Modeling the Propensity for Industry Clustering

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This paper proposes a Cluster Propensity Model that explains the forces that affect the likelihood that an industry will form clusters. The model considers the influence of the level of tacit knowledge in an industry, the level of vertical fragmentation of firms in the industry, the effects of savings due to shortened transportation distances and time for cross-company activities, and government incentives. These forces are considered in the context of resources that are external and internal to the industry. The interaction of these forces is described.

Key Words: Industrial clustering, Tacit knowledge, Vertical integration

Introduction

Industry clusters are collections of companies in the same or related industries located within close physical proximity to each other (Porter, 1998). They can be in the same city, but they usually extend beyond a single city and so are often called "valleys," "triangles," or even "forests" to capture the surrounding areas (Bradshaw, King, & Wahlstrom, 1999).

Clusters around the world have often been the pride of local citizens and their establishment has been the objective of governments (Bradshaw, King, & Wahlstrom, 1999). Healthy clusters create jobs and bring prestige to an area, so governments have tried to create clusters like Hollywood or Silicon Valley (Saxenian & Hsu, 2001). Most clusters arise without the help of governments and many die despite it (Porter, 1998; Bresnahan, Gambardella, & Saxenian, 2001). But governments often play an important role in building and maintaining these clusters or by getting in the way with difficult laws and taxes (Bradshaw, King, & Wahlstrom, 1999; Saxenian & Hu, 2001; Bresnahan, et al., 2001).

One of the main reasons for the existence of clusters is that a particular industry has a body of tacit knowledge necessary for the operations in the industry (Porter, 1998). An extreme example is the process of apprenticeship still practiced in many industries. Many quality string instruments such as violins are still hand crafted by skilled artisans who apprenticed for several years before establishing their own shop (Villareal & Lopez-Levy, 1997; Kolstein, Barrie J., 1997). The process of apprenticeship allows tacit knowledge to be passed on to others. Industries with significant levels of tacit knowledge for key functions often locate near each other in order to facilitate the movement of tacit knowledge. This closeness allows for regular visits, both formal and informal, among competitors and players in the value chain (Porter, 1998).

The purpose of this paper is to bring much of the research on industry clusters together in a cohesive model that describes why some industries are more likely than others to form clusters. This provides a foundation for further research and analysis by illuminating the interrelationships of the various forces known to affect industry agglomeration. This paper begins with a literature review of industry clusters and tacit knowledge movements. This section includes a discussion of the role of government in cluster development. A model for describing the causes of an industry's propensity to cluster is then developed.

Literature Review

Defining a Cluster

An industry cluster is a small geographic area (usually the size of a metropolitan area) that hosts a significant number of a given industry's competitors, suppliers, and/or distributors (Porter, 1998). Bresnahan et al. (2001) define a cluster as "a spatial and sectoral concentration of firms." Although descriptions of clusters are numerous (Breshnahan, et al., 2001; Enright & Roberts, 2001; Hodgetts, 1993; Ivarsson, 1999; Paci & Usai, 2000; Pandit, Cook, & Swann, 2001; Powell, Koput, & Smith-Doerr, 1996; Porter, 1986, 1998; Saxenian, 1994; Saxenian & Hsu 2001) understanding how and why they form is difficult.

Zaheer and Manrakhan (2001) describe four main reasons for a company to locate in a cluster: 1) resource-seeking, 2) market-seeking, 3) efficiency-seeking, and 4) strategic asset-seeking. Companies that deliberately choose to locate in a cluster are seeking something that the cluster offers. Resources sought might be raw materials such as a supply of oil or fresh fruit, or they could be manufactured products such as auto parts. Inexpensive labor could be another resource that a company might seek when locating within a cluster. Firms that offer products or services used by a particular industry may decide to locate in a cluster to have closer access to customers. Companies may seek efficiency and cost savings through shorter physical distance between suppliers and customers by locating within a cluster (Porter, 1986). Strategic assets often include tacit knowledge about markets and manufacturing techniques that can be acquired through regular contact with managers within the cluster (Saxenian, 1994).

