Everywhere?
The Geography of Knowledge

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Journal of Regional Science 50th anniversary symposium
Federal Reserve Bank of New York
April 2009

Key Points

- Knowledge – and innovative activity – are geographically clustered, and the "tendency toward spatial concentration has become more marked over time, not less" (Asheim and Gertler, 2005, p. 291).
- Producing knowledge is different from the production of other goods and services.
- The knowledge production function describes only a portion of all knowledge production.
  - "Most phenomena relating to knowledge are largely unmeasurable" – Foray, 2004, p. 9.

Knowledge is Different

- Knowledge production is different from the production of goods in several ways.
  - It entails greater uncertainty.
    - Uncertainty is inherent in the entire process of technological change.
  - Knowledge is embodied not only in capital goods, as commonly modeled, but also in people.
    - This phenomenon is addressed to some degree, but inadequately, by the concept of human capital.
  - Knowledge also is embodied in organizations, taking the form of organizational routines (Howitt, 1997).
    - Within firms, the resultant knowledge is greater than the sum of the individual knowledge possessed by the firm's employees (Nahapiet and Ghoshal, 1998).
    - Endogenous growth theory, as developed by Romer (1986, 1990) and Grossman and Helpman (1991, 1994) has not captured these phenomena adequately (Howitt, 1997).

Patent data

- “Nothing else even comes close in the quantity of available data, accessibility, and the potential industrial, organizational, and technological detail.”
  - Griliches (1990, p. 1702)
- Consequently and subsequently, a flood of research has exploited the large, accessible data sets on patents and patent citations
  - despite cautions, such as by Hall and Ziedonis (2001), who find a paradox: the number of patents has grown, but their quality has declined
  - Moreover, much patent-based research ignores substantial intersectoral and international differences in the propensity to patent, the uses of patents, and the prevalence of spillovers.

Localization of spillovers

- Using patent data, one can measure knowledge that "spills over" from the R&D activity of a firm or university to others that have not invested in that R&D.
- Empirical research using this approach has confirmed that university research spills over to private industry, but with distance decay.
  - The work of Jaffe (1989), Jaffe and Trajtenberg (1996), Acs et al. (1997) all support the "localization of spillovers" within a range of 50 miles from the metropolitan area of origin rather than their uniform spread from the source.
  - The higher propensity of universities to patent inventions has reduced the spillovers from research (Stephan, 1996), perhaps due to the lower quality of more recent patents (Mowery and Ziedonis, 2002).

