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Horizontal Co-optation through Corporate Interlocks

by

Peter J. Carrington

A Thesis submitted in conformity with the requirements
for the Degree of Doctor of Philosophy in the
University of Toronto

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SCHOOL OF GRADUATE STUDIES

PROGRAM OF THE FINAL ORAL EXAMINATION

FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

OF

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Room 309, 63 St. George Street

HORIZONTAL CO-OPTATION THROUGH CORPORATE INTERLOCKS

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Horizontal Co-optation through Corporate Interlocks

ABSTRACT

This thesis analyzes the relationships among industrial concentration, directorship interlocking, and industrial performance in the Canadian economy.

The research reported here is an empirical test of the proposition that directorship interlocks are a mechanism of oligopolistic co-ordination in Canadian markets: i.e. that directorship interlocks are one method used by business enterprises operating in oligopolistic markets to co-ordinate their production and pricing decisions, thereby increasing their joint power over the operation of those markets and their joint maximization of self-interest, as indexed by market profit levels. This proposition is tested by path analyses based on the following three hypotheses: (1) that directorship interlocking in a market increases with market concentration, (2) that market profit levels increase with horizontal interlocking, and (3) that horizontal interlocking explains part of the variation in market profit levels previously attributed to concentration. The tests are performed using data on profits and concentration in 1972 for all enterprises operating

in 30 "market areas" (comparable to S.I.C. two-digit industries) including most industries in the logging, mining and manufacturing sectors of the Canadian economy, and on directorship interlocking in 1972 among a sample of 5306 firms representing all major Canadian economic activity.

The results of the path analyses strongly suggest that directorship interlocking is indeed a mechanism of oligopolistic co-ordination. In the 22 market areas where horizontal interlocking exists, variation in the density of this interlocking explains 30% to 40% of the variation in profit levels previously attributed to concentration. In all 30 market areas that were analyzed, the density of a combination of horizontal interlocking and interlocks between banks and enterprises operating in these market areas (the latter of which is highly correlated -- R=0.97 -- with bank-mediated indirect horizontal interlocking) explains <u>all</u> of the variation in profit levels previously attributed to concentration.

Ronald Burt's research on vertical corporate interlocks in the U.S.A., has provided excellent circumstantial evidence that such interlocks have co-optive intent: that they are established by those who control business establishments in an attempt to co-opt other establishments that constitute problematic elements of their environments. The present study answers affirmatively two important questions that are raised by Burt's results: (1) Do <u>horizontal</u> interlocks have a similar purpose? and (2) Are they successful? -- do they in fact facilitate the co-optation of problematic others, thereby increasing organizational effectiveness? Thus the present study provides strong additional evidence for the applicability of the theory of interorganizational co-optation to directorship interlocks.

More concretely, this study shows that horizontal directorship interlocking has a strong effect on relative profit levels in Canadian industries, whether or not the effect of concentration is taken into account. Thus directorship interlocking, whose importance has until now been regarded with skepticism by most economists, appears to be a major explanation of the connection between concentration and profits, which has been well established in the industrial organization literature but is still poorly understood. This relationship between interlocking, concentration and profits has important anti-combines policy implications, especially in a country such as Canada, where it is often argued that industrial concentration is an inescapable by-product of the corporate bigness necessary for international competitiveness.

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"A flexible design for a corporate information data system."
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(with S.D. Berkowitz, Y. Kotowitz and L. Waverman)
"Economic structure and market power in Canada."
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(with S.D. Berkowitz, Y. Kotowitz and L. Waverman, and with B. Becker, R. Bradford, J. Corman, and G.H. Heil)
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Table of Contents

List of Tables

List of Figures

CHAPTER 1

Introduction

Although we now know a great deal about the structures of of corporate interlocks in industrial capitalist societies, and about the reasons for those structures, next to nothing is known about their consequences. This dissertation is intended to begin to remedy that situation by demonstrating the role that directorship interlocks play in Canadian industrial organization.

Specifically, the research reported here is an empirical test of the proposition that directorship interlocks are a mechanism of oligopolistic co-ordination in Canadian markets: i.e. that directorship interlocks are one method used by business enterprises operating in oligopolistic markets to co-ordinate their production and pricing decisions, thereby increasing their joint power over the operation of those markets and their joint maximization of self-interest, as indexed by market profit levels. This proposition is tested by path analyses based on the following three hypotheses: (1) that directorship interlocking in a market increases with market concentration, (2) that market profit levels increase with horizontal interlocking, and (3) that horizontal interlocking explains part of the variation in market profit levels previously attributed to concentration. The tests are performed using data on profits and concentration in 1972 for all enterprises operating in 30 "market areas" (comparable to S.I.C. two-digit industries) including most industries in the logging, mining and manufacturing sectors of the Canadian economy, and on directorship interlocking in 1972 among a sample of 5306 firms representing all major Canadian economic activity.

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Burt's research on vertical corporate interlocks in the U.S.A. (1979a; 1979b; 1979c; 1980; Burt et al. 1978; 1979) has provided excellent circumstantial evidence that such interlocks have co-optive intent: that they are established by those who control business establishments in an attempt to co-opt other establishments that constitute problematic elements of their environments. The present study answers affirmatively two important questions that are raised by Burt's results: (1) Do horizontal interlocks have a similar purpose? and (2) Are they successful? -- do they in fact facilitate the co-optation of problematic others, thereby increasing organizational effectiveness? Thus the present study provides strong additional evidence for the applicability of the theory of interorganizational co-optation to directorship interlocks.