The Life Cycle of Clusters

Pouder and St John (1996) studied the development cycle of industries inside and outside of hot spots or clusters. They identified three phases through which clusters pass:

1. Origination and emergence of the cluster
2. Convergence of the cluster firms
3. Firm reorientation and decline in the performance of the cluster

Their research found that the development cycles of industries within the cluster are different from those outside of the cluster. During the rise of a cluster, companies inside the cluster grow much faster than those outside of the cluster. However, during the decline of a cluster, these firms also shrink and go out of business at a faster rate than the rest of the industry. A cluster can decline even while the industry as a whole is still growing (Pouder & St. John, 1996). Understanding the reasons for these differences is the key to unlocking the mysteries of clusters.

There are several ways industry clusters can become established. Universities with breakthrough technology can be catalysts, as can a single important company that spawns spin-offs, or an abundance of government contracts, or location near a port or international border (Pouder & St John 1996). Some clusters arise as a confluence of two or more existing clusters (Porter 1998). All of these causes for clusters can fit into one or more of Zaheer and Manrakhan's (2001) four main reasons for companies to seek a cluster. Therefore the formation of new clusters and the movement of companies to existing clusters occur for the same reasons.

As an industry develops in a geographic area, other companies are created or move in to make supplies or offer services to the main companies in the new industry. These companies take advantage of close proximity to develop the products and services that they offer each other (Pouder & St. John, 1996). This advantage is particularly important in new industries that are still defining fundamental elements of their products or services (Pouder & St. John, 1996). For example, a manufacturer can have engineers from a supplier drive to the factory location in an afternoon to consider a problem on the factory floor and together they can reengineer a particular process if needed. The supplier can then pass this information on to others in the industry. This would not be so easy if the supplier were located in a distant state. This type of interaction was vital to the rise of Silicon Valley (Saxenian, 1994).

Once this basic infrastructure of companies is established, the cost of doing business becomes lower

than in non-cluster areas. New entrants to the market find that the rich mix of suppliers and service providers in close proximity makes starting up a new company much easier, faster, and less expensive than outside the cluster (Pouder & St. John, 1996). These advantages attract new entrants into the cluster, which grows rapidly. These advantages are called agglomeration economies (Rauch 1993).

Porter (1998) claims that clusters affect an industry in three ways: 1) by increasing the productivity of companies in the cluster, 2) by driving the pace direction and pace of innovation, and 3) by stimulating the formation of new businesses to fill needs within the cluster. From the point of view of an individual firm, all of this adds to the attraction of locating in a cluster. During the convergence phase, companies start aligning their operations. They use similar methods, materials, and suppliers (Pouder & St. John, 1996).

Companies in the cluster usually compete against each other intensely. However, as the industry grows globally, companies in the cluster tend to ignore new competitors outside of their cluster (Pouder & St John 1996). This lack of concern could limit innovation. As the major companies start to grow bigger, they integrate vertically, which lessens their dependence on the network of support companies in the cluster. However, this high level of integration limits the efficient use of many resources in the cluster and leads to diseconomies. Ultimately these factors result in the end of the cluster (Pouder & St. John, 1996). Understanding and preventing excessive vertical integration could help to sustain existing clusters indefinitely.

Sticky and Leaky Knowledge

Breschi and Lissoni (2001) suggest that the more important tacit knowledge is to a particular industry, the more likely the industry will form clusters. Thus the facile assimilation of knowledge is one of the factors in cluster development. Zucker, Darby, and Armstrong (1998) researched knowledge spillovers in the biotechnology industry. They demonstrated a link between physical proximity to key university professors and the success of biotechnology companies. This would be consistent with Zaheer and Manrakhan's (2001) resource-seeking reason for industries to cluster. In this case the star university biologists are the resource being sought.

Brown and Duguid (2001) discuss social practices associated with organizations and describe the concepts of "sticky" or tacit knowledge and "leaky" or explicit knowledge. They explain that sticky or tacit knowledge includes informal procedures, heuristics, and relationships that cannot be easily reproduced. A new employee learns this knowledge over time by simply interacting with coworkers. However, such interaction is no guarantee that new tacit knowledge will flow across a company (Brown & Duguid, 2001). Research divisions often have difficulty getting their ideas developed, and into the market (Brown & Duguid, 2001).

