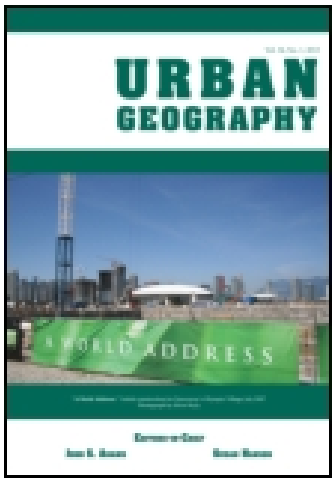

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INTERLOCKING DIRECTORATES: AN EXAMPLE OF TACIT KNOWLEDGE TRANSFER

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Abstract: This paper illustrates tacit knowledge flows between American and Canadian metropolitan areas. Using the spatial distribution of interlocking in Canada and the United States a spatial component is added to the resource dependency paradigm. Using a poisson regression model, components of cities that initiate and attract interlocking, and thus knowledge transfer, can be identified. From the results, the authors propose the concept of a "knowledge threshold" essential for the transfer of tacit knowledge. In Canada the "knowledge threshold" encompasses the entire country while it is more regionally based in the United States. [Key words: interlocking directorates, tacit knowledge transfer.]

Over the past decade, theories of the firm have suggested that the sources of firm prosperity have changed. Today knowledge, instead of land, labor, and capital, is the most viable path for competitive advantage. In this view, knowledge allows the firm to develop superior technological know-how and create innovative products better than their rivals. The ultimate challenge to management for sustained growth is to create knowledge that is not easily imitated by competitors and to use this knowledge for innovative purposes.

Business theorists have, for the sake of convenience, categorized knowledge into two forms: tacit and explicit. Explicit knowledge can be communicated as words and numbers. This makes the composition of explicit knowledge clear and distinct and therefore easily transmitted. Its codified nature allows explicit knowledge to be expressed as hard data, blueprints, computer code, and scientific formulas. These are freely processed by computer and transmitted electronically. The transmission of explicit knowledge is often carried out by impersonal means, such as through a computer or a technical manual.

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Tacit knowledge on the other hand is highly subjective, less teachable and less observable. Its ambiguous nature makes it difficult to process and communicate. With few exceptions (video conferencing and selected telephone conversations), tacit knowledge can only be learned through face-to-face communication. Nonaka and Takeuchi (1995) pointed out that subjective insights, intuitions, and hunches are examples of tacit knowledge. While technological developments warrant the effortless movement of explicit knowledge, distance constrains tacit knowledge transfer, resulting in two important ramifications. First, the codified nature of explicit knowledge allows it to be imitated relatively easily by competitors. The firm must therefore use tacit knowledge if sustainable competitive advantage is to be created. Second, geography is important for tacit knowledge transfer. Since face-to-face contact is necessary for tacit knowledge transfer, localized relationships are essential. Therefore, when attempting to explain the competitive advantage of firms, not only should the transfer of tacit knowledge be studied, but the geographical implications for tacit knowledge should be studied as well.

For long-term prosperity the firm must create new knowledge. In order to do this, external tacit knowledge must be introduced to the firm. One of the most important ways for the firm to access external tacit knowledge is through its board of directors (Useem, 1984). Considered informed and accomplished professionals, directors provide independent knowledge on the external economic climate. Being removed from everyday activities of the firm, directors offer fresh ideas for firm strategy. Perhaps the most important way a board member can obtain knowledge is to serve as a board member of another firm. Termed an interlocking directorate, sitting on two or more boards allows an individual to pass knowledge of one firm to another.

Past research on interlocking has been dominated by sociologists who have attempted to explain "why" these connections take place. From this literature, resource dependency has emerged as the dominant explanation for interlocking directorates (Pfeffer and Salancik, 1978). This theory suggests that firms can internally produce only a portion of their inputs. Consequently, they must enter into relationships to obtain all the other required resources. Perhaps the most important resource today is knowledge. By connecting to external sources, knowledge of the environment is gained and uncertainty decreased. One way the firm can link to the environment is through its board of directors.

But why does resource dependency research limit research to other firms? Why not extend the model to include additional sources where important knowledge can be obtained? The aim of this paper is to follow the principles of resource dependency but develop a spatial component. It is important to build upon the original resource dependency model because a number of factors influencing knowledge transfer do not exist at the firm level. Using metropolitan-level data, this study denotes these factors by analyzing the spatial distribution of interlocking in Canada and the United States. Using a poisson regression model, components of a metropolitan area that initiate and attract interlocking, and thus knowledge transfer, can be identified.

KNOWLEDGE, THE FIRM, AND THE BOARD OF DIRECTORS

Today, knowledge is considered the most strategically important resource. In fact, Drucker (1993) argued that knowledge is the only meaningful resource. Continuous generation of new and superior knowledge enhances a company's competitive position. A

firm maintaining superior knowledge understands how to capitalize on their traditional resources to create new products. This constant creation of new knowledge and products increases the resistance to imitation from rival firms.

Knowledge sources may lie within or outside the firm. Internal knowledge is strategically valuable because of its uniqueness to that company. Being firm specific makes it more difficult for competitors to imitate. To continually innovate though, new knowledge must be acquired. External sources are ideal for procuring such new knowledge. When the external and internal knowledges are combined, new ideas and concepts translate into new processes and innovative products.

There are several ways this can be accomplished. For example, Japanese firms are quite successful in acquiring this external knowledge. The Japanese keiretsu, known as societies of business, facilitate cooperation among a set of firms for knowledge transfer to occur. Regulated by Japanese law, keiretsu are structured in a way that collaboration is essentially required. A typical network consists of a few dozen members including a bank or large financial institution, large manufacturing firms and general trading companies. Within each group, members hold one another's shares, engage in intragroup financing, have interlocking directorates, maintain trade, and joint research and development ventures. The end result is a highly innovative network (Branstetter, 2000).

In Canada and the United States, the business network operates differently. Alliances, foreign direct investment, acquisitions, and mergers are official arrangements that sanction knowledge transfer between North American firms. Links to suppliers and buyers, interlocking directorates, start-ups by individuals belonging to another local firm, staff movement, and rumors are a few examples of less stringent but very important knowledge networks. The aim of this paper will be to use interlocking directorates to measure knowledge transfer. Since most employees deal with internal questions, many firms appoint a board of directors which has both internal and external expertise. One of the fundamental responsibilities of these directors is to determine what external knowledge should be integrated with existing resources to create innovative processes and products. As pointed out by Charon (1998), the board is the best platform for creative thinking about firm strategy.

As stated in the introduction, a distinction is often made between different types of knowledge, explicit and tacit. Nonaka and Takeuchi (1995) argued that the two types of knowledge are not mutually exclusive activities. In fact, explicit and tacit knowledge compliment each other. Social interaction between tacit and explicit knowledge actually converts old knowledge into new knowledge.

To illustrate this relationship Nonaka and Takeuchi (1995) presented a dynamic model of knowledge creation. They offer four modes of knowledge conversion that essentially make up the knowledge creation process: (1) from tacit to tacit, called socialization; (2) from tacit to explicit, externalization; (3) from explicit to explicit, combination; and (4) from explicit to tacit, called internalization. This paper is primarily concerned with the first two stages of the model of knowledge conversion. In other words, this paper deals with the avenue whereby external tacit knowledge can be introduced to the firm for the purpose of internalizing, thus creating new knowledge.