More concretely, this study shows that horizontal directorship interlocking has a strong effect on relative profit levels in Canadian industries, whether or not the effect of concentration is taken into account. Thus directorship interlocking, whose importance has until now been regarded with skepticism by most economists, appears to be a major explanation of the connection between concentration and profits, which has been well established in the industrial organization literature but is still poorly understood. This relationship between interlocking, concentration and profits has important anti-combines policy implications, especially in a country such as Canada, where it is often argued that industrial concentration is an inescapable by-product of the corporate bigness necessary for international competitiveness.

This study also has several methodological conclusions. It demonstrates that a scalar variable summarizing the internal structure of units of analysis (i.e. the density of interlocking within market areas) can successfully be employed in regression equations based on those units. It compares the effects of types of interlocking differing on both the market relationship of the firms involved and the affiliations of the interlocker with those firms. It compares the effects of different indices of interlocking in market areas and tentatively concludes that simple density is the best index. Finally, it suggests the importance of measuring interlocking between enterprises -- groups of firms operating under common control -- rather than between firms considered individually.

The dissertation is organized in the standard format of an empirical research report. Chapter 2 reviews the literature on co-optive interlocking in order to show the motivation of this research. Chapter 3 develops the detailed model to be tested. Chapters 4 through 7 describe the operationalization of the key concepts in the model. Chapter 8 describes the results of the path analytic tests of the model, and Chapter 9 summarizes the conclusions and implications of the study.

CHAPTER 2

Theory of co-optive directorship interlocks

The existence of structured corporate interlocks is plausibly explained by the theory of interorganizational co-optation. This theory was first proposed by Selznick in his study of the Tennessee Valley Authority (1949), who observed that organizations attempt to "co-opt" problematic organizations in their enviroment by appointing a representative of the problematic organization to an advisory or decision-making board of the co-opting organization. This is one of a variety of strategies used by interdependent organizations to manage their interorganizational relationships (Evan 1966; Thompson 1967).

This theory, as stated, is so general in its terms, and "obvious" in its main claim, that it has been criticized as "both vague and potentially tautological" (Ratcliff 1980: 556). In fact, however, even at this level of generality, the theory makes two significant contributions to an understanding of interorganizational relations. First, its imagery of interdependent organizations co-operating to their mutual benefit is implicitly opposed to the imagery of classic liberal individualism: a universe of unconnected atomistic individuals striving to realize self-interest in opposition to one another. Though interorganizational co-optation applies to all institutional spheres, the importance of this opposition is especially clear in the economic sphere, where the imagery of competitive individualism is overwhelmingly dominant in neoclassical economic theory. Second, the theory of interorganizational co-optation makes the theoretically important and empirically testable claim that co-optive relationships tend to occur between organizations where at least one is problematic for the other. For example, Thompson (1967) has defined problematic organizations as those that control scarce resources needed by the focal organization; thus empirical tests of the theory can be constructed by identifying such resources and organizations, and measuring the relative frequency of ties with these organizations.

2.1 Co-optive interlocking directorships

This theory has been used to explain the occurrence of interlocking directorships by Allen (1974), who argued that much of the previous, rather atheoretical, empirical research on interlocking directorates was implicitly based on the assumption that they are a co-optive strategy used by interdependent corporations. Allen has reinterpreted the major findings of earlier interlock studies in the light of this theory.

One ubiquitous finding in these studies is that the number of firms to which a firm is interlocked is related to its size (Warner and Unwalla 1967; Dooley 1969; Pfeffer 1972; Allen 1974). Allen's explanation for this is that large firms "are often the major suppliers or consumers of a particular resource and, therefore, represent a major source of uncertainty for other corporations" (1974:395). Pfeffer (1972) has also noted that large firms typically have more diversified external relationships and, therefore, need more co-optive relationships. Similarly, the universal finding that financial firms are more highly interlocked than nonfinancial firms (Warner and Unwalla 1967; Dooley 1969; Pfeffer 1972; Allen 1974; Waverman and Baldwin 1975; Bearden et al. 1975) is explained by Allen by the fact that "capital is a very generalized resource with a very dispersed demand" (1974:395); he cites Galbraith's comment that "no form of market uncertainty is so serious as that involving the terms and conditions on which capital is obtained" (1967:50). The negative correlation between management control of a firm and its number of interlocks has been explained by Dooley (1969) in terms of the desire of the management-controlled board to <u>avoid</u> co-optation by external agencies.

Allen has proposed and tested many other hypotheses concerning the relationship between the number of a firm's interlocks and the environmental contingencies that it faces. However, as Fennema and Schijf (1979) and Burt (1979a) have pointed out, this kind of research that analyzes determinants of the number of interlocks of a single firm, is insufficiently precise to constitute a proper test of the co-optation theory of interlocking directorates.