Leaky or explicit knowledge, by contrast, can be easily taught to others (Brown & Duguid, 2001). The term *leaky* implies that the knowledge can be easily learned by competitors. This can result in company plans and product designs falling into the hands of competitors, and shorten or eliminate the time a company can accrue rents from its innovations. But this category of explicit knowledge also includes industry information that is easily obtained and not necessarily proprietary. Alfred Marshall said that these areas had an atmosphere rich in ideas (Almeida & Kogut, 1999). Many companies work hard to establish security structures that prevent the flow of such knowledge outside of the firm (Brown & Duguid, 2001).

The Role of Government

Although most clusters form without the direct aid of governments, national and local governments do play a role in the formation and maintenance of successful clusters (Porter, 1998). Governments provide the supply of educated workers needed in a cluster. The better the education, the more flexible the workers are (Porter, 1998). This flexibility is vital to maintaining a cluster's competitive advantage because a flexible workforce can more easily adapt to new demands and structures as dictated by changing market conditions.

Governments also provide a fair and stable framework in which business can be conducted (Porter, 1998). Consistent laws and regulations with a fair judicial system for resolving disputes allow a

company to focus its resources on improving its government officials. Porter (1998) cites this problem as key to understanding challenges less developed countries have in creating clusters.

Governments can also provide a source of research and development that can be incorporated into companies within the cluster. These innovations typically come from government supported universities, but can also be from government laboratories (Saxenian, 1994). Governments can supply the necessary infrastructure for certain industries, especially high tech, to flourish (Saxenian & Hsu, 2001).

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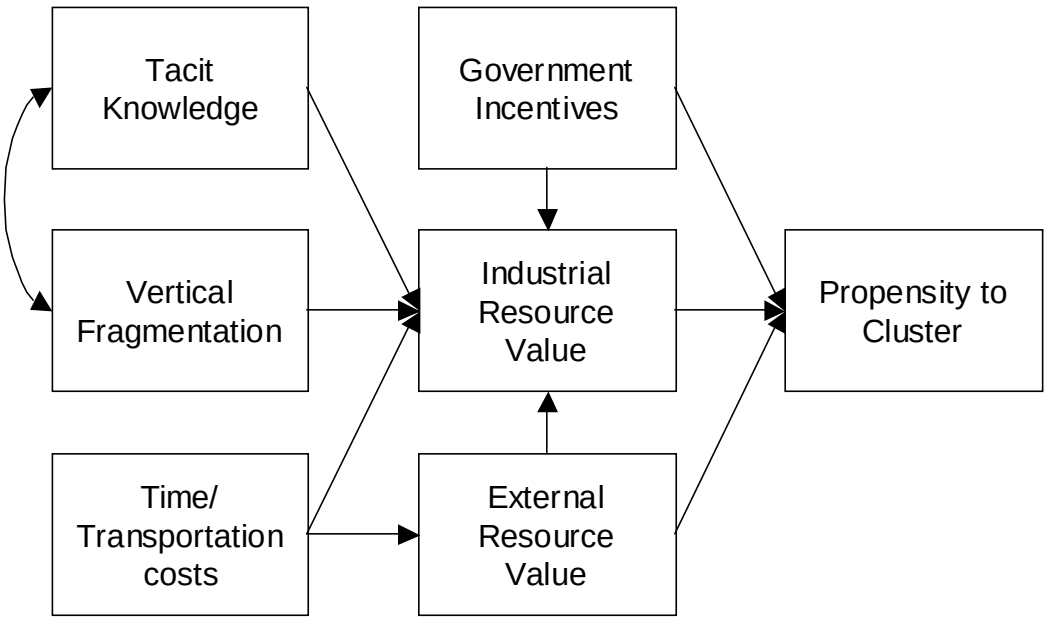
A Model of Cluster Propensity

Many industries show a propensity to cluster, while others seem to disperse. There are various forces that lead a particular industry to cluster and these forces can interact in complex ways. The cluster propensity model (see figure 1) maps these forces and illuminates their interaction. The focus of this model is on the firm or division of a firm that specializes in a particular product or service. The boxes of the left column represent forces that affect key incentives for industries to agglomerate and the middle column represents the main incentives for clustering.