Nonaka and Takeuchi (1995) termed the interaction between the four modes of knowledge as a knowledge spiral. As suggested by Teece (1998), how a firm configures this knowledge spiral determines firm competitiveness. Today, the competitive nature of the

firm stems not from owning tangible assets, but from the ability to create knowledge through this knowledge spiral (O'Hagan and Green, 2001).

Unfortunately it is difficult to visually display the socialization and externalization phases of the model of knowledge conversion. The difficulty of researching the transfer of tacit knowledge lies in its intangibility. How does one measure the quality and quantity of tacit knowledge transferred from one firm to another? The characteristics of tacit knowledge are precisely what make it difficult to measure. Clearly it has not been easy to empirically measure tacit knowledge transfer. Glazer (1998, p. 177) verified this limitation by suggesting that if our understanding of knowledge is to increase, "it is crucial to develop valid and reliable measures of knowledge. For, despite the flurry of activity, it is becoming clear that no real progress can be made in our efforts to treat knowledge either as a variable to be researched or as an asset to be managed unless we come to terms with the issue of measurement/valuation."

Here we face a theoretical dilemma. It is important that research increasingly recognize the importance of firm knowledge for competitive advantage. However, it is problematic for ideas of knowledge transfer to disregard empirical validation. The solution to measure the flow of knowledge is to take actors that possess a great deal of tacit knowledge and a medium that allows for this tacit knowledge to be transferred. We argue that directors are important actors of the firm that possess a great deal of quality tacit knowledge. They understand company goals and company strategy to achieve these goals. Interlocking directorates are a means by which these directors can pass tacit knowledge on from one firm to another. In other words, the knowledge transferred from one company to another company via an interlock is in the form of tacit knowledge.

It is important to study the concept of tacit knowledge transfer because what the company does with this new knowledge can help lead to its prosperity. As recognized by Kuznets (1966) overall performance of a company depends on its ability to turn its knowledge resources into new knowledge. This new knowledge creates value and allows the firm to continually innovate. We propose that directors play an important role in this process because they introduce external knowledge to the firm.

Returning to Nonaka and Takeuchi's (1995) concept of the knowledge spiral, it is possible to display the significance of the knowledge that directors procure through knowledge links. Serving on the board of a second firm through an interlocking directorate allows a director to gain tacit knowledge from the other directors sitting on that board (socialization). The knowledge gained from his/her experiences with the second firm can then be brought back to the first firm where eventually it will be displayed for employees in an explicit manner (externalization). This explicit knowledge can be combined with old explicit knowledge already possessed by the firm to create new explicit knowledge. This new knowledge can then go through the process of internalization where the workers of a company turn the explicit knowledge back into a new form of tacit knowledge for further knowledge creation.

GEOGRAPHICAL RESEARCH ON KNOWLEDGE

Most economic geography research over the past ten years discusses knowledge and information as it relates to a locale. This research dates back to Marshall (1920) who suggested firms in spatial agglomerations benefit from technological spillovers. Ever

since, academics have acknowledged the region as an important source of intangible assets necessary for competitive advantage.

Malmberg (1996), Maskell and Malmberg (1999), and Morgan (1997) claimed that physically proximate firms interact to create innovative processes and products. They termed these areas dynamic regions, and suggested they are an important source of new knowledge. Areas of specialization with their high levels of direct face-to-face relations support a commitment toward collective learning and shared prosperity. As they relate to one another, trust develops between individuals that encourages the diffusion of technical knowledge and skills. In particular, Morgan (1997) suggested that feedback loops are an important source of knowledge. A lack of feedback indicates activities like research and development have little chance to learn from past experiences.

There is no doubt that regional interaction is important for the transfer of tacit knowledge. But to consider local interdependencies as always superior is inadequate. For example, even in the entertainment business, not all relevant firms and holders of knowledge are located in Hollywood. Oinas and Malecki (1999) pointed out that relationships with firms in other regions contribute unique experiences and provide a basis to contrast local ideas. They called the combination of sustained local and nonlocal relationships a spatial innovation system.

The relationships beyond the immediate area are less apparent as sources for knowledge (Amin and Cohendet, 1999). What matters most are not the number of relationships, but the quality of these relationships. For example, individuals adjacent to each other protecting their knowledge may actually prevent knowledge transfer and innovation. In contrast, the likelihood of knowledge transfer increases in these spatial innovation systems where individuals trust one another, no matter what the spatial separation.

Interlocking directorates provide a unique setting for studying the sharing of knowledge. Over time, relationships are built up not only with other directors in the same urban area, but also with directors in distant locations. While local relationships are important, it needs to be increasingly emphasized that nonlocal connections also play a significant role in sustaining competitiveness. These provide additional sources of knowledge about producers, consumers, and regulators.

As suggested by Holtshouse (1998) the key to the creation of new knowledge involves "tapping into and unlocking" individual tacit knowledge. This requires communication between individuals in a face-to-face work environment. The face-to-face contact is vital because the transfer of tacit knowledge is procured, for example, through firsthand observation and body language. Interlocking provides a forum through which tacit knowledge can be transferred from one company to another no matter what the distance between firms. Indeed, it seems clear that interlocking to local or distant regions is a means of achieving competitive advantage through knowledge transfer.

PREVIOUS RESEARCH ON INTERLOCKING DIRECTORATES

A substantial amount of literature exists on the study of interlocking directorates. From this literature, resource dependency has emerged as the dominant theory to explain why interlocking directorates occur. This theory states that firms are unable to generate all the necessary inputs for production. Firms respond with relationships to external elements of the environment to ensure a supply of the required resources. Organizations are

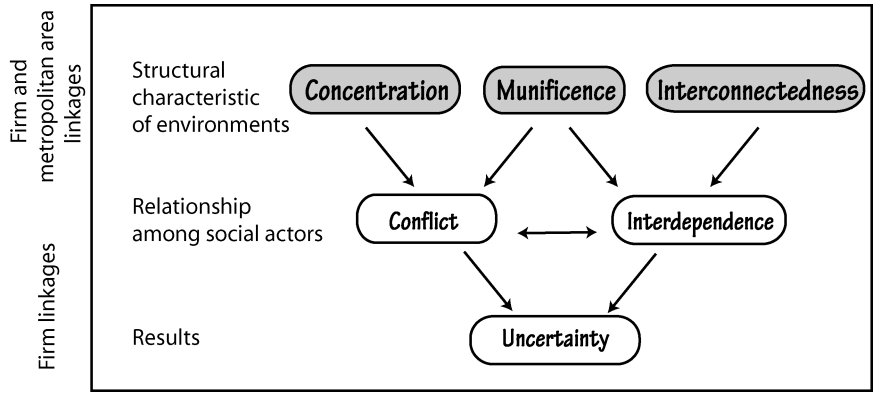


Fig. 1. Relationships among dimensions of organizational environments. Adapted from Pfeffer and Salancik, 1978.

viewed as actively manipulating and controlling their environment to secure a steady supply of inputs. For the most part, firms increase control of their environment through relationships with other firms. One way to establish a relationship with another firm is through the board of directors.

