

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

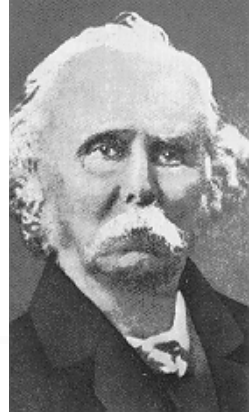
■ General Research Questions

- 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?

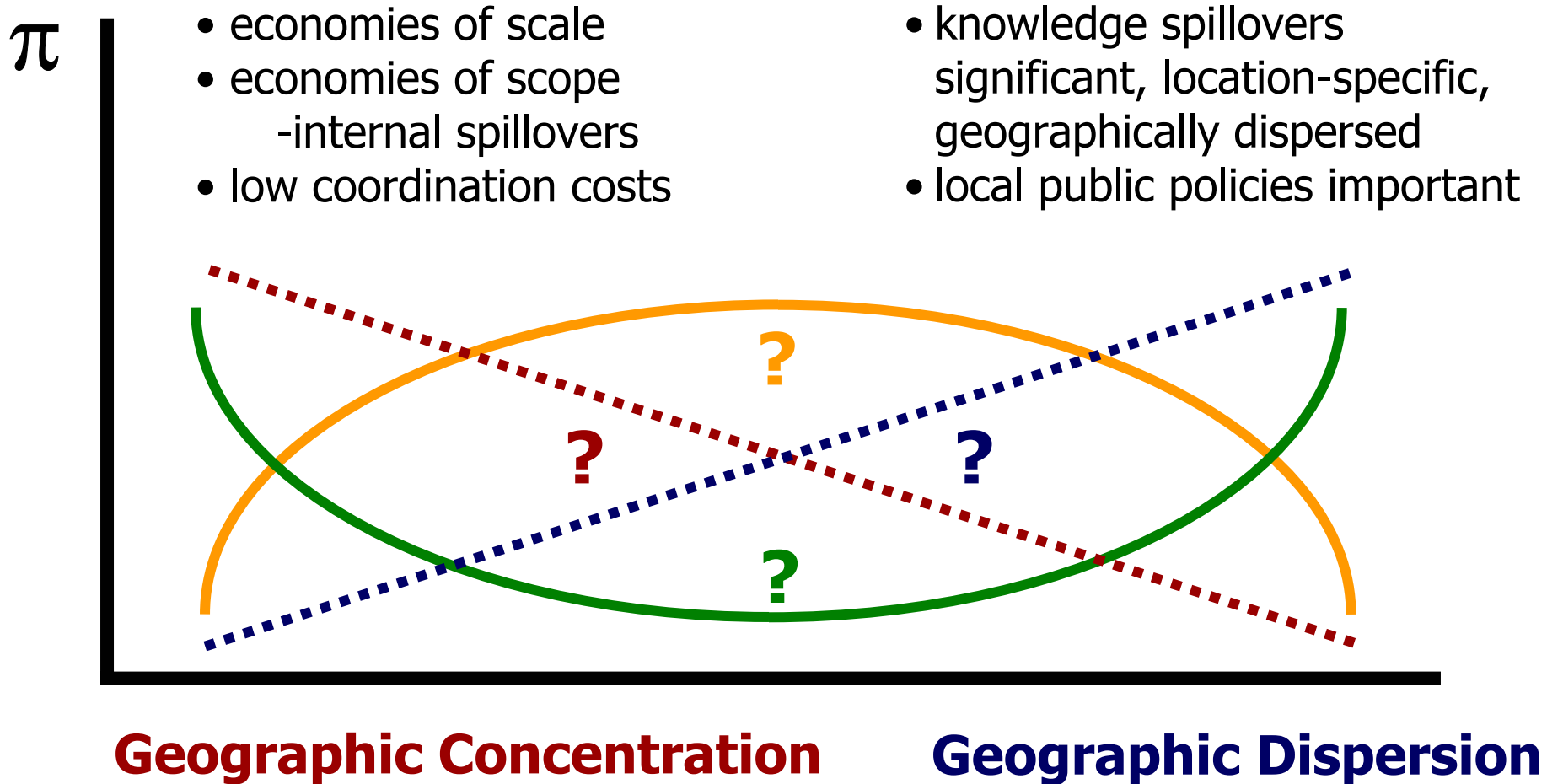
- Supply-side characteristics
 - factor endowments & local labor market characteristics
 - industrial composition (Glaeser et al.)
 - competitive dynamics (Shaver & Flyer)
 - potential spillovers (Jaffe Trajtenberg Henderson)
 - qualities of the local scientific and technical base (Alcacer & Chung)
 - 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)

*Most effective
public policies?*

Agglomeration, Economic Activity, and Innovation

- 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
 - see Jaffe (1989), Jaffe, Trajtenberg, & Henderson (1993), Feldman (1994), Audretsch & Feldman (1996)
 - 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