Figure 1



Propensity to Cluster

Propensity to cluster refers to the likelihood that an industry will form clusters. It is the culmination of all of the factors that affect the likelihood that a given industry will agglomerate. Several authors (Porter, 1998; Saxenian, 1994; Saxenian & Hsu, 2001; Zaheer & Manrakhan, 2001) have discussed why industry clusters form. This model pulls together many of their ideas into a cohesive structure. Although a high propensity to cluster indicates that an industry is likely to agglomerate, it does not predict where and precisely when. Catalysts are still needed for a cluster to form. The factors that affect this propensity to cluster are discussed below.

Government Incentives

Government incentives refer to a government's efforts to produce a cluster. These incentives include

a wide range of activities such as subsidized facilities in a research park, tax holidays for locating in a city or region, exclusive buying agreements as a reward for locating in the cluster, etc (Saxenian & Hsu, 2001; Porter, 1998). These incentives can overwhelm advantages of other locations (and so increase the propensity to cluster), but the cluster generally dries up once the incentives are removed, unless the industrial resource value of the cluster can become high enough to sustain the cluster.

These government incentives directly and positively affect the propensity to cluster. These incentives also improve the industrial resource value, which, in turn, increases the propensity to cluster.

Industrial Resource Value

The industrial resource value (IRV) refers to the attractiveness of locating near other businesses in the industry. Companies often locate in a cluster to gain or improve access to buyers, suppliers, service providers or competitors. Zaheer and Manrakhan's (2001) market-seeking reason for clustering would fall under the category of the industrial resource value. From the perspective of company specific assets, so would the resource-seeking and strategic asset-seeking reasons that Zaher and Manrakhan mentioned.

The industrial resource value is a pivotal factor in the creation of many industry clusters. Often the actual location of the IRV is unimportant because there is no vital external resource required in the industry. However, once the location is determined and industry players move in, the cluster can be self-sustaining and moving it can be very difficult. The IRV directly affects the propensity to cluster such that the higher the IRV, the more likely the industry will form clusters.

External Resource Value

The external resource value (ERV) refers to a resource that because of its nature cannot be integrated into a company, but directly affects the propensity to cluster. These resources are often immovable from the point of view of the firm such as a mine, beach, or seat of government. The beach and climate of a Florida resort cannot be built in Omaha, Nebraska, so a beach resort hotel must be built by a beach. There are a number of places in the world that have the right mix of climate and soil for growing grapes, so vineyards must cluster in these areas. Government service providers often locate in capitals to have ready access to their prime customers. The ERV considers external (to the industry) elements of Zaheer and Manrakhan's (2001) resource-seeking, market-seeking, and strategic asset-seeking reasons for clustering. The ERV affects the propensity to cluster such that the greater the ERV, the more likely an industry is to cluster.

Tacit Knowledge

Tacit knowledge refers to the difficulty of articulating knowledge in a given field. Explicit knowledge can be easily transmitted in written messages or texts, over the phone in conversations, or even in physical products. However tacit knowledge often requires someone to "show you how" something is done. Location within a cluster provides much greater opportunity to visit a buyer's factory, have a consultant spend time in your office, or have daily face-to-face meetings to solve problems between a supplier and buyer.

Hedlund (1994) identified four agents of tacit knowledge transfer: individuals, small groups, organizations, and the interorganizational domain. Individuals can carry tacit knowledge with them from place to place. Small groups can pass tacit knowledge on to their newcomers. Organizations can have formal and informal training programs for the dissemination of tacit knowledge. Interorganizational exchanges, societies, and alliances can serve as a platform for this knowledge transmission. The implication of Hedlund's interorganizational agents is that industry agglomeration facilitates their operation and the more tacit the knowledge base of an industry, the greater the need for these interorganizational agents and the more likely an industry is to concentrate in geographical regions. Therefore, the greater the level of tacit knowledge is in an industry, the higher the IRV, and the greater the propensity is for an industry to cluster.