2.2 Systemic co-optive interlocking directorships

The theory of interorganizational co-optation claims that organizations co-opt other organizations that are problematic for them. Thus an adequate test of this theory in application to interlocking directorships requires analysis of the <u>structure</u> of these interlocks: do they in fact exist between firms that are problematic for one another? Large firms and banks, the heavy interlockers, may or may not be problematic for the particular firms with which they are interlocked. As Ratcliff has argued (1980:556), this style of research has assumed a "basically atomized organizational set ... such an individualized approach does not appear to do justice to the problem." In a recent series of papers, Burt (1979a; 1979b; 1979c; 1980; Burt et al. 1978; 1979) has proposed and carried out such a test. He begins by assuming that the major organizational goal of a corporation is maximization of profits. Two major constraints on a firm's profits are the prices it pays and receives for its inputs and outputs respectively (Burt's model doe not deal with a third major economic constraint, the cost of capital, and does not deal directly with interlocks with financial firms). Thus three major sets of potentially problematic firms for the focal firm are those two sets to which it is "vertically" related (i.e., those from which it can buy its inputs and those to which it can sell its outputs) and the set to which it is "horizontally" related (i.e. those with which it is competing to purchase inputs and sell outputs).*

Although a firm may actually buy from a certain subset of potential suppliers and sell to a certain subset of potential consumers, all firms selling its input goods and all firms buying its output goods are potentially problematic, since the production and pricing decisions of all actors in a market (subject to their relative size) affect market prices, and, since the possibility always remains open of varying its particular suppliers and consumers. Thus, in the network of intercorporate sales and purchases, or commodity flows, all firms that produce similar goods (classified by economists as a <u>sector</u> or <u>industry</u>) are "structurally equivalent" (White et al. 1976) and form a "jointly occupied position" which has a

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*The terms "vertical" and "horizontal" are used in economics to refer to relative positions in the chains of production, which often involve several intermediate firms, from raw materials to finished products. Vertically related firms are at different levels of the same production chain; horizontally related firms are at the same level and are therefore in competition to buy their similar inputs and to sell their similar outputs.

characteristic commodity-flow tie to the position consisting of all firms that consume those goods. Hence, the Leontief input-output table for an economy is a "blockmodel" (White et al. 1976) with real-valued edges, in which industries are nodes and inter-industry commodity flows are edges. Since an industry may, and often does, buy inputs from multiple industries and sell outputs to multiple industries, a focal position will have multiple potentially problematic supplier positions and multiple potentially problematic consumer positions in addition to itself as the locus of potentially problematic competition.

The degree to which a potentially problematic position is actually problematic depends upon the market structure,* (or degree of competitiveness) of each of the positions involved. According to the neoclassical theory of competition in markets, the actions of a given firm in a market do not affect the market price if the market is purely competitive. However, if the market is <u>concentrated</u> -- i.e. there are relatively few large firms that dominate sales in the market -- then their actions do affect market price. Furthermore, if a focal industry buys inputs from many supplier industries or sells to many consumer industries, its profits are less affected by any one of

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*This term is used here in the sense that is standard in the economic industrial organization literature. This and other industrial organization concepts used in this chapter are discussed at more length in Chapter 3 below.

those industries. Thus the degree to which a vertically related industry is problematic for a focal industry depends upon the volume of transactions, the market structure (competitiveness) of the vertically related industry, and the diversity of vertically related industries vis-a-vis the focal industry.

Since the theory of interorganizational co-optation claims that co-optive ties are attempts to deal with problematic others, Burt is able to test the theory in application to putatively co-optive ties between firms by measuring the degree to which the existence of these ties between industries is in fact associated with inter-industry problematicity, measured as above.

With respect to directorship interlocks, the focus of the present study, Burt finds that his model is successful in predicting co-optive ties between vertically related industries (Burt et al. 1979:26-27). However, he finds that, contrary to his hypothesis, directorship interlocks tend markedly <u>not</u> to occur between competing firms. He suggests that this may be due to (U.S.) government anti-trust regulation or to a too-broad definition (two-digit S.I.C. groups) of sets of competing firms, and concludes that "intraindustry co-optation clearly remains an issue to be explored in subsequent research" (Burt et al. 1979:28).

Another explanation for Burt's failure to find a relationship between horizontal relationships and co-optive interlocks is that he has failed to take into account the effect of the market structure (competitiveness) of the focal market. For vertical relationships, Burt hypothesized that the market structure of the vertically related industry affected its problematicity for the focal industry. One would expect the same to hold true for the horizontal case. In a perfectly competitive industry, the actions of other competing firms have no effect on the prices experienced by the focal firm; hence they are not problematic for it. But in a concentrated industry, the actions of competing firms do affect prices; hence competitors are problematic for the focal firm (Pennings 1976:2-3). Burt should have hypothesized that horizontal interlocking varies with concentration, rather than simply that it is always relatively high (1979a:422; Burt et al. 1979:8). I have taken the latter approach in the present study.

2.3 Consequences of co-optive interlocking.

Conceived very narrowly, the theory of interorganizational co-optation claims merely that co-optive relationships are an <u>attempt</u> (Allen 1974:393) made by organizations to manage problematic elements of their environment. On this reading, a sufficient test of the theory consists in demonstrating that apparently co-optive relationships occur where a rational actor would be expected to create them -- i.e. with problematic others -- as Burt has demonstrated in the case of vertical interlocking, for example. This is essentially a theory of motivation in which interorganizational ties are explained by the imputed motives of the organizations (or whoever controls them) that create the ties.

However, many writers have interpreted the theory more broadly as claiming that not only do these ties represent an attempt at co-optation, but also that the attempt is at least partially successful. In this interpretation, interlocks are the means by which organizations do co-opt elements of their enviroments, rather than merely attempting to. This distinction has not, to my knowledge, been made explicitly, but has very important consequences for empirical research. To demonstrate that these ties do enable organizations to manage their environments more effectively, one must show not only that they exist where they are expected to exist, but that they result in some increase in "organizational effectiveness", as the organizational literature terms an organization's success in attaining its goals.