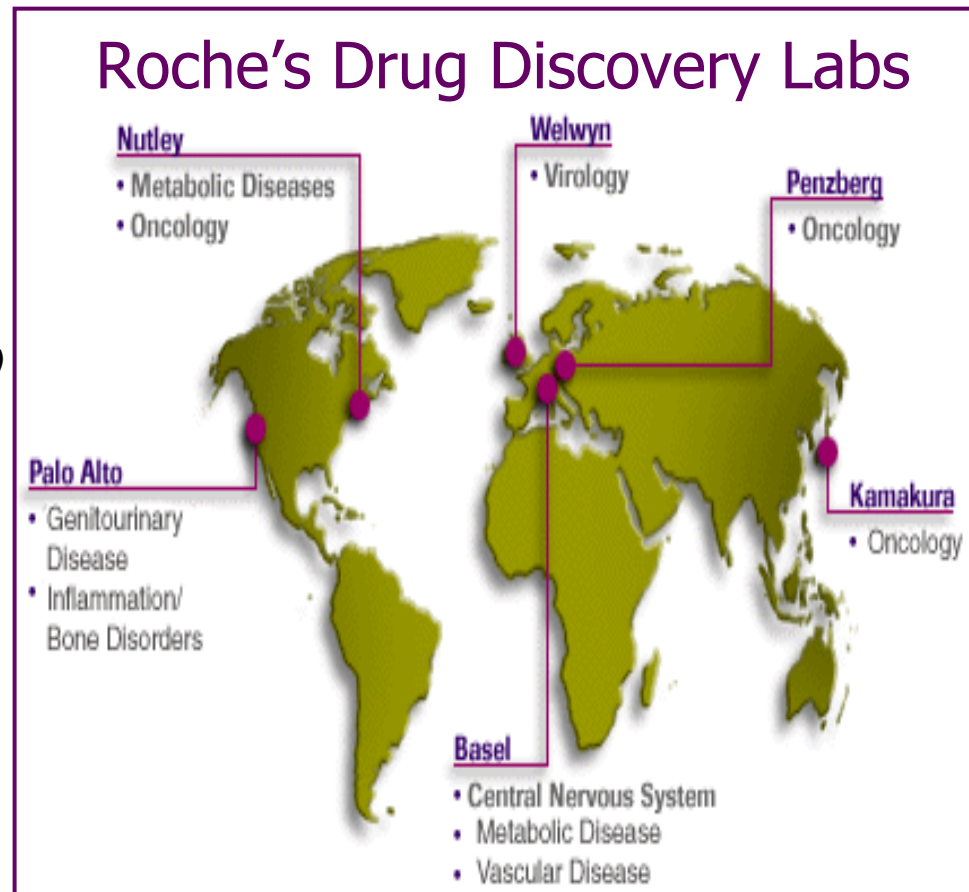


Some Key Questions about Firm R&D Investment & Location

- 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?

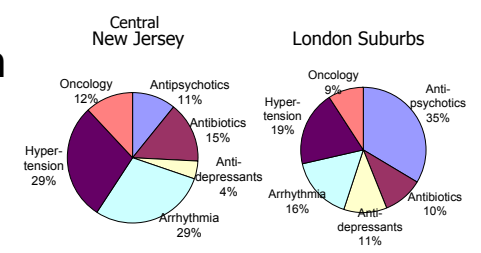
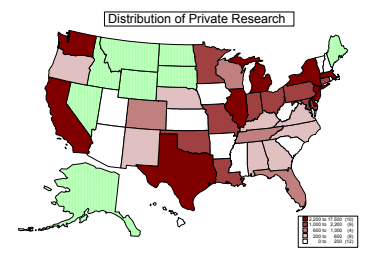
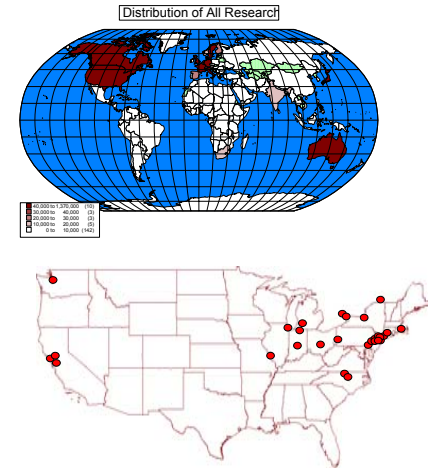
Specific Context: Firm location in the pharmaceutical industry

- 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!*



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
 - Spence (1984); Levin & Reiss (1988); Cassiman & Veugelers (2000), Katsoulacos & Ulph (1998); d'Aspremont & Jacquemin (1988); de Bondt (1996); Gersbach & Schmutzler (1999)
 - 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)
 - Lieberman & Chacar (2004)
 - 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*)