Vertical Fragmentation

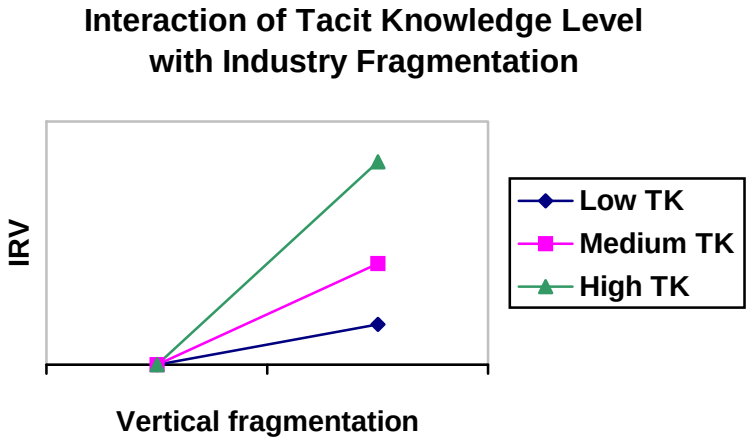
Vertical fragmentation refers to the level of vertical integration found among companies in an industry. If an industry is composed mainly of many small

companies that work together to produce final products, then co-location facilitates daily business with other industry players. However, if a company is vertically integrated, then it becomes its own supplier and buyer.

Two examples of the consequences of excessive vertical integration are played out in Silicon Valley in California and Route 128 in Massachusetts. Saxenian (1994) compares Silicon Valley companies to Route 128 companies and shows how Route 128 minicomputer companies vertically integrated and then cut themselves off from the cluster network. This transformed the cluster into a group of independent companies not linked to any significant network. As a group of insular companies, they were not able to adapt to the competition from personal computers and the cluster disintegrated. Silicon Valley went though a similar problem with memory chip manufacturing, but returned to its network-centric operation in time to save at least CPU microchip manufacturing and to generate other related industries such as personal computers (Saxenian, 1994). These examples illustrate that when vertical integration is high, other companies in the industry have little or nothing to offer it, so the IRV is low and co-location becomes unimportant.

The two factors of industry fragmentation and tacit knowledge interact with each other. The nature of the interaction is shown in figure 2. When a firm controls all of its supplies and distributes its own product, coordination can occur via fiat. Even tacit knowledge across divisions can occur by transferring employees or even chartering a regular airline flight between two locations to allow employees with vital tacit knowledge to commute to key locations as needed. When industry fragmentation is high and tacit knowledge levels are low, there is a modest positive effect on the IRV. The greatest positive effect occurs when both industry fragmentation and tacit knowledge levels are high. However, when industry fragmentation is low or zero (i.e., all firms in an industry are fully vertically integrated), there is no positive effect on IRV regardless of the level of tacit knowledge.

Figure 2



Time and Transportation Costs

Products that have a low value to weight ratio suffer from high transportation costs as a percentage of the overall price. When large quantities of these products are necessary for production, co-location with a supplier lowers the transportation costs, which then significantly impacts the overall costs of production. Just-in-time methods seek to lower inventory costs by co-locating supplier factories so that deliveries of supplies can be made in an hour or two, rather than a day or two. The greater the savings

from such just-in-time operations are, the greater the IRV for clustering.

Transportation costs also affect the external resource value. Vital materials that have a low value to weight ratio (such as lime and sand for cement) will encourage clustering around the external resource. However, if the value to weight ratio is high (and the ratio of transportation costs to overall costs is low) then clustering near the external resource is unnecessary. For example, most diamond cutting is not done near diamond mines because relative transportation costs are very low.

Therefore, the IRV and/or the ERV will increase when the ratio of transportation costs to total costs are high. In extreme cases, an industry will form many small clusters around immovable external resources. The IRV will also increase if clustering offers significant savings from the shortened time to coordinate with suppliers, buyers, etc.

Conclusion

Although the forces that lead to the creation of an industry cluster are complex, the Cluster Propensity Model presents a way to understand these forces and their interactions as they influence the likelihood for an industry to form clusters. This model makes no attempt at predicting the actual location of a cluster or how to bring a cluster to a given location. Governments may try to create a cluster in their areas, only to fail because they cannot raise the IRV to self-sustaining levels. Future research can look at various elements of this model to empirically test its assertions.

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References

Almeida, P., & Kogut, B. 1999. Localization of knowledge and the mobility of engineers in regional networks. *Management Science,* 45: 905-917.

Bradshaw, T. K., King, J. R., & Wahlstrom, S. 1999. Catching on to clusters. *Planning,* 65 (6): 18-21.

Breschi, S., and Lissoni, F. (2001). Knowledge spillovers and local innovation systems: A critical survey. *Industrial and Corporate Change* 10 (4): 975-1005.

