An Overview of Research on Location and Economic Activity
with specific reference to R&D and the Pharmaceutical Industry

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Research Questions on (R&D) Location & Economic Activity

General Research Questions
- Which factors affect the location of economic activity?
- Which factors affect the location of innovative activity?
- Which factors affect firm-level decisions about where to locate facilities?

Specific Research Questions
- Which factors affect firm decisions about where to locate (R&D) facilities in the pharmaceutical and biotechnology industries?
- Does pharma/bio location affect performance?
  - location & productivity in drug discovery?
Motivating Quote

“When an industry has thus chosen a locality for itself, it is likely to stay there long: so great are the advantages which people following the same skilled trade get from near neighbourhood to one another. The mysteries of the trade become no mysteries; but are as it were in the air, and children learn many of them unconsciously.”

Alfred Marshall, *Principles of Economics* (1890)
Early & recent research on the location of economic activity

- Classical research
  - von Thünen (1826) & Weber (1909)
    - farming & industry locations minimize transportation costs
  - Marshall (1890)
    - co-location of economic activity (agglomeration) encouraged by positive, location-bound externalities

- New economic geography
  - revival of interest in 1990s
    - driven by competitiveness crisis in US, lower trade barriers, ...
  - Krugman – formal models of increasing returns & co-location
  - Porter – drivers of national industrial competitive advantage
  - Romer – role of ideas-producing sector in economic growth
What attracts economic activity to particular regions?

- Supply-side characteristics
  - factor endowments & local labor market characteristics
  - industrial composition (Glaeser et al.)
  - competitive dynamics (Shaver & Flyer)
  - potential spillovers (Jaffe Trajtenberg Henderson)
    - qualities of the local scientific and technical base (Alcacer & Chung)
    - local institutions encouraging communication, labor mobility, and effective professional networks (e.g., Saxenian, 1994)

- Demand-side characteristics
  - proximity, size, & composition of key markets (Berndt; Ellison)

- Regulatory characteristics
  - local tax & other public policies (Hines; Danzon)
  - pressures for innovation-oriented competition (Porter)
Theorists suggest that geographic regions characterized by externalities will exhibit higher rates of growth
- Romer (1990), Lucas (1993), and Krugman (1991)

R&D Spillovers and Local Knowledge
- Economic knowledge created by an organization conducting R&D may spill over for application by other organizations
  - See work of Zvi Griliches & students; Bernstein/Nadiri; Grossman/Helpman
- Knowledge spillovers tend to be geographically bounded within the region where the new economic knowledge was created
  - Especially true for tacit/sticky knowledge (von Hippel, 1994) & science

- Innovative activity likely to be more concentrated than other economic activities
- Regions with greater concentration of innovative activities more likely to experience economic growth
The Economic Geography of the Firm: Concentration vs. Dispersion

- economies of scale
- economies of scope
  - internal spillovers
- low coordination costs
- knowledge spillovers
  - significant, location-specific, geographically dispersed
- local public policies important

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Geographic Concentration  Geographic Dispersion
Some Key Questions about Firm R&D Investment & Location

- Do R&D facilities serve different functions in different locations?
  - *listening posts* vs. *knowledge factories* (e.g., Frost, 1999)

- What are the competitive dynamics associated with R&D location? (e.g., Shaver & Flyer, 2000)
  - *lagging* firms may enter clusters to *access* spillovers
  - *leading* firms may avoid clusters to *limit* spillovers
  - role of location in mergers? (Danzon, Epstein, Nicholson, 2004)

- How does R&D location affect innovative productivity?
  - what are the ideal number, size, location, and coordination mechanisms among multiple R&D sites?
Specific Context: Firm location in the pharmaceutical industry

- Types of facilities
  - Discovery
    - *multiple authors*
  - Development
    - *e.g., Azoulay*
  - Manufacturing
    - *e.g., Nickerson/Macher (in progress)*
  - Marketing/Sales
    - *e.g., Danzon/Kyle*

- Example: Discovery
  - multiple labs per firm
  - multiple locations
  - multiple therapeutic classes
  - *significant changes in 90s!*

Roche’s Drug Discovery Labs
Key facts about location in the pharmaceutical & biotech industries

- Facilities not necessarily co-located
  - discovery, development, manufacturing, sales can be coordinated across distances
    - note: this is unusual, as product development & manufacturing often tightly coupled (e.g., automobiles)
  - less true for biotechnology

- Marketing & Sales
  - products enter broadly but selectively (Danzon/Kyle)

- Manufacturing
  - sensitive to local labor markets & policies/incentives
    - e.g., agglomerations in Ireland and Puerto Rico

- R&D concentrated in US, UK, W&N Europe, & Japan
  - distribution of public & private research differs by location
  - location of research varies by therapeutic class & by firm
  - therapeutic class specialization varies by region & by firm
Economics of location in the pharmaceutical industry

Centralize, locate near knowledge, or outsource?

- **Scale, scope, & (internal) spillovers** suggest that programs should be ‘housed’ in single location
  - if internal spillovers weaken with distance (Allen, 1977)
  - if coordination costs are high
  - if cross-program spillovers are substantial (H&C, 1996)

- **Research in economic geography** suggests firms may benefit from locating close to knowledge sources
  - if knowledge spillovers exist (& are local) (Jaffe et al., 1993; Audretsch & Stephan, 1996; Zucker & Darby, 1998)
  - if knowledge is dispersed, this can mean managing multiple, dispersed programs

- **Outsourcing & Vertical Disaggregation**
  - strong property rights & viable market for ideas
  - rise of contract research & contract manufacturing
Challenges for Research on Location in Pharma/Biotech

- **Theoretical Challenges:** Structural models require specification of demand, strategic interaction in investment, & production functions
  - inter-firm spillovers imply that R&D is endogenous to competitor choices in intensity (and location) with complicated dynamics
  - considering intra-firm spillovers across multiple locations and therapeutic classes considerably increases complexity

- **Empirical Challenges:** identification, exogeneity, & data
  - data & measurement!
  - exogeneity of local scientific and technical knowledge?
  - accounting for merger activity
Some relevant research: R&D location in Pharma/Biotech

- Role of institutional environments & national policies in encouraging innovation (and entry)
  - Thomas (1994); Danzon (2004); Kyle (2004)
  - networks can strengthen local ties, bridge distant ties (Powell; Pammolli)

- Especially in early years, biotech locates close to universities & star scientists (Audretsch & Stephan; Zucker & Darby)

- Recent Research on Location & Discovery Productivity
  - Japanese pharmaceutical companies with international R&D more productive than those with purely domestic research (Shaver & Penner-Hahn, 2005)
    - firm-level analysis
    - NCEs/firm lower for US firms with more non-US labs
  - Furman, Kyle, Cockburn, & Henderson (2005)
    - firm-therapeutic class analysis
    - locating close to public sources of knowledge increases productivity
R&D location in Pharma/Biotech: Data & Measurement Challenges

- **Measuring R&D Outputs**
  - patent-based measures (*important* patents)
  - other observables may be too distant from concepts of interest
    - INDs, NCEs, ...
  - sales? – of interest, difficult to tie to inputs

- **Measuring R&D Inputs**
  - subject to same difficulties as other inputs studies in Pharma
    - must be classified by program level
    - must be classified by location
  - expenditures?
  - employment?

- **Measuring Relevant Local Knowledge**
  - publications – potentially useful
    - can classify by location (*SCI data*)
    - can classify by (loosely) therapeutic class (*Medline MeSH headings*)