Resource dependency asserts that the board is an integral component of the effective firm. In this model, the board is used to gain access to scarce resources and knowledge (Boyd, 1990). If a firm is connected to boards of several other firms, it is in the center of a network and has access to a valuable resource: knowledge. Obtaining knowledge is difficult because of its embedded nature in the firm and in the people of the firm (Badaracco, 1991). But a director sitting on the board of two firms allows knowledge about corporate policy to be transferred. Pennings (1980) and Solvell and Zander (1995) argued that an interlocking directorate provides a link by which knowledge can be communicated between two firms. Lorsch and MacIver (1989, p. 27) supported this argument with firsthand evidence. Citing a chief executive officer the authors suggested,"You can learn so much about situations that you may become faced with."

But why is knowledge conveyed through interlocks so significant? Haunschild and Beckman (1998) suggested that reasons include the inexpensive, trustworthy, credible nature of directors. All publicly traded firms in the U.S. are required to have a board of directors of at least three people. In Canada these same firms are required to have a board of directors with at least one person. Therefore, the knowledge that is gained from a director that sits on the board of another company is an inexpensive by-product of this mandatory regulation.

Limitations of the Resource Dependency Model

The following section is divided into five parts. First, the resource dependency model proposed by Pfeffer and Salancik (1978) is further analyzed. Second, shortcomings of the resource dependency model are raised. Third, modifications to the resource dependency model are proposed. Fourth, research that explores the geographical implications of inter-

locking is summarized. Finally, improvements to both the resource dependency model and geographical research on interlocking are presented.

A three-tiered model of resource dependency proposed by Pfeffer and Salancik (1978) is provided in Figure 1. From this model, they display *how structural characteristics of environments* are associated with *relationships among social actors*. The combination of these two dimensions results in *uncertainty*. Interestingly, they suggested the dimensions of a firm's environment are not mutually exclusive. Moreover, they argue a causal relationship exists between these three dimensions.

If we assume the relationship between these three dimensions is causal, then a number of factors influence the level of uncertainty possessed by the firm. According to resource dependency, the level of uncertainty possessed by the firm impacts the performance of a firm. Using interlocking directorates as a means of decreasing uncertainty, a great deal of literature documents the relationship between interlocking and firm prosperity.

Unfortunately, these studies do not offer a distinct definition of a firm's environment. Herein lies a problem with the resource dependency approach. For example, Pfeffer (1972) observed that the number of attorneys on a board increased as the level of regulation increased. In other words, the level of uncertainty for a firm's environment centered on regulation. In another study, Pennings (1980) found that profitability increased with ties to financial institutions. Thus, the environment for firms in Penning's (1980) study surrounded financial uncertainty.

Defining the firm's environment in different ways has led to conflicting results. Some have found positive effects of interlocking on firm profits, albeit weak relationships (Pennings, 1980; Burt, 1983). As interlocking increases, a firm becomes more aware of its external environment. By increasing information, it decreases uncertainty and is more likely to make sound business decisions. On the other hand, others have found negative effects (Fligstein and Brantley, 1992).

In the past, these results have been justified in two ways. First, firm prosperity is a complex process. Interlocks and the resources they secure are only a portion of what makes a firm successful. Second, Mizruchi (1996) suggested that interlocking may be both a cause and effect of profitability. For instance, unprofitable firms may be more likely to interlock. Richardson (1987) found that bankers are more likely to join a board of directors when that company is in financial difficulty. Thus, it is precisely when profits are lowest, that interlocking occurs.

In response, we as geographers suggest that asking the question, does interlocking increase the profitability of a firm is to answer only one question. An alternative question is where do interlocking directorates occur. From this one can suggest reasons why interlocking directorates provide a basis for knowledge transfer. This type of study does not examine the position of the firm at the time of the interlock or how management of the company uses this knowledge. It can only be assumed that increased knowledge introduced by the director enables superior intelligence that decreases firm uncertainty and leads to better business decisions.

While resource dependency research argues that knowledge varies across firms, it does not suggest that knowledge varies across space. This lack of a spatial component is a deficiency of the resource dependency and interlocking literature. Lundvall and Johnson (1994) indicated how learning is not a placeless process. Sassen (1991) added to this argument by suggesting that an important attribute of knowledge is its irregularity over

space. It exists in certain places but not in others. Consequently, geographical differences should emerge as an important rationale when attempting to explain the acquisition of knowledge in resource dependency and interlocking directorates.

This raises the question, how does one define the firm's environment? Put another way, how does one define the three dimensions of Pfeffer and Salancik's model. As argued by Boyd (1990, p. 421), "a comprehensive definition of environmental characteristics is essential if we are to conduct an accurate test of resource dependence." Since knowledge is an increasingly important component of a firm's environment, and knowledge varies over space, any meaningful explanation of resource dependence must encompass locational factors that affect the flow of knowledge.

Perhaps a better explanation of the dimensions of an organization's environment would follow Pfeffer and Salancik's model but include the individual, firm, and metropolitan area. At the base, uncertainty is heightened and can only be reduced through knowledge transfer from one individual to another. A greater chance of knowledge transfer occurs when the individual is employed by a firm that is interdependent with a number of other firms or where conflict between the firm he/she works for and additional firms is diminished. The quality and quantity of knowledge transfer to these firms should be dependent upon the extent to which knowledge is distributed over the environment (concentration), the relative level of knowledge available in the environment (munificence), and the degree of interconnection among elements in the environment (interconnection).

While Pfeffer and Salancik claimed that the firm should be the main unit of analysis of the third tier, the authors of this paper contend that the metropolitan area is also important. Dess and Beard (1984, p. 52) suggested that "the resources required for organizational survival are the most relevant focus in defining organizational environments." From this, the importance of other firms in an organization's environment is obvious. Perhaps less obvious though, are other sources of knowledge when defining a firm's environment. Firms cannot maximize their knowledge by only linking to other firms. Additional sources are crucial if the firm is to obtain knowledge. Surely, the quantity and quality of tacit knowledge in one metropolitan area will be somewhat different from the knowledge that exists in another metropolitan area. Social, economic, and political institutions will vary from metropolitan area to metropolitan area. Media, political figures, and research institutions are just a few examples of knowledge sources that exist at the metropolitan area level but not at the firm level.

Even Pfeffer and Salancik (1978, p. 12) suggested, "the environment includes every event in the world which has any effect on the activities or outcomes of the organization." Therefore, a locational explanation is just as meaningful for the third level of the hierarchy. This paper addresses the limitations of Pfeffer and Salancik's (1978) definition of a firm's environment by considering the concentration and munificence of knowledge at the metropolitan-area level. In addition, how connected a metropolitan area is to another should influence the flow of knowledge between these centers. This helps us determine whether interlocking directorates provide the basis for knowledge transfer.

The Geography of Interlocking Directorates

There are only three studies that conceptualize the spatiality of knowledge transfer through interlocking directorates. Green (1980) and Green and Semple (1981) were the

first researchers to examine the geographic conceptualization of interlocking directorates. By examining the interlocking of 183 American firms spatially, the authors observed that firms in cities of the U.S. manufacturing belt preferred to interlock with firms in cities of the same region. From their findings the authors proposed that this regional internalization denied firms of access to useful information that existed in other regions of the United States. This study was a start to the spatiality of knowledge as it relates to interlocking. Unfortunately the theoretical foundation is outdated and techniques at the time did not allow for the analysis of a large number of firms.

Geographers are not the only researchers to acknowledge the importance of space for the study of interlocking directorates. Kono et al. (1998) argued that sociological research on interlocking directorates tends to ignore the power of the city, focusing instead on individual leaders and firms. The ability of large urban areas to provide a diversity of functions in the same area should be an important contributing factor in the study of interlocking directorates.