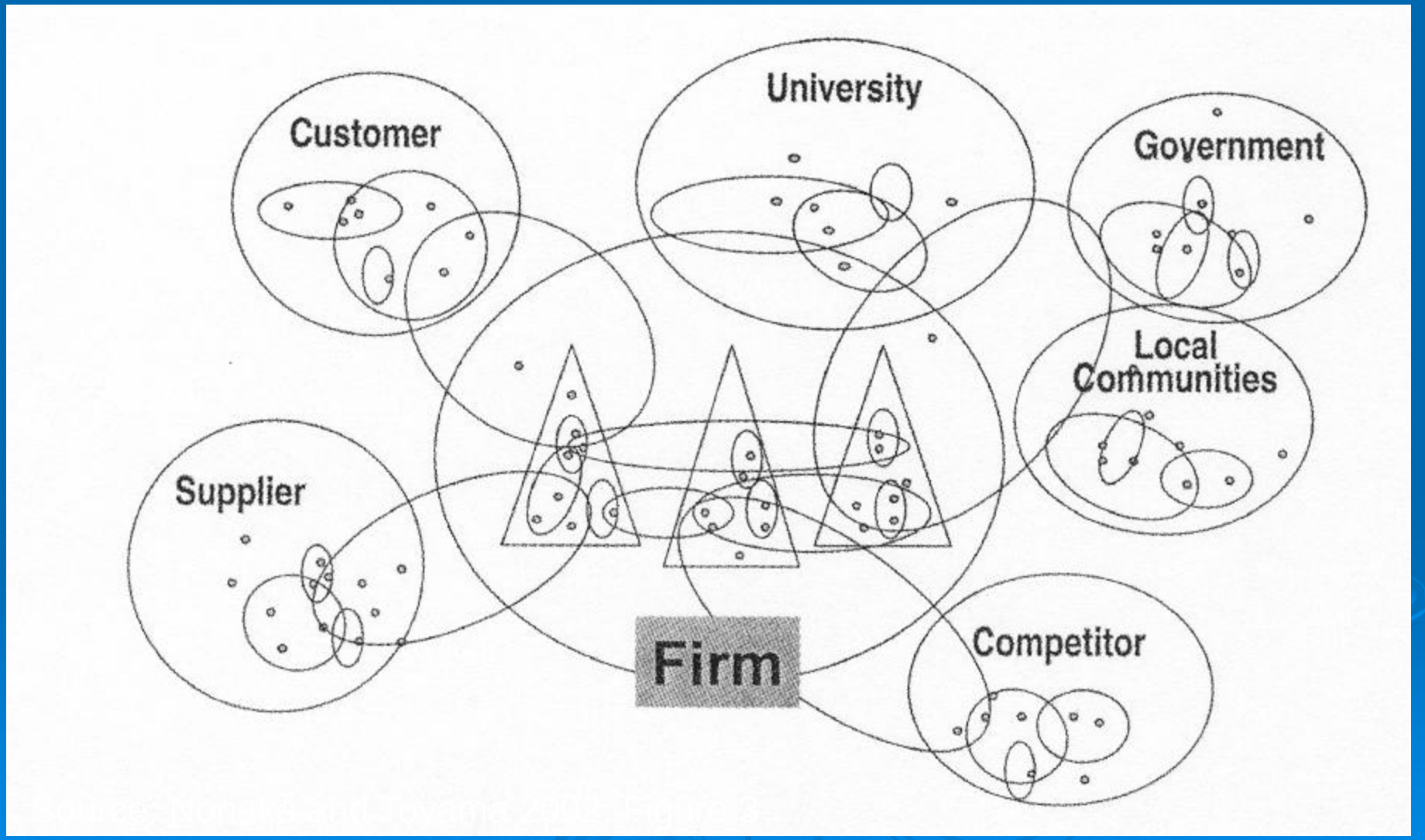
Not Only Spillovers

- Patents and citations to patents do not capture all spillovers – despite the attraction of availability of data.
- A big set of missing beneficiaries of R&D – in this case, its consumers – are in the service sector, in which firms do relatively little R&D (Scherer, 1982).
- A more important gap is that patents represent only *codified* knowledge, and not *tacit* knowledge
  - This is a distinction of major significance since the publication of Nonaka and Takeuchi's (1995) *The Knowledge-Creating Company*.
- The most invisible knowledge is tacit knowledge, which is central to innovation as a *learning process*.

R&D Is No Longer Confined to R&D Labs

- Even corporate R&D no longer is confined to firms' R&D labs; it takes place within dispersed networks of sources, both internal to the firm but also increasingly from outside it.
  - Global production networks (GPNs) and global innovation networks embody widespread connections among sources of knowledge (Ernst, 2002, 2009; Ernst and Kim, 2002).
- The "new ecology of R&D" or "open innovation" model suggests that the R&D-based knowledge production function is less and less an accurate reflection of empirical reality
  - Chesbrough, 2003; Coombs and Georghiou, 2002
- Therefore, there is more to knowledge than merely R&D, whether "open" or otherwise.
  - Singh (2008), for example, suggests that achieving net positive spillovers seems to require informal mechanisms that promote knowledge integration and learning across locations and specific application of a firm's knowledge and capabilities or what Teece (1986) calls its "complementary assets" and "core competences.".

External Sources of Technology



Learning

- “Learning by doing” and “learning by using” were early ways of capturing these kinds of learning that take place outside of formal R&D.
- We now recognize that user-producer interaction is a key mechanism for how outside knowledge and technologies are obtained, understood, and incorporated.
  - The list of types of learning has expanded greatly over the years, now encompassing learning by operating, training, hiring, searching, trying, interacting, selling, borrowing, and failing.