Bresnahan, T., Gambardella, A., & Saxenian A. (2001). Old economy inputs for new economy outcomes: Cluster formation in the new Silicon Valleys. *Industrial and Corporate Change,* 10 (4): 835-860.

Brown, J. S., & Duguid, P. 2001. Knowledge and organization: A social-practice perspective. *Organization Science,* 12: 198-213.

Chui, M., Levine, P., & Pearlman, J. (2001). Winners and losers in a North-South model of growth, innovation, and product cycles. *Journal of Development Economics,* 65: 333-365.

Enright, M. J., & Roberts, B. H. 2001. Regional clustering in Australia. *Australian Journal of Management* 26: 65-85.

Feldman, M. (2001). The entrepreneurial event revisited: Firm formation in a Regional Context. *Industrial and Corporate Change,* 10 (4): 861-891.

Frost, T. S. 2001. The geographic sources of foreign subsidiaries innovations. *Strategic Management Journal* 22: 101-123.

Granovetter, M. 1985. Economic action and social structure: The problem of embeddedness. *American Journal of Sociology* 91 (3): 481-510.

Hedlund, G. 1994. A model of knowledge management and the N-form corporation. *Strategic Management Journal* 15: 73-30.

Henderson, R., & Cockburn, I. 1994. Measuring competence? Exploring firm effects in pharmaceutical research. *Strategic management Journal,* 15: 63-84.

Hodgetts, R. M. 1993. Porter's diamond framework in a Mexican context. *Management International Review,* 33 (2): 41.

Ivarsson, I. 1999. Competitive industry clusters and inward TNC investments: The case of Sweden. *Regional Studies,* 33 (1): 37-49.

Kolstein, Barrie J. (1997). Recapturing the golden period. *Strad* 108 (1291): 1190.

Leamer, E. E., & Storper, M. 2001. The economic geography of the Internet Age. *Journal of International Business Studies* 32 (4): 641-665.

Maskell, P. (2001). Towards a knowledge-based theory of the geographical cluster. *Industrial and Corporate Change,* 10 (4): 921-943.

Paci, R., & Usai, S. (2000). Technological enclaves and industrial districts: An analysis of the regional distribution of innovative activity in Europe. *Regional Studies,* 34, (2): 97-114.

Pandit, N. R., Cook, G., & Swann, G. M. (2001). The dynamics of industrial clustering in British financial services. *The Service Industries Journal,* 21 (4): 33.

Piore, M., & Sabel, C. (1984). *The Second Industrial Divide.* New York: Basic Books, Inc.

Pouder, R., & St John, C. (1996). *Hot spots and blind spots: Geographical clusters of firms and innovation* 21 (4): 1192.

Powell, W., Koput, K., & Smith-Doerr, L. (1996). Interorganizational collaboration and the locus of innovation: Networks of learning in biotechnology. *Administrative Science Quarterly*, 41: 116.

Porter, M. (1998). Clusters and the new economics of competition. *Harvard Business Review,* 76, (6): 77-81.

Porter, M. (1986). *Competition in Global Industries*. Boston: Harvard Business School Press.

Rauch, J. (1993). Does history matter only when it matters little? The case of city-industry location. *Quarterly Journal of Economics* 108 (3): 843-867.

Saxenian, A. (1994). *Regional Advantage: Culture and Competition in Silicon Valley and Route 128.* Cambridge: Harvard University Press.

Saxenian, A. & Hsu, J. (2001). The Silicon Valley-Hsinchu connection: Technical communities and Industrial Upgrading. *Industrial and Corporate Change* 10 (4): 893-920.

Shaver, J. & Flyer, F. (2000). Agglomeration economies, firm heterogeneity, and foreign direct investment in the United States. *Strategic Management Journal* 21: 1175-1193.

Villareal, Fernando & Lopez-Levy, Marcela (1997). Four's a tradition. *Strad* 108 (1281): 30.

Zaheer, S. & Manrakhan, S. (2001). Concentration and dispersion in global industries: Remote electronic access and the location of economic activities. *Journal of International Business Studies* 32 (4): 667-686.

Zucker, L., Darby, M., & Armstrong, J. (1998). Geographically localized knowledge: Spillovers or markets? *Economic Inquiry,* 36: 65-86