The administrative headquarters of large corporations are drawn to large metropolitan centers to enjoy the advantages of proximity to financial establishments on which they depend, the specialized business services that such cities offer and the information processing industries that congregate in the city. Top managers can acquire strategic information informally from elites of other firms headquartered in its city by living in the same neighborhoods, sitting on the same corporate boards, and belonging to the same social clubs. Thus cities that have many business service firms, financial institutions, and corporate headquarters should be the best sites for the acquisition of strategic knowledge.

Using a "city as a growth machine" model, Kono et al. (1998) applied sociological research on interlocking directorates to a geographical scale. For the top 500 American firms in 1964, the authors suggest that some types of interlocks are better suited for local links while others are better suited for nonlocal links. Kono et al. (1998, p. 895) argued that if they did not separate the interlocks geographically, they would have "erroneously concluded that hypothesized determinants had no influence on interlocking at all." For example, when local and nonlocal interlocks were aggregated into the same sample, the independent variable "presence of exclusive upper-class social clubs in a corporation's headquarters city" did not influence corporate interlocking.

However, when the sample was broken down, it was found that the independent variable "presence of exclusive upper-class social clubs in a corporation's headquarters city" did influence local and nonlocal interlocks. When corporations were headquartered in cities with exclusive upper class social clubs, they were more likely to maintain local interlocks. On the other hand, corporations with headquarters in cities without exclusive upper class social clubs were more likely to maintain nonlocal interlocks.

By examining the problem spatially, the authors were able to prove that these finding supported the class hegemony model. However, their theoretical contribution also appears to support the resource dependency model. Yet they failed to investigate this. In addition, Kono et al. (1998) examined sociological variables as either intracity or nonlocal. In other words, a nonlocal interlock of 40 km was treated the same as an interlock of 4000 km.

While resource dependency advocates (Pfeffer and Salancik, 1978) sufficiently examined interlocks as a method of knowledge transfer between firms, they failed to consider the spatiality of knowledge. Conversely, geographers (Green, 1980; Green and Semple, 1981; Green, 1983; Rice and Semple, 1993) have recognized the power of the

city as it relates to interlocks. But geographers have failed to point out the spatiality of tacit knowledge transfer as it relates to interlocks. The present study acknowledges the strengths and weaknesses of both of these divergent ideals to measure interlocking as a means of knowledge transfer between cities. Using interlocking data on directors of firms, the firms where these directors work, and the cities where these firms are located, this paper unveils where tacit knowledge flows across Canada and the United States and why it flows there.

DATA

Data used in this study include all direct interlocks of the 1996 *Fortune* 500. A direct interlock occurs when one company's director also sits on the board of a different firm. The board of directors was obtained from *Standard and Poor's Register of Corporations, Directors and Executives.* For Canadian interlocking, the top 200 industrial firms and top 50 financial institutions were selected from *The* Financial Post *500* (1997). The directorships of each of these 250 companies were then retrieved from the publication *Directory of Directors.*

While there are thousands of firms with boards of directors in Canada and the United States, only the largest 750 firms were selected for study. It is argued that interlocking is most important to these firms for two reasons. It seems reasonable that small firms will not expand their market reach to the extent of large firms. Therefore, it is not as important for smaller firms to access knowledge that exists in distant cities. Second, large firms have a greater number of employees and the necessary resources to obtain superior knowledge on the local environment.

Using the above sources three samples were constructed. Sample USA-CAN, consisting of both Canadian and American interlocking, produces a 750×750 adjacency matrix. Sample USA includes only American interlocking to other American firms, generating a 500×500 adjacency matrix. Finally, Sample CANADA is composed of domestic Canadian interlocks to create an adjacency matrix that is 250×250.

DISTRIBUTION OF INTERLOCKS IN CANADA AND THE UNITED STATES

Of the top 500 American firms 90% had at least one direct link. Of the top 250 Canadian firms 82% also had at least one direct link. In total, the 8,909 directors produced a web of 7,512 interlocks, an average of 10 interlocks per company. It was hypothesized that firm size should be strongly related to number of interlocks. But a statistical test did not verify this. Using revenue as a proxy for firm size produced an $r^2 = .20$ (assets as a proxy for firm size produced an $r^2 = .17$). This may be due to the fact that we are using a censored sample of the largest companies in Canada and the United States. A list of dominant firms in the network of interlocks is supplied in Table 1. Together these 25 companies generate 21% of all the corporate interlocks. Most connected were Royal Bank of Canada (62 interlocks), Canadian Imperial Bank of Commerce, (55 interlocks) and Chase Manhattan (45 interlocks). From this table, the importance of finance and insurance companies as well as New York City (six of the top 25 companies are within commuting distance to New York City) and Toronto (nine of the top 25 companies) is impressive.

TABLE 1.—TOP AMERICAN AND CANADIAN INTERLOCKING COMPANIES, 1996

Company	Headquarters location	Direct interlocks
Royal Bank of Canada	Toronto	62
Canadian Imperial Bank of Commerce	Toronto	55
Chase Manhattan	New York City	45
Canadian Pacific	Montreal	44
NOVA	Calgary	44
Novagas Clearinghouse	Calgary	43
Noranda Mines Ltd.	Toronto	43
Morgan Stanley	New York City	39
Dean Witter Group	New York City	39
Sara Lee	Chicago	38
Brascan Ltd.	Toronto	38
Avenor Inc.	Montreal	37
Toronto-Dominion Bank	Toronto	36
Manulife Financial	Toronto	36
CT Financial Services	Toronto	35
Power Corporation	Montreal	35
Bank of Nova Scotia	Toronto	34
Union Carbide	Danbury	34
Ameritech	Chicago	33
The Great-West Life Assurance	Winnipeg	33
Sun Life Assurance	Toronto	33
Bell Canada Enterprises	Montreal	33
Prudential	Newark, NJ	33
Norcen Energy Resources	Calgary	33
Metropolitan Life Insurance	New York City	31

It is also hypothesized that certain economic sectors possess a greater than average number of interlocks. In an industry where continual innovation of products and processes is important, interlocks should result in greater rewards. For example, the communications industry is more likely to benefit from the knowledge transfer through interlocks than wholesale trade.

In order to test this hypothesis, the Standard Industrial Classification Codes (SICs) for all 750 firms were obtained. Canadian firm SICs were acquired from *Canadian Key Business Directory* (1997) and American firm SICs were obtained from *D&B Million Dollar Directory: America's Leading Public and Private Companies* (1997). Table 2 is an amalgamation of firms into selected industries. Here the importance of finance, communications, as well as mining is unmistakable. Previously, theorists would suggest that this disproportionate representation of banks could be explained by the need for large