Urban Learning Dynamics

- In models of urban growth based on agglomeration economies, agglomeration serves only as a vehicle for proximity which, in turn, inspires interaction.
- The process of *interactive learning* is absent, despite recognition of its importance (Lundvall and Johnson, 1994).
  - Knowledge also can be gained through know-how trading (Carter, 1989), and much is in the realm of *untraded interdependencies* (Storper, 1997).
  - Just as not all firms do R&D, and not all knowledge is patented, regions vary in their level of untraded interdependencies for a variety of reasons.

From Knowledge to Knowledge Systems

- Outside the world of the standard economic model, research on knowledge has not been limited to the knowledge production function.
- It has grown from evolutionary or neo-Scumpeterian economic thinking. That means that an emphasis is placed on learning, institutions, and the disruption of equilibrium
  - (Boschma and Frenken, 2006; Freeman, 1994; Hodgson, 1988; Nelson, 1995, 1998; Quéré, 2008).
- A great deal of the critical process of learning-by-interacting is user-producer interaction, which involves the exchange of knowledge that is *complex*, *imperfect*, and *changes rapidly* – key features of many creative activities
  - (Lundvall, 1988; Gertler, 1995; Storper and Venables, 2004).
- The rich body of research on national and regional innovation systems goes some way toward understanding the implications of institutional variation on the production of knowledge and innovation.

Innovation Systems, Knowledge and Learning

- "Well-functioning" innovation systems do not exist in all regions
  - (Chaminade and Vang; Lawson, 1999).
- Examples include *knowledge economies*, or "localized and regionalized, clustered, collective learning systems" (Cooke, 2002, p. 187).
- Other regions, by contrast, are "innovation-averse" (Rodriguez-Pose, 1999).
- The literature on national and regional innovation systems, however, generally still fails to capture the flows among regions.

Table 1. From Data to Creativity:

Concepts Related to Information and Knowledge

[Source: Malecki and Moriset (2008, p. 29, Table 2.3).]

Concept	Characteristics
Creativity	Creativity presumes a capacity to order and reorder information with the aid of a knowledge system.
Expertise	Specialized, deep knowledge and understanding gained via experience. Expertise is personalized. An individual with expertise is able to create new knowledge is his or her area of expertise.
Competence	Embodied knowledge. There are at least three types: (1) instrument-oriented competence, (2) sector-specific competence, and (3) regional-specific competence.
Knowledge	Structurally ordered information. Includes reflection, synthesis, and context. Information laden with experience, truth, judgment, intuition and values. Concepts, ideas and patterns are subsets of knowledge. Often tacit, hard to transfer.
Information	Data endowed with relevance and purpose.
Data	Simple observations of states of the world; easily structured, easily captured on machines, easily transferred.

