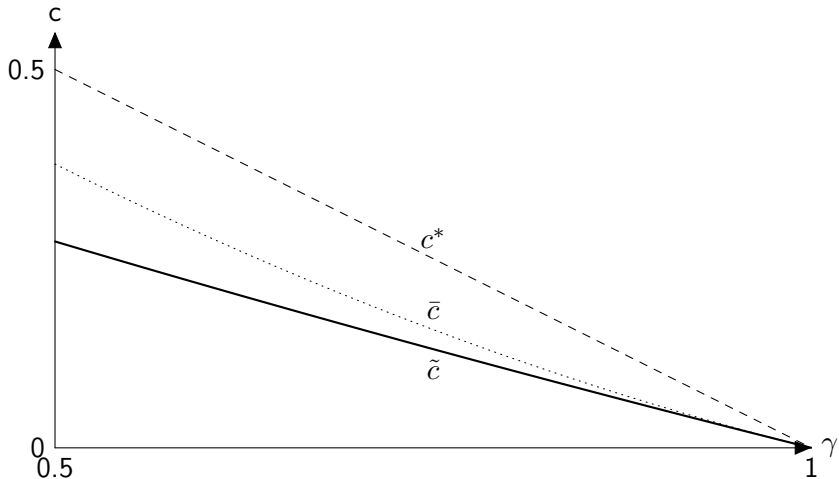



Figure 7: Critical values of $c$, for $A = 3$.

# Main message

- A cautionary tale for innovation as a means of escaping competition
- Related issues:
  - External validity
  - Political equilibrium