TABLE 2.—Interlocking of American and Canadian Industries, 1996

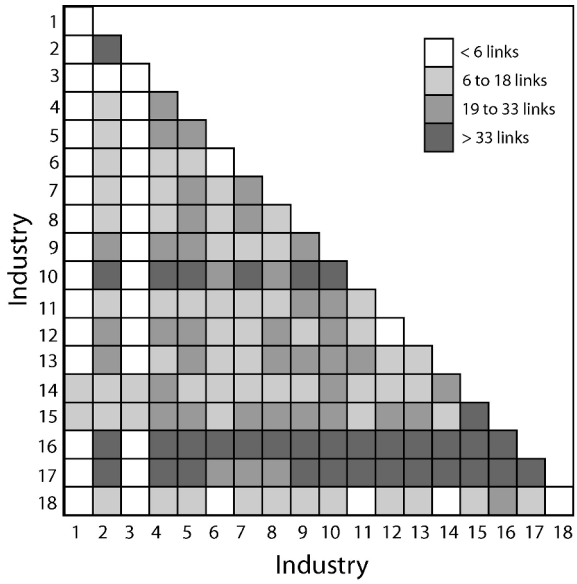
Industry	Linkages	Linkages per company
Agriculture products and services	13	6.50
Mining	476	14.42
Construction	30	4.29
Food and kindred products	421	11.38
Chemicals and allied products	468	10.88
Petroleum refining	235	13.82
Industry and commercial machinery	337	9.11
Transportation equipment	349	12.03
Paper, printing, and publishing	457	12.03
Other manufacturing	790	10.26
Transportation	283	11.32
Communications	317	15.85
Electric, gas, and sanitation services	421	8.77
Wholesale trade	308	5.60
Retail trade	481	6.59
Finance	1072	15.31
Insurance and real estate	879	11.88
Services	175	2.78

amounts of short-term capital. The concern for quick access to capital is diminished with a connection to a large bank. But the authors of this paper suggest that interlocks with banks can be explained by the fact that industrial corporations now require knowledge capital. In other words, the prosperity of a firm is no longer asset based, but knowledge based. Banks are an excellent source of knowledge on the general economic climate.

Communications and mining are extremely technical, resulting in a disproportionate amount of interlocking in these industries. The communications industry is highly competitive with increasingly shorter product lifecycles. On the other hand, mining firms are always searching for superior techniques for extracting resources. Knowledge through interlocks allows firms to stay in tune with essential developments in both of these industries. This provides companies with new knowledge necessary for competitive advantage.

Figure 2, a simplified coded table, explores this further through interindustry linkages. The four categories are separated into hinges. Hinges are similar to separating data into quartiles except that the median is used instead of the mean. Hinges are a synopsis of values in the middle of each half of a data set (Velleman and Hoaglin, 1981). It was determined that the median should be used because the linkages are not normally distributed across industries.

Figure 2 reveals how firms from almost all industries are extensively linked to finance as well as insurance and real estate. This is because banks, insurance companies, and real estate firms possess extensive knowledge on the general economic climate. On the other hand, we know from Table 2 that mining companies possess abundant linkages. But these



1. Agriculture products and services
2. Mining
3. Construction
4. Food and kindred products
5. Chemicals and allied products
6. Petroleum refining
7. Industrial and commercial machinery
8. Transportation equipment
9. Paper, printing, and publishing
10. Other manufacturing
11. Transportation
12. Communications
13. Electric, gas, and sanitation services
14. Wholesale trade
15. Retail trade
16. Finance
17. Insurance and real estate
18. Services

Fig. 2. Simplified coded table of American and Canadian industry interlocking, 1996.

linkages are concentrated within the mining sector. Mining companies would largely benefit from knowledge linkages to other firms in their industry. This will allow them to procure superior techniques for extracting resources.

As evident from Figures 3A and 3B, Eastern Canada and the Northeastern United States are the dominant locations for interlocking. Toronto is the most important with 1,090 total interlocks (13.63 per firm). New York City produces the next largest number of interlocks with a total of 815. However, New York City firms exhibit more interlocks per firm with 15.67 per firm. With a few exceptions, a hierarchical pattern emerges in Figure 3A. The top 20 cities account for over 71% of interlocking in Canada and the United States.

This map supports the notion that interlocks are initiated by and attracted to cities that are the most important for conducting business at the regional, national and global levels. As pointed out by Sassen (1991), the most important cities now function in four new ways. First, cities act as highly concentrated control points. Second, the most important cities are locations for finance and for specialized service firms. These industries have displaced manufacturing as the leading economic sectors. Third, these cities are sites of innovation. Finally, the most important cities are markets for the products and innovations produced.

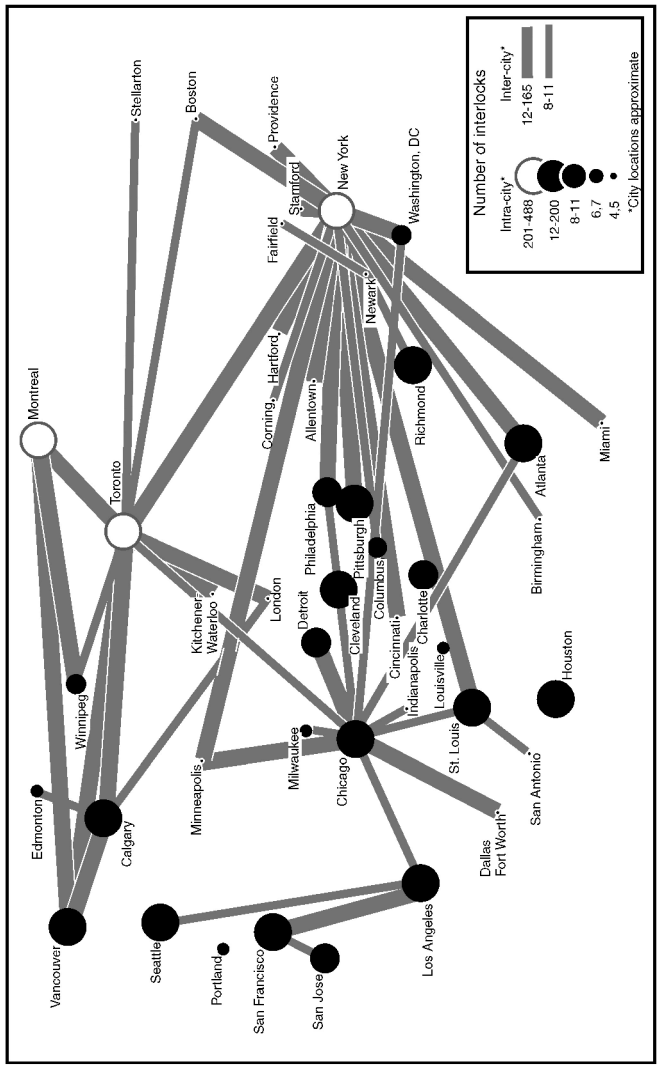


Fig. 3A. North American interlock network, 1996 (strongest links).