Knowledge: More than Human Capital

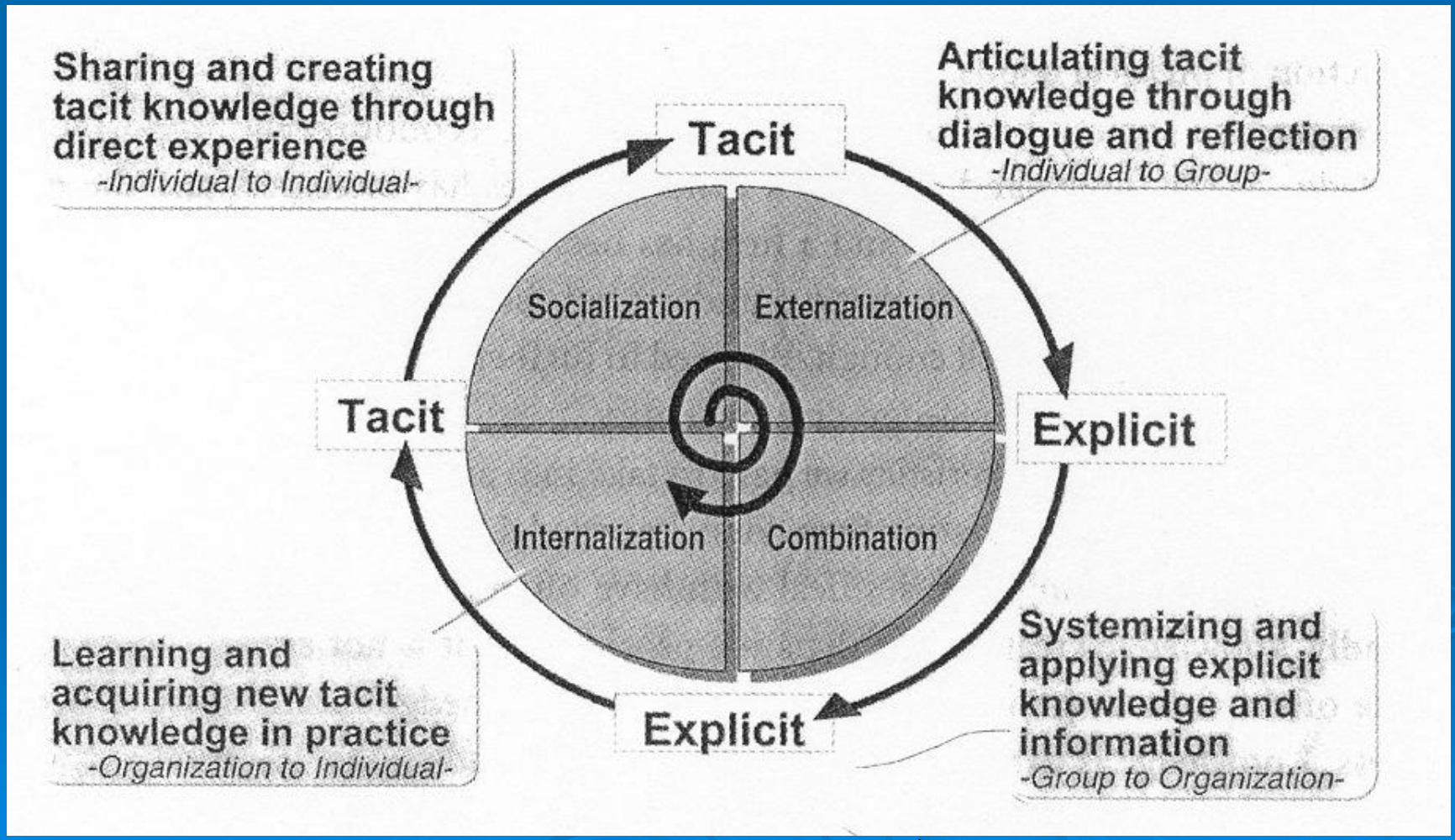
- "One of the most persistent predictors of urban growth over the last century is the skill level of a city" (Glaeser, 2005, p. 143).
- Zucker and Darby's (1996) work suggests that the presence of universities and of an educated population might be good in a general sense, but for specific technologies, the presence of research universities – a small fraction of the total – and, most importantly, of star scientists at a few of those universities determines the geographic pattern of technology start-ups.
- Educational attainment does not measure ongoing learning – especially collective learning – which includes many types and responds to institutional variation.
  - Jobs vary not only in the cognitive knowledge they require, but also in the degree to which they involve complex communication with other people (Levy and Murnane 2004; Johnson et al. 2005).

R&D: More than innovation

- Innovation is one major outcome of knowledge production; competence is the other (Lundvall, 2004).
  - Firms gain competence through their R&D, through which they accumulate related knowledge as well accomplish specific technological objectives (Cohen and Levinthal, 1994).
  - *Absorptive capacity* – a richer concept than competence – is the second "face" of R&D.
  - "While R&D obviously generates innovations, it also develops a firm's ability to identify, assimilate, and exploit knowledge from the environment – what we call a firm's 'learning' or 'absorptive' capacity" (Cohen and Levinthal, 1989, p. 569; 1990).

Communicating Knowledge

Source: Nonaka and Toyama 2002, Figure 1



Tacit knowledge is difficult to transfer over long distances

- Tacit knowledge is localized between partners who share basic commonalities, such as language, conventions, “codes” of communication (such as jargon), and trust based on prior knowledge of one another (Asheim and Gertler, 2005).
  - Within firms, where many of these commonalities are present within the corporate culture and norms, knowledge transfer remains difficult as knowledge sourcing becomes geographically more diverse.
  - Tacit knowledge does not flow automatically, and companies go to enormous lengths to facilitate knowledge transfer between those who have it and those who don’t.
  - Tacit knowledge is created within specific institutional contexts that are far from uniform (Gertler (2003; Henry and Pinch, 2006).
  - Knowledge becomes “territorially sticky” and “multiple geographies of tacit knowledge” operate within and between firms (Faulconbridge, 2006).

