Endogenous Product Cycles

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Product Cycles (Vernon 1966)

- Innovation and initial production occurs the North (developed countries), close to large, high-income markets.
- After production methods become standardized, technology transfer or imitation shifts production to the South (developing countries) due to lower wages there.
- The North exports the latest, innovative goods in exchange for older, more established goods from the South.
Product Cycle Model (Krugman 1979)

- Exogenous Technological Change
  - New products are introduced in the North at an exogenous rate.
  - Southern firms become able to produce goods at an exogenous rate.
- Finds that relative wage paid to Northern labor (compared to Southern labor):
  - Increases in the rate of innovation relative to imitation,
  - Decreases in the relative size of the Northern labor supply.

Endogenous Technological Change

- Innovation: To be able to produce a new product, Northern entrepreneurs must expend resources.
  - Design good and perfect production techniques.
- Imitation: To be able to produce an existing product, Southern entrepreneurs must expend resources.
  - Engage in reverse engineering to learn about production processes developed in the North.
Reward to Innovation

- Since innovation involves costs, there must be enough reward to innovation success for innovation to occur, and similarly for imitation.
- The expected, present discounted value of profits earned acts as the reward to R&D.
- Successful innovators earn profits until imitation occurs.
- Successful imitators earn profits forever but magnitude shrinks over time.

Structural Parameters

- Since innovation and imitation endogenous, can look at effects on them of changing parameters:
  - Northern and Southern labor supplies,
  - Productivity of labor in innovation and imitation,
  - Policies such as tariffs and R&D subsidies.
Consumers (Households)

- Demand side is standard CES setup with symmetric differentiated products.
- Preferences for differentiated products identical across countries.
- Consumers seek to maximize time-separable intertemporal utility function.

\[ U_i = \int_t^\infty e^{-\rho(\tau-t)} \log[u(\tau)]d\tau \]

- \( \rho \) is subjective discount rate.

Consumers (Households)

- Instantaneous sub-utility function

\[ u(\tau) = \left[ \int_0^n x(j)^\alpha dj \right]^{1/\alpha} \]

- \( x(j) \) is consumption of product \( j \) (\( j \) is \( \omega \) in the article)
- \( n \) is measure of varieties available at time \( \tau \).
Consumers (Households)

- Intertemporal budget constraint: present discounted value of expenditure cannot exceed that of income (plus initial assets).
  \[ \int_{t}^{\infty} e^{[R(\tau)-R(t)]}E(\tau)d\tau \leq A(t) + \int_{t}^{\infty} e^{[R(\tau)-R(t)]}Y(\tau)d\tau \]

- \( R(t) \) is cumulative interest rate from time 0 to \( t \),
- \( E(\tau) \) is spending and \( Y(\tau) \) factor income at time \( \tau \),
- \( A(t) \) is value of initial asset holdings at time \( t \).

Consumers (Households)

- Intertemporal utility maximization requires
  \[ \dot{E} / E = \dot{R} - \rho \]

- Instantaneous utility maximization generates instantaneous demand for variety \( j \)
  \[ x(j) = \frac{p(j)^{-\epsilon}}{\int_{0}^{\infty} p(j')^{1-\epsilon} dj'} E \]

  - \( p(j) \) is price of variety \( j \)
  - \( \epsilon = 1 / (1 - \alpha) > 1 \) is the constant elasticity of substitution between every pair of products.
Production

- Single primary input is labor.
- Production of any variety requires $a_x$ units of labor for each unit of output.
- Marginal cost is $w_i a_x$ in county $i$.
  - $w_i$ is wage in country $i$.
- Producers behave as Bertrand competitors.
  - Take prices of other firms’ products as given.

Monopoly and Duopoly

- Two Northern firms will never invent the same variety.
  - Would price at cost and earn no profits.
  - Must earn profits to offset innovation costs.
- Similarly, two Southern firms will never imitate the same variety.
- Each new variety starts as a monopoly.
  - Becomes a duopoly following imitation.
Profit Maximization, Northern Firms

- Consider a Northern firm that is the only firm able to produce a variety.
- Faces demand curve with constant elasticity $-\varepsilon$.
- Profit-maximizing price is fixed markup over marginal cost.

$$p_N = \frac{w_N a_x}{\alpha}$$

Profit Maximization, Southern Firms

- Consider a Southern firm that is only firm that has imitated a variety.
  - Competes against Northern innovator of that variety.
- Two possible outcomes depending on the size of the gap between Northern and Southern wages.
  - Based on whether Northern innovator constrains price of Southern imitator.
Pricing by Southern Firms

- Wide gap case: If \( w_S < \alpha w_N \), Southern firm can charge its monopoly price (markup over its costs) without fear of competition from Northern rival.
  \[
p_S = \frac{w_S a_x}{\alpha}
\]
- Narrow gap case: Otherwise, Southern firm sets price equal to the cost of the Northern innovator.
  \[
p_S = w_N a_x
\]

R&D Learning Activities

- When entrepreneur hires labor for innovation or imitation, derives
  - appropriable blueprint for producing a variety.
  - Non-appropriable additions to general knowledge.
- These knowledge spillovers enhance productivity of subsequent learning efforts within the country.
Southern Imitation

- Southern entrepreneurs chooses at random an existing product that not yet imitated.
- Must devote \( a_S/K_S \) units of labor to mastering the production process.
  - \( a_S \) is productivity parameter for imitation (\( a_I \) in article).
  - \( K_S = n_S \) is knowledge stock in the South, and is proportional to cumulative imitation experience.
  - \( n_S \) is measure of imitated varieties.

Northern Innovation

- Northern entrepreneurs must devote \( a_N/K_N \) units of labor to mastering the production process.
  - \( a_N \) is productivity parameter for innovation (\( a_D \) in article).
  - \( K_N = n \) is knowledge stock in the North, and is proportional to cumulative innovation experience.
  - \( n \) is measure of existing (innovated) varieties.
R&D Valuation Conditions

- When imitation occurs in equilibrium, present-discounted value of Southern profits must equal the cost of imitation.
  \[ \int_{t}^{\infty} e^{-[R(\tau)-R(t)]} \pi_s(\tau) d\tau = w_s(t) a_s / n_s(t) \]

- When innovation occurs in equilibrium, present-discounted value of Northern profits must equal the cost of innovation.

Labor Constraints

- Labor demand for innovation and production in the North cannot exceed Northern labor supply.
  \[ a_n \dot{n} / n + a_x n_n x_n = L_n \]

- Labor demand for imitation and production in the South cannot exceed Southern labor supply.
  \[ a_s \dot{n}_s / n_s + a_x n_s x_s = L_s \]
Results for Wide Gap

- Expansion in Northern labor supply or improvement in productivity of innovation does not affect innovation and imitation. Northern relative wage rises.
- Expansion in Southern labor supply or improvement in productivity of imitation increases innovation and imitation. Northern relative wage falls.
- If stronger intellectual property rights (IPR) protection increases difficulty of imitation, both imitation and innovation would fall.
- Ad valorem tariff or export subsidy by either country does not affect innovation or imitation!

Results for Narrow Gap

- Expansion in Northern labor supply or improvement in productivity of innovation increases innovation and decreases imitation. Northern relative wage rises.
- Expansion in Southern labor supply or improvement in productivity of imitation increases innovation and imitation. Northern relative wage falls.
- Again, if stronger intellectual property rights (IPR) protection increases difficulty of imitation, both imitation and innovation would fall.