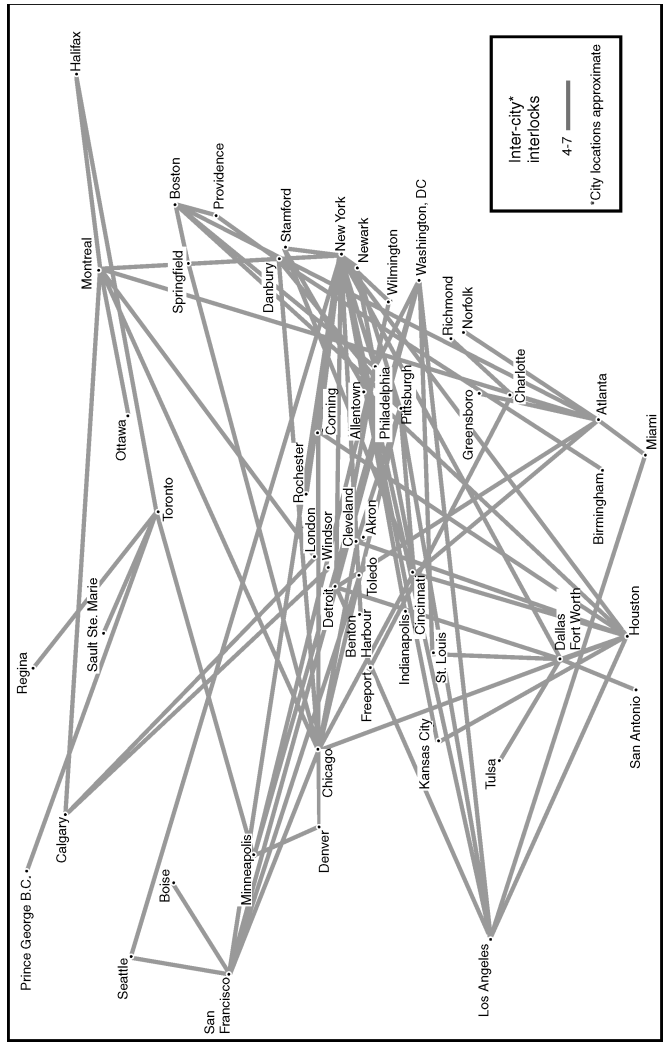


Fig. 3B. North American interlock network, 1996 (weaker links).

The top eight top cities in Figure 3A generally adhere to these four principles with respect to their domestic economies. In the United States, New York, Chicago, and Los Angeles are generally the three most important cities with respect to Sassen's four principles. The same holds true for the Canadian cities of Toronto, Montreal, and Vancouver.

The only exception in the United States, Atlanta, may be explained by its dominant position in southeastern United States. Figure 3B visually displays this importance. The data further verify the importance of Atlanta, which possesses 162 interlocks. The next most important metropolitan area in the U.S. Southeast is Richmond with 76 interlocks. In Canada, Calgary is an exception because so many companies want to tap into the knowledge in the oil industry that exists in that city. Of the 419 linkages with Calgary, 76% are associated with firms in the oil and gas industry. Following Malmberg (1996) and Morgan (1997), firms want to link to this metropolitan area because it is a crucial for new knowledge in this industry.

Figure 3B reveals regional hubs in the knowledge network. The importance of Atlanta, Houston, Los Angeles, San Francisco, Pittsburgh, Chicago, New York, Toronto, and Montreal is evident. This suggests regional metropolitan areas are fundamental to the transfer of tacit knowledge in the Canadian and American network.

SPATIAL INTERACTION MODEL

The aim of this paper is to explain how concentration and munificence of knowledge in cities and the interconnectedness of these cities influence interlocking directorates. By using a spatial interaction model, the paper seeks to answer two questions. First, what influence does distance have on interlocking between two cities? Second, what characteristics of cities promote the flow of knowledge between them?

The independent variables are tested on the three models previously mentioned where the dependent variable is the number of interlocking directorates between one metropolitan area and another. With interlocks focused among a small number of cities, a standard linear regression is not appropriate. The bulk of cities in the sample have a small number of interlocking directorates. In fact of the 7,512 interlocks that take place, one-third of the cities have less than 10 interlocks. Consequently, a combination of cities with numerous interlocks (such as the 165 interlocks between Toronto and Montreal) is rare. As a result, the dependent variables for Sample USA-CAN, Sample USA, and Sample CANADA possess a distribution that is highly skewed. This makes a poisson regression approach more applicable than a least squares approach (see Liao, 1994, pp. 70-79).

INDEPENDENT VARIABLES

Population

Large cities possess more social, economic, and political resources than smaller cities. This translates into a greater amount of existing knowledge. The snowballing of information and knowledge in larger cities procures more knowledge and thus results in more knowledge links. Firms want to associate with other firms in such centers where knowledge already exists. Following Pred's (1977) principle of circular cumulative causation, it seems logical that population and knowledge do not have a direct linear relationship. Fig-

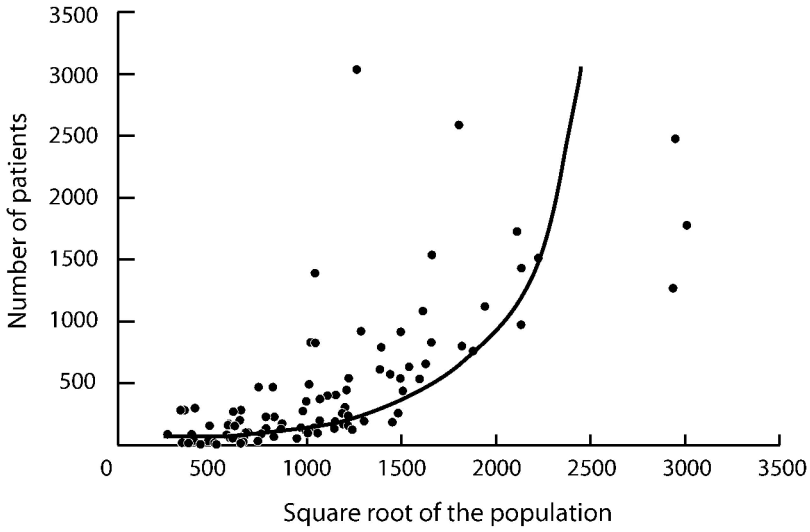


Fig. 4. Patents versus metropolitan population for the United States. *Sources:* U.S. Patent Office (1997) and U.S. Bureau of the Census (1996).

ure 4 reveals the relationship between patents (used here as a proxy for knowledge) and the square root of metropolitan area population for the United States in 1996. Testing produced a Pearson's correlation coefficient of $r^2 = .52$. From this, it is hypothesized that cities with large populations should be the focus of more interlocking activity than cities with small populations and this interlocking should expand at an increasing rate.

Headquarters

Similar to population, cities that contain a greater number of headquarters should be the best sites for the acquisition of strategic knowledge. When attempting to explain the increase in Japanese competitiveness during the 1970s and 1980s, Ohmae (1995) suggested that only a few firms guided by strong leaders were responsible for this incredible achievement. These individuals were an important component of a management team located at the firm's headquarters. Since firms want to tap into the knowledge that these people possess, cities with a greater number of headquarters should experience more interlocking. Of course, headquarters are highly correlated to population. But the two variables do display somewhat different patterns and therefore produce different results. The variable headquarters were obtained from *Corporate Affiliations Plus* (1997). In this data set, 717 firms were headquartered in Canadian cities and 12,641 were headquartered in American cities.

Metropolitan Area Growth

An economically expanding metropolitan area maintains the necessary climate for growth. Within this milieu firms and individuals either possess or learn the knowledge

essential to remain competitive today. External firms need to access this knowledge to determine what makes internal firms successful in this economic environment. To maximize profit (which is assumed to be the desire of all companies), firms must continually acquire the most recent techniques and processes. These techniques most likely exist in cities experiencing the highest rates of development. Metropolitan area growth was calculated as the population change from 1991 to 1996.

Industry Concentration

Michael Porter (1990) suggested that industries should try to obtain the knowledge that spills over between firms. He argued that local firms in the same industries should expand at a faster rate because geographically concentrated companies can learn from each other better than isolated ones. For example, it is certainly beneficial for a software development company to link to the knowledge that exists in Silicon Valley.