Failure to demonstrate that putatively co-optive ties have consequences relegates them to the status of scientific curiosities: interesting, and now explicable, phenomena that have no social importance whatsoever. This has been the position of managerialist skeptics who argue that management control and financial autonomy of large modern firms make co-optive interlocking unnecessary (Gordon 1966; Rose 1967;

Galbraith 1967). The answer to this skeptical position that is implicit in much of the research showing the empirical patterns of interlocks, and made explicit by Allen (1974:404), is that

> the coherent structure of corporate interlocking and its stability through time suggest, to the contrary, that interlocking directorates are an important and significant feature of the corporate economy.

However, this begs the question of whether interlocks are "important and significant" simply because, like Mount Everest, they are *there*, or because they have some important social consequences. Similarly, Scott's argument that "persistent practices [i.e. corporate interlocking] persist by virtue of their functions" (1979:101) requires the question - "What functions?" Do corporate interlocks perform the relatively insignificant function of providing prestigious window-dressing to corporate boards, as the managerialists argue, or the very important co-optive function ascribed to them by the theory of interorganizational co-optation?*.

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*Interlocks between *banks* and industrial corporations have been found to form bank-centred clusters in several industrial capitalist economies, including that of Canada (Carroll et al. 1977). This has been taken as support of Hilferding's (1913 [1910]) theory of the domination of industrial capital by financial capital. Niosi (1978) has argued convincingly on historical grounds, and from the lack of ownership ties, that banks do not dominate Canadian industry. The alternative explanation explored here is that banks are key elements in intercorporate co-optation--both bank-industrial co-optation and bank-mediated industrial-industrial co-optation.

The inability of researchers working in the interorganizational paradigm to demonstrate that corporate interlocks do have co-optive effects justifies Ratcliff's rather harsh criticism that

> what is largely missing is any attempt to demonstrate whether interlock patterns, and more specifically the structures of private economic power embodied in such patterns, lead to consequences of substantial importance for the larger society (1980:554).

Ratcliff finds this especially disappointing in view of the fact that research on corporate interlocks was originally motivated by very important questions about their significance for power in society as a whole (Hilferding 1923 [1920]; Brandeis 1913; Mills 1956).

On the other hand, a demonstration that corporate interlocks are successfully co-optive, that they do improve the organizational effectiveness of corporations, would both support the theory of interorganizational co-optation and establish the significance of interlocks in discussion of issues of social power. Organizational effectiveness in interorganizational relations, or the ability of an organization to attain its goals in dealings with other organizations, is in fact synonymous with power as Weber defined it, and the broad social range of the power of business organizations is undisputed.

The need for research on the consequences of corporate interlocks has not gone entirely unnoticed. Pennings has noted that "there is surprising little systematic research on the consequences of interlocking directorates" (1978:17), and has advocated research on the antecedents and consequences of horizontal, vertical and financial interlocks (1978:5, 19-23). Similarly, in a review of his own research on intercorporate co-optation, Burt has called for further research on the anticompetitive consequences of apparently co-optive ties:

> Perhaps more important than the actual understanding of how co-optation operates, although difficult to address without such an understanding, are the consequences of co-optation....The immediate question raised by our results is whether or not such patterning of co-optive relations is capable of eliminating market constraints. Merely attempting to co-opt market constraints is not equivalent to eliminating the constraints...[if co-optation is not effective] then the original impetus for researching co-optive uses of directorates as a menance to the free market is lost (Burt et al. 1979:29-30).

Indeed, Burt tested the hypothesis that co-optive diversification ties affected industry profit rates (an indicator of market power or effectiveness) and found no evidence to support it (1980). Although his original research design for the study of co-optive directorship interlocks also proposes to test the hypothesis that they affect profit rates (1979a:424), his later reports on the research (1979b; Burt et al. 1979) do not mention this hypothesis; so one does not know whether it was tested, and with what results. Presumably one is safe in assuming that confirmation of the hypothesis would have been reported.

Relative profit rates are an obvious index of the effectiveness or market power of corporations because the primary (according to many, the only) goal of business organizations is the maximization of profits. Ratcliff has criticized the use of profit rates as an indicator of the significance of interlocking, arguing that although they

> are relevant to an understanding of the ability and success of firms in seeking to maximize their own interest...[and] also provide a standard for examining the ability of firms and groups of firms to accumulate concentrations of capital...[and] are directly relevant to the issue of what forces motivate organizational behaviour...corporate profits are not clearly related to the theoretical and substantive questions concerning the societal effects of private economic power that originally motivated most studies in this area (1980:555,557).

One can only wonder, in answer to Ratcliff's objection, what theoretical and substantive questions he has in mind. Surely, Brandeis, Mills and Hilferding, not to mention Adam Smith, Karl Marx, and almost any modern political economist or sociologist you would care to name, would agree that questions about the "societal effects of private economic power" cannot be answered satisfactorily without understanding "what forces motivate organizational behaviour" or the ability of firms to collude and thereby "maximize their own interests" and "accumulate concentrations of capital"-- issues that Ratcliffe agrees are addressed by relating profit rates to interlocking.

