Product differentiation can protect against competitive destruction.
Protection by Differentiation

- Firms produce something different from rivals
- If product different enough that cross-price elasticity of demand near zero, no competition
  - Called a different product industry in this course
  - E.g., bicycles vs. automobiles or vs. apples
- Differentiation theories are for intermediate cases
  - Firms compete with each other
  - But differentiation lessens competition
- Technology: one way to achieve differentiation, tech. progress may differ across sub-markets
Economic Theories of Differentiation

• Types of differentiation:
  – *Horizontal*: different features
  – *Vertical*: same features, different quality levels

• Abstract away from technological change
  – We just studied theories with vertical and horizontal differentiation caused by technological change
  – For now, analyze differentiation with no tech. change, or with firms’ current technologies
Economic Theories Cont.

• Define “product differentiation space”:
  – Line segment, e.g. sellers along a beach, car colors
  – Circle, e.g. beach around a lake, seasons of the year
  – 2-D square or circle, e.g. locations in a city, fertilizers
  – 2-D surface of a sphere, e.g. location on Earth

• Define how competition happens
  – Customers decide where to go
  – Pay a “transportation cost” to “get there”
  – Make purchasing decisions accordingly
Economic Theories Cont.

Drinks stands along a beach

Customers evenly spread out along the beach
They walk to nearest stand, if price is same
Assume price is same, for simplicitly
Where do you locate?
- how many firms?
- near each other or spread apart?
- leapfrogging?
May be distance along beach, or preference distance (e.g. car colors)
An Ecological Theory of Differentiation

• Hannan & Freeman (1989) borrow from ecology

• First, understand simple logistic growth model:

\[ \frac{dN}{dt} = rN \left( \frac{K - N}{K} \right) \]

- N number of firms, t time, K carrying capacity, r growth rate
- Number of firms grows until reaching carrying capacity
- Think of N as population, r(K–N)/K as birth-death rate

- Solution is: \[ N_t = \frac{KN_0}{N_0 + (K - N_0)e^{-rt}} \]
Ecological Theory Cont.

• Next, allow for different market “niches”:
  \[
  \frac{dN_i}{dt} = r_i N_i \left( \frac{K_i - N_i - \sum_{j \neq i} \alpha_{ij} N_j}{K_i} \right)
  \]
  
  – Much like before, but each i (or j) refers to a different market niche (a different “species”)
  
  – \( \alpha_{ij} \) is competition coefficient between species i and j
  
  – Each species grows to its carrying capacity or is eliminated by competition
  
  – Solve by computer (you can use Stella II in Computer Centre)
Firm Strategies and Differentiation

• Produce 1 or multiple varieties?
• Products different from competitors, or same?
• “Leapfrog” to retain best positions?
• Produce best varieties right away?
• Relation to entry and exit?
Strategies in UK Fertilizer Manufacture

- Test ideas about product differentiation
- Using UK fertilizers as an example (Shaw, 1982)
- Square product differentiation space
  - Two sets of chemical elements to help plants grow
  - Nitrogen
  - Phosphorous & potassium (usu. in equal proportions)
Figure 4
Distribution of Fertilizer Products in the Straight Nitrogen: High N; 1:1:1; Low N; and Binary PK Groups.

Key
- X: Fisons products
- O: ICI products
+: UKF/Sheltor products

Notes
1. 2 products
2. 3 products

Omitted products
1. 0:14:28 Fisons, from 1958/59 onwards.
Figure 5
Distribution of Fertiliser Products in the Straight Nitrogen; High N; 1:1:1; Low N; and Binary PK Groups.
Technology and Differentiation

- Shakeout theory has vertical differentiation
  - Firms innovate to improve their product quality
- Market leadership turnover has horizontal and/or vertical differentiation
  - Disruptive technology yields better quality (calculators)
  - Or creates a competing market niche (hard disks)
- What if technology creates new, largely independent submarkets?
  - Protects firms from competition (penicillin)
Differentiation and Success in US Penicillin Manufacture

- Penicillin: drug, attacks bacterial disease
- Produced naturally by some mold
- Natural penicillin: types G, O, or V
  - Patents disallowed (World War II projects)
  - Produced by many firms
- Circa 1958, new techniques:
  - Extract chemical produced by mold
  - Modify it by chemical methods
  - Give to mold, get new types of penicillin
- Semi-synthetic penicillins: phenethicillin, ampicillin, …
  - Treat different diseases from natural penicillin
  - Developed by specific firms, patented
  - Legal battles limited patent rights for first 2
  - Later types patented, licensed to few firms
Table: US Penicillin Manufacturers by Type

- Also in course notes, pp. 109-110
- Drawn from Klepper and Simons (1997)
- Main source *Synthetic Organic Chemicals*
- 1948-1993
- Organized by penicillin type
  - Earliest first
  - 1988+ if made only by Beechem not all listed
- Key innovations identified by †
  - According to Achilladelis (1993)
- Innovating firm identified by *
- Table has 4 pages, numbered at bottom
Penicillin G† [Innovation dated as 1942 by Achilladelis]
Abbott 1948–1964
Baker 1948–1952
Commercial Solvents 1948–1959
Cutter 1948–1954
Heyden 1948–1953
Hoffman LaRoche 1948–1949
Merck 1948–1986
Pfizer 1948–1992
Schenley 1948–1953
Squibb 1948–1982
Wyeth 1948–1993
U.S. Rubber 1949
Monsanto 1954
Penick, S.B. 1954–1955

Penicillin O
Pfizer 1968–1975

Penicillin V†
*Lilly 1955–1990
Abbott 1956–1974
Squibb 1968–1976
Pfizer 1976–1988
[*Also developed by Glaxo (UK).]
Phenethicillin†
*Bristol 1959–1975
Wyeth 1962–1966
[*Also developed by Beecham (UK).]

Ampicillin†
Bristol 1963–1993
Wyeth 1966–1993
*Beecham 1968–1990
Squibb 1968–1976
Trade Enterprises 1971–1981
Biocraft 1972–1993
Kanasco 1986–1992

NEP penicillin
Merck 1963

Methicillin
Bristol 1961–1985
Beecham 1972–1982
Wyeth 1991

Oxacillin
Bristol 1961–1985
Beecham 1969–1992
Biocraft 1979–1992
Cloxacillin
Bristol 1964–1985
Beecham 1968–1993
Kanasco 1991–1992

Nafcillin
Wyeth 1964–1990

Dicloxacillin
Beecham 1968–1992
Biocraft 1983–1993
Kanasco 1990, 1992

Hetacillin

Carbenicillin† [Innovation dated as 1969 by Achilladelis]
*Pfizer 1972–1986, 1988
Biocraft 1986
Amoxicillin
Beecham 1973–1993
Biocraft 1976–1993
Bristol 1977–1993
Trade Enterprises 1978–1979
Wyeth 1980–1985
Kanasco 1986–1992

Ticarcillin
Beecham 1976–1993

Azlocillin† [*Developed 1978 by Bayer (Germany)]

Cyclacillin
Wyeth 1978–1985
Bristol 1984–1985
Biocraft 1986, 1988
Epicillin Trade Enterprises 1978–1982
Kanasco 1986

Piperacillin
Bristol 1982–1993

Amdinocillin† [*Developed 1984 by Roche (Switzerland)]

Sulbactam† [*Developed 1986 by Pfizer]

Floxacillin
Beecham 1989+?