But today more than ever, firms use input from and produce output for diverse industries and locations. A metropolitan area where employment is distributed evenly over a number of sectors should contain knowledge in a wide array of industries. Jacobs (1969) and Glaeser et al. (1992) wrote that the most important knowledge transfers come from outside the core industry. As a result, neighboring firms producing a variety of products encourages innovation and growth. For example, if General Motors were to exclusively link to sources of knowledge in Detroit, the firm could fail to recognize shifting trends within the industry as it relates to suppliers and buyers.

The model needs to ascertain whether interlocks adhere to the theory proposed by Porter (1990) or the theory proposed by Jacobs (1969) and Glaeser (1992). This can be accomplished by using the coefficient of variation, which determines the relative variability between data distributions. Using industrial sector employment from U.S. Bureau of the Census and the Statistical Profile on Canadian Cities, the coefficient of variation was used to calculate the concentration of a metropolitan area's economy in particular industries. A greater coefficient of variation suggests greater concentration of employment in one industry. It is hypothesized that most firms in today's global economy cannot limit acquisition of tacit knowledge to certain areas possessing specific knowledge. It is important for firms to access a wide range of knowledge to remain competitive. Therefore, interlocks should be inversely related to industry concentration.

Research Institution Presence

Universities play an important role in the accumulation of knowledge at the metropolitan area level. They potentially contribute knowledge in two ways. First, they are a critical source of knowledge and learning activities. Second, they provide essential knowledge infrastructure. Since possessing both the physical and intellectual capital is tremendously beneficial it is hypothesized that interlocking will have a positive relationship with universities.

Based upon a number of components, *U.S. News and World Report* (1997) ranks American universities from Tier 1 to Tier 4. Tier 1 universities yielded the highest weight while Tier 4 universities yielded the least weight. Canadian universities are ranked by *Maclean's* magazine (1997). They are separated into three categories, Doctoral, Compre-

hensive, and Primarily Undergraduate. Universities with doctoral programs were given a rank similar to Tier 1 universities in the United States, Comprehensive a rank similar to Tier 2 firms, and Primarily Undergraduate a rank similar to Tier 3 universities. All universities and their weights were then amalgamated for a metropolitan area total.

Spatial Separation

From previous research it appears that interlocks have spatial attributes and spatial determinants. Saxenian (1994, p. 161) suggested, "geographic proximity promotes the repeated interaction and mutual trust needed to sustain collaboration." As a relationship develops, individuals build a basis for sustained trust that is conducive to the diffusion of knowledge. The hypothesis of this study suggests that the degree of knowledge transfer will decrease as distance increases. Spatial separation was calculated as the straight-line distance from metropolitan-area headquarters of one firm to the metropolitan-area headquarters of the second firm involved in the interlocking.

Finance, Insurance, and Real Estate (FIRE) Employment

An alternative explanation to resource dependency model is financial control. Similar to resource dependency, financial control suggests that firms need to maximize control over resources necessary to conduct business. But financial control essentially supports the notion that capital is the key input for large corporations to remain competitive in today's business environment. All firms require capital. Theorists suggest that the need for large amounts of short-term capital make industrial corporations dependent on financial institutions. The concern for quick access to capital is diminished with a connection to a large bank. By electing a banker to the board of directors, a company may expect to have more ready access to bank funds.

Previously access to large amounts of short-term capital made industrial corporations dependent on financial institutions. But today, large corporations can generate the necessary capital internally more easily. This poses the question, why would firms still place an emphasis on interlocking with financial institutions?

It is hypothesized by the authors that financial control model has undergone dramatic change in the "knowledge economy." In other words, interlocking with financial institutions has moved beyond the bank as a source of funding. This can be explained by the necessity for corporations to procure knowledge capital. As stated previously, banks by their nature are an excellent source of knowledge on the economic environment. Since borrowing and lending are contingent upon the overall economic climate, banks must be knowledgeable of this to turn a profit. This knowledge is what provides banks with a competitive advantage and more interlocking.

Two variables were created to measure the relationship between interlocking and financial services. First, percentage of employment in FIRE examines the concentration of a metropolitan area in finance, insurance, and real estate. It was calculated by dividing total employment in finance, insurance, and real estate by total employment for all industries. The second variable associated with finance and insurance is the number of chartered banks in a metropolitan area. The authors hypothesize that firms want to link to

cities that provide banking and investment services. Therefore, both variables should be positively associated with interlocking.

Region

Storper (1997) suggested that the region is now the fundamental basis of obtaining knowledge. Providing the example of the Hollywood entertainment industry, Storper argues that firm interdependence within a region can result in (among other things) greater knowledge and information transfer.

The variable region is defined as an interlock to the largest metropolitan area of a region. A dummy variable was created where those interlocks to the largest metropolitan area were coded 1, and 0 otherwise. By interlocking to the largest metropolitan area, firms are able to secure tacit knowledge on the regional market. Knowledge in the largest metropolitan area should be more plentiful than any other metropolitan area within the region. Interlocking to the largest cities in the eight U.S. census regions was used as the level of measurement for the United States. For Canada, a director was considered interlocked if he was connected to the largest metropolitan area of the province.

EMPIRICAL RESULTS

For comparison purposes, two models from each of the three samples are presented in Table 3. Results for Sample USA-CAN produce r^2's of .50 and .54. All estimated coefficients have the expected sign with the exception of industry concentration. The results suggest that interlocks are likely to increase as metropolitan-area population, metropolitan-area growth, research institution presence, and finance and insurance presence increases. The largest metropolitan area in the region is likely to have a positive relationship with interlocking as well. Although not indicated in Table 3, statistical testing verified that headquarters and banks also maintained a positive relationship with interlocking.

The only variable with a negative relationship on interlocking is distance. This is of particular interest from a geographer's perspective. The negative relationship shows that firms interlock with other firms in the immediate area. Interlocking with regional firms provides important knowledge on the local economy where a majority of their suppliers and buyers are located. This consideration is verified by the fact that firms interlock with other firms in the largest metropolitan area of the region.

Unfortunately the spatial interaction models were unable to determine with any degree of certainty whether industry concentration was negatively or positively associated with interlocking. The results suggest that some firms adhere to the principles put forth by Porter (1990) and link to metropolitan areas that concentrate in similar production to their own. Alternatively, other firms adhere to the principles put forth by Jacobs (1969) and Glaeser et al. (1992) by linking to metropolitan areas that contain knowledge in a wide array of industries.

To resolve the conflicting results, the residuals produced by industry concentration were examined. All models (not only Sample USA-CAN but also Sample USA and Sample CAN) in Table 3 drastically underestimate metropolitan areas with large linkages. Since these linkages generally occur in large metropolitan areas, we argue that the impor-

TABLE 3.—POISSON REGRESSION RESULTS, CANADIAN AND AMERICAN INTERLOCKING, 1996

	Sample USA-CAN		Sample USA		Sample CANADA	
Variable[a]	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Population 1	1.211*		1.139*			2.386
Population 2	0.796*		0.681*			2.047*
Headquarters 1					1.892*	
Headquarters 2					2.209*	
FIRE as % of Employment 1	1.642*	1.987*	0.992*		2.169*	
FIRE as % of Employment 2	0.873*	0.524*	2.247*		0.476	
Industry concentration 1	5.133*	5.139*	–1.101**		1.843*	
Industry concentration 2	–2.049*	–2.075*	-0.625		–4.648*	
Region	0.807*	0.661*	0.438*	0.447*	–0.416*	–0.299*
Population change 1	0.045*	0.039*		0.012*		0.004
Population change 2	0.015	0.011*		0.003*		0.008*
University presence 1		1.228*		1.093*		
University presence 2		1.232*		1.071*		
Distance	–0.653*	–0.628*	-0.62300	-0.617	–0.434	–0.424
Constant	–16.467*	–6.118*	–8.564*	1.165*	0.544	–23.068*
Log likelihood	–4190.807	–3930.808	–1910.729	–1913.170	–285.927	–697.859
LR chi2(10)	8560.000	9079.990	4078.380	4073.490	5240.330	4416.460
Prob>chi2	0.000	0.000	0.000	0.000	0.000	0.000
Pseudo R2	0.500	0.540	0.520	0.520	0.900	0.760

[a]Under variables: 1 indicates origin city; 2 indicates destination city.
*$p > .01$. **$p > .05$. ***$p > .10$.

tance of dispersion is overwhelmed by the sheer quantity of knowledge that exists in these large urban centers.