This point is well argued in Ornstein's review of P. Marchak's In Whose Interests, a recent book on power in the Canadian economy. Ornstein argues that

> [this book's] contention that corporations are primarily interested in increasing their power, not with accumulating capital, removes the need for an economic theory. In my view, she presents no convincing evidence that the pursuit of power supercedes the profit motive....One might, at first glance, be skeptical that the objectives of corporate power and profit need ever conflict, especially if the definition of power is tied to assuring the social and political conditions for long-term profitability. This substitution of power for profit motivation, does, however, have important consequences, for it removes the possibility of understanding the growth of the Canadian, or any other, capitalist economy (1980:318).

2.4 Summary

Application of the theory of interorganizational co-optation, narrowly interpreted, to corporate interlocking results in the prediction that interlocks should occur between pairs of firms where at least one is problematic for the other. Early research, implicitly or explicitly within this paradigm, provided some support for this theory by demonstrating that firms that are likely to be generally problematic tend to be relatively highly interlocked. This research was limited by its individualistic or atomistic approach to an inherently relational or structural problem. Burt's excellent system-level research on co-optive interlocking in the U.S.A. demonstrated that vertical interlocking between industries is clearly explicable in terms of this theory.

Implicit in the theory of co-optation is the idea that it is at least partially successful: i.e. that it has significant consequences. Otherwise, co-optive interlocking is merely a scientific curiosity. Therefore, it is necessary to demonstrate both that interlocks occur with problematic others, and that they increase organizational effectiveness, or power. Profit rates are an obvious indicator of business effectiveness in markets, or market power, since they show a firm's ability to achieve its primary goal (profit maximization) and also its ability to accumulate capital, which is a mainspring of social power in capitalist societies.

The present study begins where Burt left off. Burt was unable to demonstrate that horizontal directorship interlocks had co-optive intent, and was unable to find a relationship between profits and any form of co-optive intercorporate ties. In this study, I focus exclusively on horizontal interlocks. I hypothesize that horizontal directorship interlocks increase with the inter-problematicity of competing firms, which is related to industrial concentration; and that profits increase with horizontal interlocking. Thus horizontal interlocking is hypothesized to be an intervening variable between concentration and profits: actors in oligopolistic industries are able to collude via directorship interlocks to jointly maximize profits. This conceptual framework is developed at length in the next chapter.

CHAPTER 3

Conceptualization

If economic power is defined as power that is exercised through economic institutions, then there is a wide variety of kinds of economic power, ranging from the ability to influence people to buy a particular kind of toothpaste to the ability to destabilize national governments. In this study of the effects of interlocks on economic power, I am looking at only one kind of economic power, namely market power, or the ability to influence the operation of economic markets. A model has been developed by economists working in the area of "industrial organization" to analyze the effects of various factors on market power. Because this model is appropriate to the problem at hand, because it is readily amenable to quantitative analysis, and because an enormous amount of research has been done by economists within the framework of this model since its creation forty years ago, I have adopted it for the present research. In this chapter I describe the industrial organization model and relate it to the theory of interorganizational co-optation. I then develop specific hypotheses relating interlocks to market power. The following account of the industrial organization model is based mainly on standard industrial organization textbooks by Bain (1959) and Scherer (1970) and review of the field by Weiss (1971).*

The neoclassical theory of markets assumes a large enough number of competing sellers (and buyers) that are small enough relative to the market that no actor is able to affect total supply or demand, and therefore prices, to its own advantage. In the real world of modern industrial capitalism, many markets deviate significantly from this model. The most dramatic deviation is the monopoly, a market where there is only one seller (or the monopsony, with only one buyer). With no one competing to supply the market, the monopolist can restrict supply and raise prices (or buyers will bid them up) above the level that would exist in a competitive market - subject only to his own production cost parameters and the fact that if prices are too high, buyers will do without the monopolized commodity. Thus the monopolist can realize abnormal profits ("monopoly profits") on the sale of this commodity by virtue of his power over the operation of the market.

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*There is a conceptual distinction between "market" and "industry". In general, economic theory refers to the market, and empirical research is often forced to use the industry as an acceptable substitute for the market, which is harder to collect data on. I use these terms more or less interchangeably until Chapter 4, where the distinction is clarified.

Market power and monopoly profits are far from merely technical concerns of economists. To the extent that markets are the principal economic allocative mechanism, power over their operation is power over the allocation of economic goods - and economic goods are readily transformable into other social goods and into other forms of social power (Carrington, 1978:13-14).

Even in markets which are not monopolies, it has been found that where a few firms have a relatively large share of total sales ("oligopolies"), profit levels are higher than those predicted by the theory of pure competition (Bain 1959; Scherer 1970). Somehow these dominant firms manage to co-operate in keeping prices high - i.e. in "jointly maximizing" profits - instead of competing and driving prices down to competitive levels.

The field of industrial organization economics grew out of this problem: to explain the relationship between "concentration" of sales and excess profits. Two aspects of the phenomenon call for explanation: by what mechanism(s) does concentration affect profits and how does concentration come about at all? In Lazarsfeld's language, industrial organization studies attempt to specify the relationship by discovering antecedent and intervening variables.

Although concentration -> profits is the classic relationship in industrial organization, the problem has been generalized to one of investigating the relationship between aspects of markets' "structure" - i.e. ways in which markets deviate from the assumptions of perfect competition - and their "performance" - i.e. ways in which markets succeed or fail in performing the functions they are assumed to perform. Concentration is only one aspect of structure, though in practice it has received by far the most attention. Profits are only one aspect of performance, but again are of paramount concern. The generalized intervening variable that "explains" how structure affects performance is held to be "business conduct"; the structure of the market affects what its members do by way of pricing behaviour, research, advertising, etc., and this affects performance. The generalized antecedent variable is "underlying conditions": the nature of the commodity being sold, the level of technology required (and capital requirements), the environment defined by government, unions, etc., and many other "givens" affect what kind of structure the market will have.