Knowledge Bases and Communities

- Knowledge bases come in three types: analytical, synthetic, and symbolic (Asheim and Coenen, 2005; Asheim et al., 2007).
  - Scientists work mainly with analytical knowledge
  - Engineers work with synthetic knowledge
  - Artists work with symbolic knowledge.
    - However, even within a field such as medicine, distinct patterns characterize knowledge and innovation. Ramlogan et al. (2007) show that different patterns of collaboration and experimentation contribute to knowledge of different diseases.
- Even within firms, knowledge travels within epistemic communities of like-minded and like-trained specialists
    - (Brown and Duguid, 2000; Amin and Cohendet, 2004).
  - Epistemic communities form because knowledge is dissimilar.

Other forms of knowledge

- Although knowledge is one outcome of research, there are other forms of knowledge.
  - Bhidé (2008) stresses levels of know-how: from high-level general principles to mid-level technologies to ground-level management know-how. All are needed for the commercialization of new products and services.
- This continuum, or multidimensional space, of knowledge includes both *component knowledge* and complex *architectural knowledge*.
  - Component knowledge, largely technical and typically patented, can be codified, offshored, and ubiquitous (Maskell, 2001; Maskell and Malmberg, 1999, 2007).
  - *Architectural knowledge* relates to the organization of an entire system (including regional systems) as well as the structures and routines for organizing knowledge (Pinch *et al*. 2003).

The competence theory of the firm

- Firms are repositories of competence.
  - The firm is essentially a repository of skill, experience and knowledge, rather than merely a set of responses to information or transaction costs (Hodgson, 1998; Langlois and Robertson, 1995).
  - These capabilities of a firm comprise “the ability to identify, expand, and exploit the business opportunities” that arise (Carlsson and Eliasson, 1994, p. 694).
  - “What is involved with managerial and entrepreneurial skills is not mere information or knowledge but sophisticated but essentially idiosyncratic judgements and conjectures in the context of uncertainty” (Hodgson, 1998).

Chart Businesses: Novel Knowledge

- Some industries, such as the cultural industries, are “chart businesses,” which must produce products and markets for novelty.
  - These businesses live or die by the volume and success of their output being valued as “best” in the marketplace for a limited period (Jeffcutt and Pratt, 2002).
  - Schoales (2006) identifies several other services as constantly innovative, with short product life cycles.
  - The study of creative industries (Caves, 2000) illustrates how firms’ objectives vary, resulting in infinite variety of products.
  - However, Jeffcut and Pratt (2002) suggest that there is not a single ideal organizational form of such firms, but rather different forms that emerge as “local solutions” at different times, and for different technologies and industries.

Spillovers everywhere? Not yet

- Castellacci and Archibugi (2008) identify three technology clubs characterized by markedly different levels of development.
  - The clubs differ with respect to the dynamics of their capabilities over the decade, as the most advanced group and the intermediate one are found to be much more dynamic than the large cluster of less developed economies.
  - Two major factors explain most of the variance in the distribution of knowledge among 131 countries. Both factors contribute to determine the innovative capability of nations.
    - The first factor is a broad measure of technological infrastructures and human skills which together define a country's absorptive capacity.
    - The second factor is a measure of the creation and diffusion of codified knowledge.

The knowledge spillover theory of entrepreneurship

(Acs et al. (2009) and Audretsch et al. (2006)

- Knowledge created endogenously results in knowledge spillovers, which allow entrepreneurs to identify and exploit opportunities.
- Entrepreneurs are among the few agents who "penetrate the knowledge filter" created by patented knowledge. In other words, entrepreneurs are key agents.
  - A new firm is created endogenously via entrepreneurship, which is the recognition of an opportunity and its pursuit by an agent (or team of agents) to appropriate the value of that knowledge.
  - Spillovers, as measured by start-up firms, are very localized – within 500 meters – according to a study of Canadian biotechnology firms (Aharonson et al., 2007).

