EC2212 Industrial Growth
and Competition

# Lecture 8

# 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

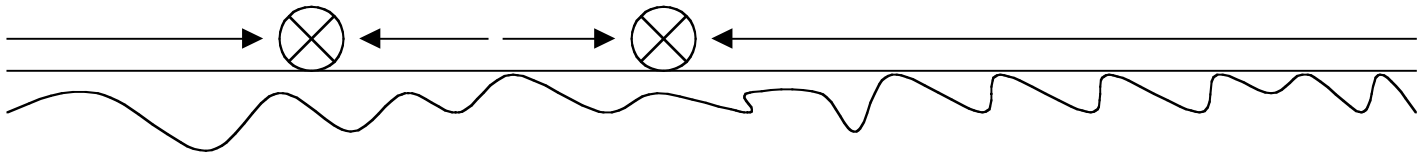
- Types of differentiation:
  - *Horizontal*: different features
  - *Vertical*: same features, different quality levels
- Abstract away from technological change
  - We just studied theories with vertical and horizontal differentiation caused by technological change
  - For now, analyze differentiation 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)

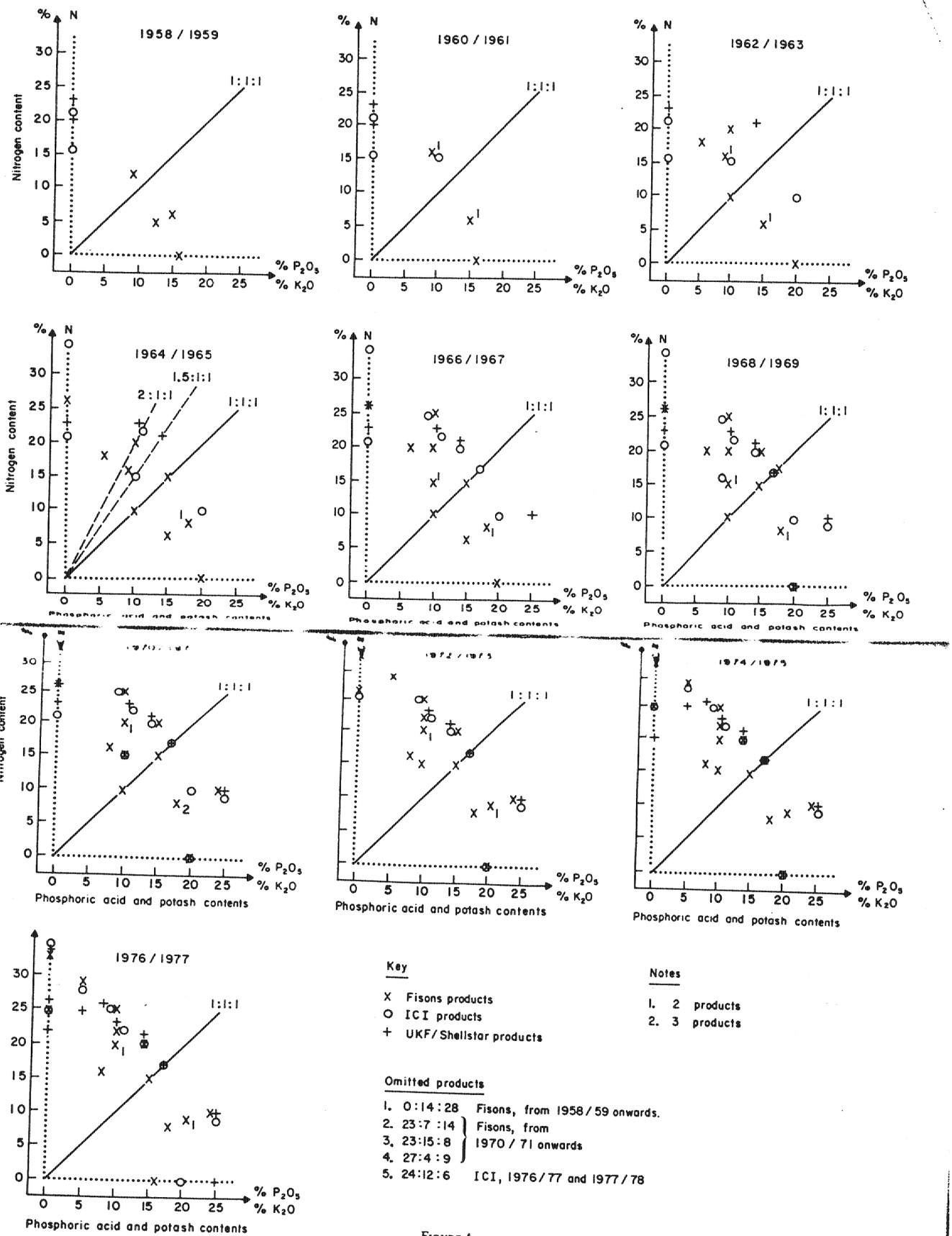



FIGURE 4

Distribution of Fertiliser Products in the Straight Nitrogen; High N; 1 : 1 : 1; Low N; and Binary PK Groups.