This general model of industrial organization analysis is shown in Figure 3-1. There are "feedback" arrows indicating that, for example, conduct affects structure and basic conditions. However, the important relationships, in theory and in research practice, are the two shown by one solid arrow from structure to conduct and thence to performance.

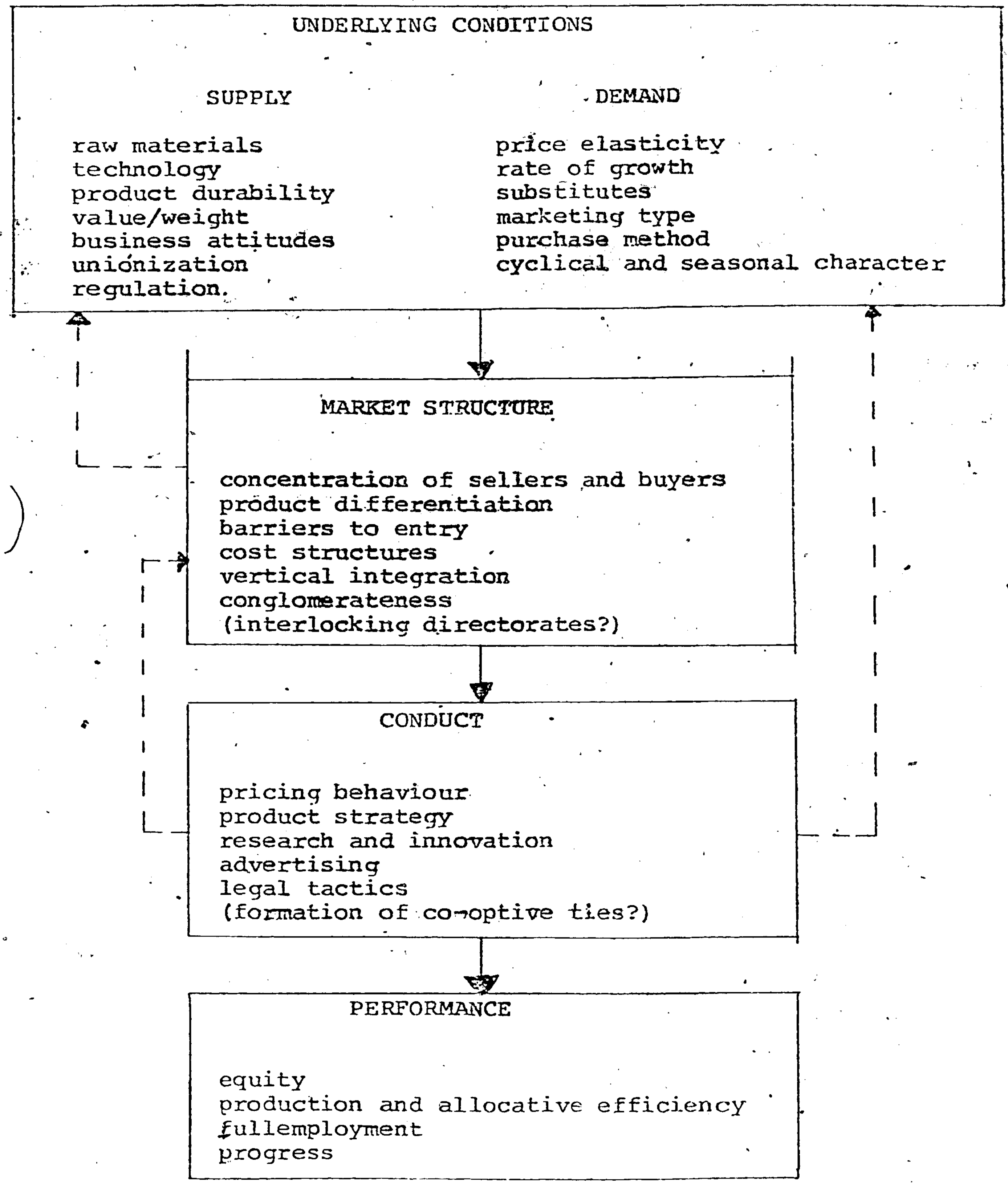

Figure 3.1

Scherer's model of industrial organization analysis*

*(Adapted from F.M. Scherer, <u>Industrial Market Structure and Economic Performance</u>, p.5.)

Although there are straightforward and widely accepted theories of economic behaviour under conditions of pure competition and pure monopoly, the problem of oligopoly has not yet been solved so neatly. According to Scherer:

> Ecomonists have developed literally dozens of oligopoly pricing theories....This proliferation of theories is mirrored by an equally rich array of behavioral patterns actually observed under oligopoly. Casual observation suggests that virtually anything can happen. (1970:131)

However, what all of these theories and patterns of behaviour do have in common is the basic problem that confronts the oligopolist: on the one hand he recognizes that price levels and, therefore, his profits will be higher if he co-operates with the others in maintaining them; on the other hand, he is always tempted to try to increase his share of sales by "chiseling" - competing with the others by means of price or some other weapon.