A Research Agenda for Knowledge

- Paul Krugman: “developing solid models of knowledge spillovers is of urgent necessity”
  - As such models are developed, it is critical to maintain the distinctions among knowledge bases.
  - The science-based or analytical knowledge base measured by patents is only one model; other, less codified types of knowledge lead to innovation (Bhidé, 2008; Foray, 2004).

Needed: More on Knowledge flows

- Less fully understood and still absent from formal models are the flows of knowledge over distance, such as from one city to another.
  - These flows take place over *channels*, or diffuse transmission across space, or through *pipelines*, which are restrictive, usually as a result of appropriated knowledge (Owen-Smith and Powell, 2004).
  - Firms and industries vary greatly in their technological regimes and knowledge characteristics (St. John and Pouder, 2006; Iammarino and McCann, 2006).
  - Firms in the biotechnology and information technology sectors exhibit dramatically different reliance on local and distant sources of knowledge

Needed: New Data Sets

- To get beyond the study of patents and patent citations, the easily measured tip of the iceberg of knowledge production, will require recognition of the importance of the process of interactive learning.
  - To some degree, this is possible in Europe, where several generations of the *Community Innovation Survey* provide a rich data set not available in the USA. See, for example, Arundel et al. (2006), Simmie (2003), and Tether (2002).
  - There is evidence that knowledge production in the US and in Europe is governed by different territorial dynamics or geographical processes (Crescenzi et al., 2007).
  - Breschi and Lissoni (2001, p. 270-271) suggest: “More research efforts should be placed on finding out how knowledge is transmitted, among whom, at what distance, and on the basis of which codebooks” and more needs to be known about the labor market, firm networks, and “the ‘real’ impact of research facilities and local universities on firms’ innovative activities.”

Needed: Understanding Migration and Communication

- Migration
  - How international migration shapes the emerging geography of knowledge.
  - Many nations try to attract the same pool of highly skilled talent, thus relying on international flows to fill existing or future gaps in supply.
- The effect of information and communication technologies to reduce, as one would expect, the spatial and proximity effects of agglomeration.
  - What might be happening instead of substitution is complementarity (Gaspar and Glaeser, 1998; Song et al., 2007).
  - Electronic communication must be complemented with periodic co-location for the transmission of complex and tacit knowledge (De Meyer, 1993).
  - But we do not know much more.

Needed: Understanding Demand for Knowledge

- For what demand is knowledge produced?
  - Howells (2002) points out that little or no research has addressed the demand for knowledge.
  - Perhaps formal schooling would be the sole exception
- Tacit knowledge has no actual market demand.
  - "Compared with goods and other services, information and knowledge cannot be so readily 'bought as required'. We do not know the value of information until after it is purchased" (Hodgson, 1998, p. 183).
- A category of demand on which too little is presently known is innovation under conditions of "scarcity"
    - (Srinivas and Sutz, 2008).
  - Demand at the "bottom of the pyramid" has led to "frugal engineering" and innovation for poor people rather than only for rich people

Needed: A Focus on Trademarks

- The trademark, another form of intellectual property right, has been little studied and not fully acknowledged by economists
  - (Mendonça et al., 2004; Ramello and Silva, 2006).
- Apple Inc. has devoted great effort to obtaining trademarks rather than merely patents for its iPod and iPhone.
  - Unlike the more common utility and design patents, which exist to cover functions and the ornamental look and feel of products and expire after a set number of years, trademarks can remain in force potentially forever.

Conclusion

- This review of the geography of knowledge confirms that knowledge is acquired, transmitted, and transformed in many different ways.
  - The standard model of knowledge production and spillovers, involving R&D effort that results in patents, which cite prior patents, holds most strongly at broader levels of aggregation, and "becomes less compelling is at the disaggregated microeconomic level of the enterprise, establishment, or even line of business" (Audretsch, 2003, p. 168).
- The standard model deals well with scientific advances, but less well with user needs and capabilities, and with problems raised by integration in complex technological systems (Foray, 2004).
- The geography of tacit knowledge and learning has become more complex and more local as the world has "shrunk" thanks to new technologies.