Sample USA results (American interlocking) are broadly similar to those estimated for Sample USA-CAN. Table 3 reports two r^2's of .52. These models suggest that domestic interlocking in America will increase as metropolitan-area population, metropolitan-area growth, research institution presence, and finance and insurance presence increases. The largest metropolitan area in the region is likely to have a positive relationship with interlocking as well. Once again, the number of headquarters located in a metropolitan area, and the number of banks maintained a positive relationship with interlocking but were not revealed in the best models.

Distance and industry concentration were inversely related to interlocking. The inverse relationship with industry concentration would suggest that American firms are more

likely to interlock to cities with a dispersed economy. Care should be taken when making this conclusion though because the relationship was only significant at the 0.10 level.

Poisson regression models for the Sample CANADA (Canadian interlocking) are also displayed in Table 3. They yield r^2's of .90 and .76. Interlocks increase as metropolitan-area population, the number of headquarters located in a metropolitan area, population change, and finance and insurance presence increases. On the other hand, distance and region are inversely related to interlocking.

Once again it is difficult to determine if a definite relationship between interlocking and industry concentration exists. While one of the industry concentration variables retains a positive relationship, the other maintains a negative relationship. Unfortunately, it is difficult to construct a number of models for the Canadian sample because the variables headquarters, population, total FIRE employment, university presence, and banks all maintained an intercorrelation greater than 0.8. In testing though, all five variables maintained a positive relationship with interlocking.

The negative relationship for region is surprising. This can be explained if we explore the strength of the independent variables between samples. In Sample USA-CAN and Sample USA the negative influence of the variable distance was stronger than for Sample CANADA. In other words, distance was not as much of a deterrent for knowledge transfer in Canada. In addition, interlocking in Sample CANADA possessed a much stronger relationship with metropolitan area population than it did in Sample USA and Sample USA-CAN. Thus, tacit knowledge transfer in Canada was greatly influenced by city size.

These results suggest a hierarchical interlocking structure in Canada. Distance is still an important determinant of interlocking in Canada because of intra-city interlocking. In fact, in Canadian cities with more than five interlocks, the intracity link was most prevalent in seven of the nine Canadian cities. This suggests that obtaining tacit knowledge on the local market is important to Canadian firms. But the results also imply that regional structures of interlocking are nonexistent in Canada. We propose that this is attributable to a knowledge threshold essential for the transfer of tacit knowledge.

A knowledge threshold is an area that must be encompassed to ensure adequate knowledge. In this instance, the knowledge threshold is the minimum distance required to obtain knowledge necessary to make qualified business decisions. In Canada, the knowledge threshold encompasses the entire country. Here, distance is overwhelmed by two things. First, the dispersed Canadian economy makes it necessary to obtain knowledge at an increased geographic scale. Second, a smaller base population of reputable and accomplished professionals is only available over a greater geographic area. Therefore, firms must extend interlocking further distances to obtain the tacit knowledge possessed by these individuals. From Figure 3A and Figure 3B, it is possible to argue that the only concentrated interlocking in Canada occurs in southern Ontario. After the local metropolitan area, tacit knowledge transfer will occur in the largest metropolitan areas with distance being immaterial.

On the other hand, the network of interlocking has developed more extensively in the United States. Figures 3A and 3B suggest the flow of tacit knowledge is more regionally based and widely distributed in the United States when compared to Canada. A greater number of headquarters, research institutions, and banks allow American firms to link shorter distances to obtain the knowledge necessary for sound business decisions. This is verified by the inverse relationship of interlocking with distance and the positive relation-

ship with the variable region in Sample USA. In addition, large regional populations do not force firms to procure knowledge over greater distances. A large pool of capable directors is available at shorter distances. Hence, the knowledge threshold in America is much shorter.

CONCLUSIONS

The main goal of this research was to develop a spatial component of the resource dependency model. This was accomplished by using variables that measure knowledge existing at the metropolitan-area level. Results support the resource dependency theory. All poisson regression models verified that interlocks increase as metropolitan-area population, number of headquarters located in a metropolitan area, metropolitan-area growth, research institution presence, and finance and insurance presence increases. These results suggest that firms want to access knowledge-rich metropolitan areas. As stated earlier, firms are unable to generate all the necessary inputs for production. They respond with relationships to external elements of the environment to ensure a supply of the required resources and decrease uncertainty. Perhaps the most important source is knowledge. By linking to knowledge-rich metropolitan areas, firms ensure a supply of the most important resource.

The data were then divided into Canadian (Sample CAN) and American (Sample USA) interlocking. We hypothesized that different spatial patterns and economy ages influence the level of interlocking. In other words, the spatial patterns and metropolitan area characteristics influencing knowledge transfer in Canada and the United States are different. Poisson regression models verified our expectations. Examining the sign of coefficients suggests that the only difference between Canada and the United States is region. When combined with results of the variables distance and population, a significant distinction emerges between Canada and the United States. It appears that distance is less likely to discourage tacit knowledge transfer in Canada than in the United States. We argue this is due to the fact that the knowledge threshold in the United States is geographically condensed when compared to Canada.

Figures 3A and 3B further this argument. One can see that Canadian interlocking was highly concentrated in four cities (supported by the r^2 of .90): Toronto, Montreal, Calgary, and Vancouver. Of total interlocking that took place in Canada, 85% was inclined to take place in these four cities. On the other hand, while New York City was the most important origin and destination for interlocking in the United States, the top 20 cities account for less than 70%. This suggests that tacit knowledge transfer, and thus knowledge creation, takes place primarily in a few geographically dispersed cities across Canada. American interlocking is more diversified and scattered.

This paper is a foundation for future research on the spatial dynamics of interlocking, and thus tacit knowledge transfer. Since this research suggests a geographical threshold, the next step is to verify if one does exist. From Figures 3A and 3B it appears that knowledge transfer is a spatially complex phenomenon. But it also reveals that knowledge transfer is associated with the region. A network analysis would allow a more appropriate identification of prime cities existing within distinctive regions of the United States and Canada. It also allows for the recognition of any existing hierarchical patterns. Further, a longitudinal study on interlocking allows for the examination of the concept of a knowl-

edge threshold over time. Has the knowledge threshold expanded or contracted over time? How do changes to the Canadian knowledge threshold compare to changes to the American knowledge threshold? The theoretical concept of the knowledge threshold is interesting because it introduces additional questions to be answered.

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