Ideally, oligopolists would get together, decide on the most jointly advantageous price and market share arrangements, and enforce them strictly on one another - in effect act as a group monopolist. This is the ideal-typical cartel, which, except under certain conditions with explicit government approval, is illegal in the U.S.A. and Canada.

Instead, economists postulate that oligopolists use various informal (and legal--until proved otherwise) methods to convey their pricing and market share preferences to one another, and to enforce jointly advantageous tacit agreements. Thus one of the focuses of industrial organization research has been to identify ways in which oligopolists communicate with one another and maintain solidarity, aspects of industry structure that facilitate this communication, and the impact of forms of communication and solidarity-maintenance upon market performance (Scherer 1970: Chapters 5-17).

Thus, oligopolistic co-ordination is a special case of the general phenomenon of inter-organizational co-optation: in order to reduce uncertainty, organizations develop channels of information and influence with "problematic others" - in this case, "competing" oligopolists.

The possibility that interlocking directorates are oligopolistic co-ordinating devices has been considered by economists but not tested empirically. Scherer (1970:47) distinguishes two types of interlocks: direct ties between competitors, and indirect ties between competitors mediated by another firm, "often a financial firm" (i.e. separate directors of a financial firm sit on the boards of two or more competitors - the competitors are linked "at one remove", or at "P2").

On direct interlocks, he notes that they were prohibited (in the U.S.A.) between large directly competing firms by the Clayton Act of 1914 and concludes that most current instances have "little or no effect on competition". On indirect financial ties he notes that banks "take pains to ensure" that confidentiality is preserved and unethical practices prevented. Nevertheless, Scherer concludes

> the opportunity for abuse exists...our ignorance on this subject is great and we can scarcely afford the complacent assumption that interlocking directorates--have no significant behavioral effects.

Bain is more positive about the role of interlocks, although he, too, cites no evidence. According to Bain,

> a more accurate estimate of the significance of interlocking directorates through investment-banking firms is that these interlocks, and these firms, (a) provide channels of communication between the managements of otherwise independent companies, and (b) provide a vehicle for the arrangement of coalitions, agreements, or treaties among otherwise independent firms...[but] it is not clear, moreover, that interlocking directorates, with or without the service of investment bankers, are crucial in providing a basis for coalitions or for collusive activity generally. There are myriad means or devices [for collusion]...the telephone, the business lunch, the service club, the golf course, and so on. The interlocking directorate is just one of these means, and probably not an indispensible one (1959:106-107).

One might describe these authors' attitudes as sympathetically skeptical. The only empirical research of which I am aware on director interlocks as co-optive devices among competitors was carried out by Ron Burt. Although he found that co-optive directorship ties occurred as expected between business establishments and their potentially problematic suppliers and customers, he could find no evidence that they occurred with more than chance frequency between competing establishments (Burt et al. 1979:27-28). Burt attributed this finding to possible (U.S.) antitrust regulation, or to attenuation caused by aggregation of industries in his data. Of course the lack of interlocking among competitors precluded a test of its connection with profit levels, and Burt reports none.

In summary, there is reason to expect co-optive oligopolistic interlocking, but no evidence of it has been found. It it did exist, one would expect that ties, such as interlocking directorates, that perform the function of co-optation would exist to the extent that industries are oligopolistic, and would tend to increase profits in these industries, as successful attempts at co-ordination. Furthermore, to the extent that such ties are important factors in oligopolistic co-ordination, they should "explain" the relationship between concentration and profits: i.e. when the presence of such ties is "controlled", the relationship between concentration and profits should decrease. In other words, to the extent that such ties are important factors in oligopolistic co-ordination, then concentration should affect profits only to the extent that it results in the creation of informal ties.

This is of course a case of an intervening variable, and is diagrammed in path analytic form in Figure 3-2. If corporate interlocks were expected to be the only form of oligopolistic co-ordination, then beta4 would be expected to be 0; however, this seems most unlikely in view of the other mechanisms that have already been discovered. I hypothesize (in H4 below) only that director interlocks are one method among others, and that beta4 is therefore less than beta1 (which is defined in H1 and Figure 3.2 below). The following hypotheses are therefore proposed (intercept terms are omitted for simplicity; both standardized and unstandardized coefficients will be calculated in the tests of the hypotheses).

H1: ln P = beta1CO + R1, beta1 > 0
where: P = profits,
CO = concentration,
R1 = residual term.

According to H1, profits should be positively correlated with concentration; this is the basic relationship. Failure to find that this hypothesis is consistent with the data would obviously have serious consequences for the analysis, since: (1) there would be no relationship to specify, and (2) given the degree of acceptance due to large numbers of successful replications of this relationship (Weiss 1971:364), one would be forced to conclude that the data were in some way inaccurate as used.

H2: ln P = beta2DI + R2, beta2 > 0
where DI = degree of interlocking.