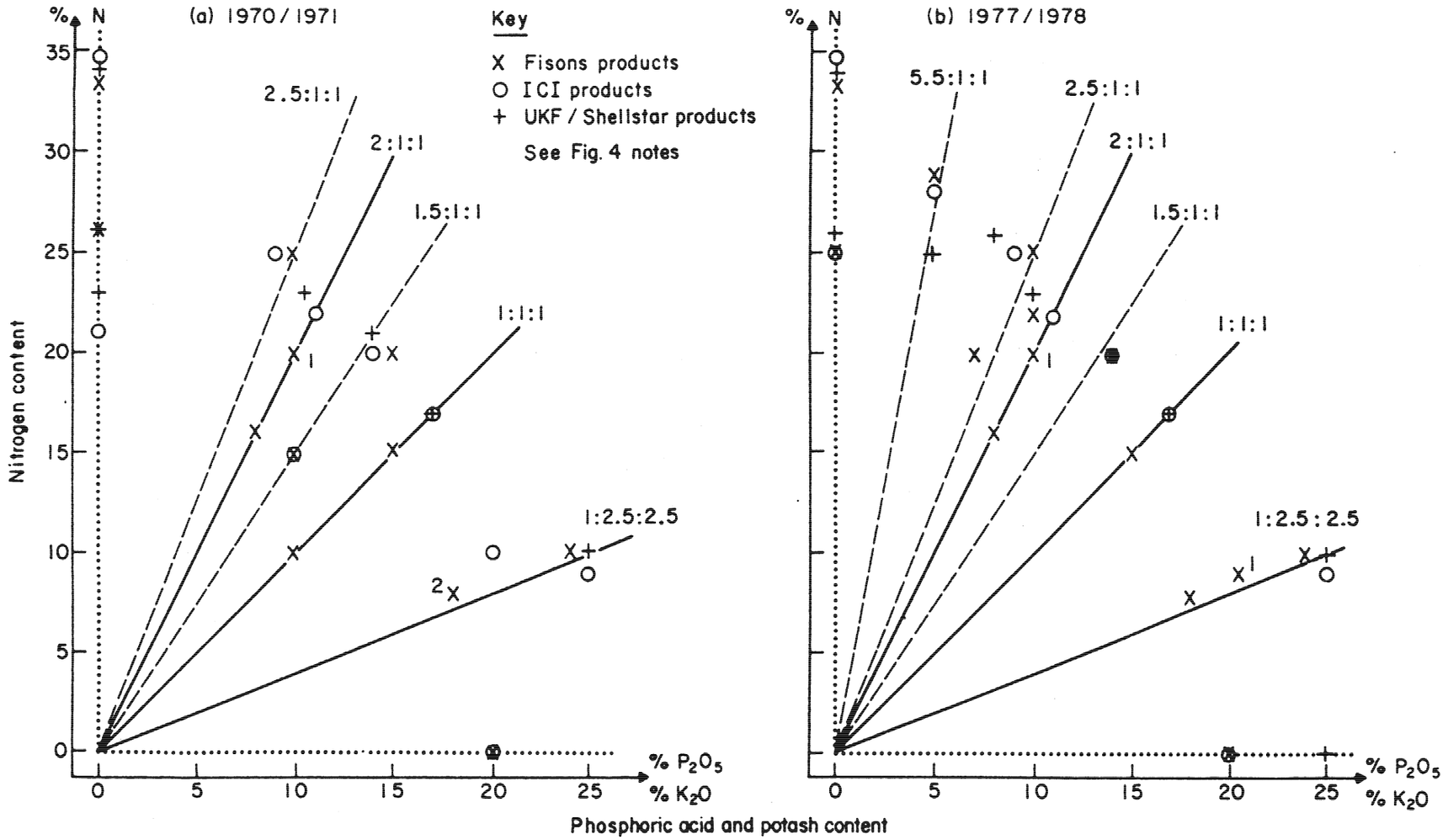



FIGURE 5

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 Beecham 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**
**Bristol 1948–1959, 1961, 1974, 1977, 1981–1983**
**Commercial Solvents 1948–1959**
**Cutter 1948–1954**
**Heyden 1948–1953**
**Hoffman LaRoche 1948–1949**
**Lederle 1948–1949, 1954–1955**
**Lilly 1948–1969, 1972, 1976–1981**
**Merck 1948–1986**
**Pfizer 1948–1992**
**Schenley 1948–1953**
**Squibb 1948–1982**
**X 1948–1953, Upjohn 1954–1957**
**Wyeth 1948–1993**
**U.S. Rubber 1949**
**Monsanto 1954**
**Penick, S.B. 1954–1955**

**Penicillin O**
**X 1951–1953, Upjohn 1954–1964, 1966**
**Pfizer 1968–1975**

**Penicillin V†**
***Lilly 1955–1990**
**Abbott 1956–1974**
**Wyeth 1956–1976, 1983–1985**
**Bristol 1958, 1970–1985, 1987, 1989–1993**
**Squibb 1968–1976**
**Pfizer 1976–1988**
**[*Also developed by Glaxo (UK).]**

**Phenethicillin†**
***Bristol 1959–1975**
**Pfizer 1960–1965, 1967–1971**
**Squibb 1960–1961, 1963–1964**
**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**
**Biocraft 1980–1988, 1990–1993**
**Kanasco 1991–1992**

**Nafcillin**
**Wyeth 1964–1990**
**Beecham 1975–1976, 1984–1988, 1990–1991**
**Bristol 1975–1977, 1979–1985, 1987**

**Dicloxacillin**
**Bristol 1966–1979, 1981–1985**
**Beecham 1968–1992**
**Wyeth 1968, 1970–1975, 1977–1989**
**Biocraft 1983–1993**
**Kanasco 1990, 1992**

**Hetacillin**
**Bristol 1966–1979, 1981–1991**

**Carbenicillin† [Innovation dated as 1969 by Achilladelis]**
***Beecham 1970–1985, 1987, 1989+?**
***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+?**