Profits are expected to depend on the degree of interlocking, representing one form of co-optation. This should be true regardless of the degree of concentration, however:

H3: ln DI = beta3CO + R3, beta3 > 0

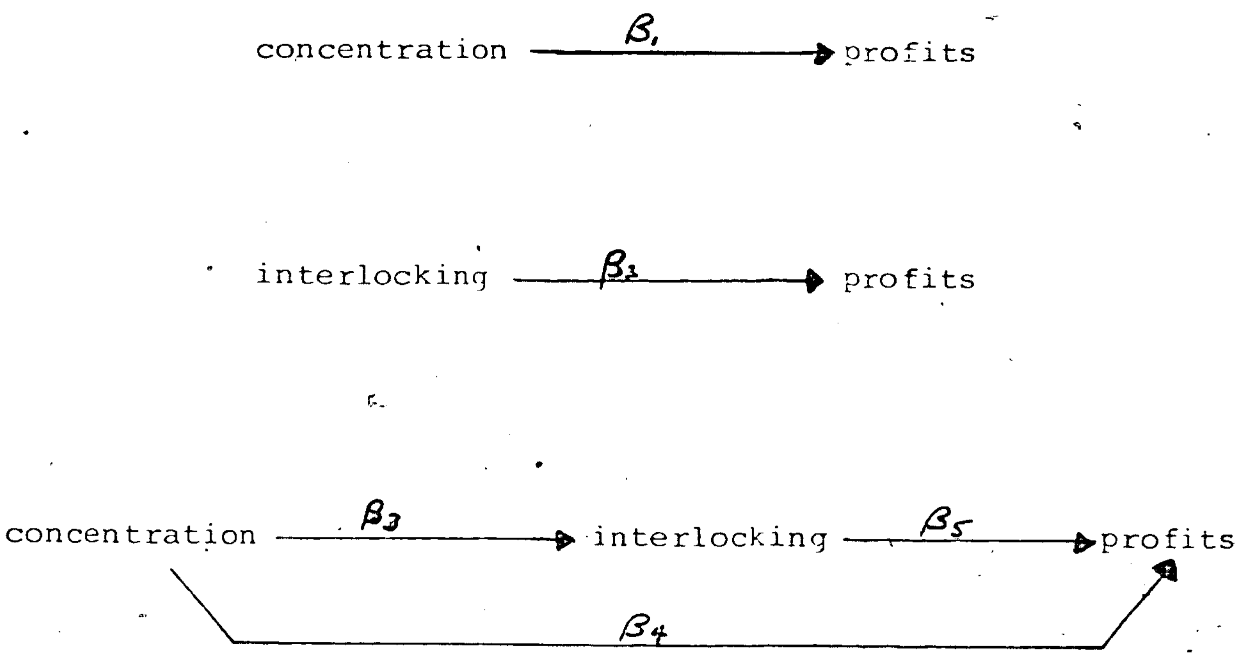

Figure 3.2

Path model for effects of concentration and interlocking on profits.

Interlocks are expected to vary with concentration: in concentrated industries, interlocks are formed for co-ordination, but in less concentrated industries there is no possibility of co-ordination. Thus concentration is a precondition of interlocking, and therefore of monopoly profits.

ln P = beta4CO + beta5DI + R4,

H4: beta4 < beta1, and

H5: beta5 = beta2

H4 says that interlocking explains some of the dependence of profits on concentration; H5 says that the relationship between interlocking and profits is not at all spurious (i.e. due to their common dependance on concentration).

Of course it is crucial to test hypothesis five, and indeed to include concentration in the model being analyzed. If one were simply to take the (expected) zero-order correlation between interlocking and profits as evidence that interlocks affect profits one would leave open the possibility that their relationship was entirely spurious. One can certainly imagine the possibility that interlocks are essentially epiphenomena of concentration: that in concentrated industries interlocks are created, but make no contribution toward co-ordination, and therefore profits. Concentrated, highly profitable industries might well have a host of attributes that are characteristic of spurious correlations: more pregnancies among secretaries, higher expenditures on liquor, and more damage in fires. Hypothesis 5 protects us from this possibility.

It seems reasonable to expect some of these relationships to be non-linear. For example, in a very highly concentrated industry, interlocks among the few top firms might be embarrassingly obvious and unnecessary for co-ordination. Thus DI would fall off for high values of CO, and P would have abnormally high values for these low values of DI accompanied by high values of CO. Conversely, in some unconcentrated industries, there could be some local interlocking and excess profits, which would also appear as distortions of the linear relationships. Thus it may be necessary to transform the variables or remove certain industries as outliers before computing linear regression coefficients.

If Bain, Scherer and many other writers are correct that financial firms, especially banks, serve a co-ordinating role in industries, then hypotheses one to five should be true for horizontal (i.e. between competitors) and financial ties, either separately or in combination. Thus there are three kinds of interlocks for which the hypotheses should be tested: horizontal ties (between competitors), bank-mediated P2 horizontal ties, and financial ties (i.e. ties between a firm and a bank that do not necessarily create a horizontal P2 tie).

It seems reasonable to expect effects among the three variables--concentration, interlocking and profits--other than the ones diagrammed in Figure 3.2 (cf. Figure 3.1). It is likely that interlocking affects concentration, i.e. that the two variables are reciprocally causal. A co-optive relationship could begin with an interlock and end in merger, which would increase concentration. Interlocking and concentration could also have a partly spurious association caused by their mutual dependance on underlying conditions. In addition, profits could affect both concentration and interlocking. High profits should encourage entry by new firms, reducing concentration (Comanor 1971:408) and overall interlocking.

Thus a complete model of the expected relationship among concentration, interlocking and profits would include many more causal links than those diagrammed in Figure 3-2. The present research is limited to the simple recursive "intervening variable" model, because the purpose of this research is to establish the importance of interlocks, not to provide a complete model of the determinants of profits. Because there are many problems in the measurement of interlocks (see Chapters 6-7), the conceptual scheme in which they are employed should be as simple as possible so that any empirical relationships that do exist are not obscured. Also, the inclusion of reverse causation would create a non-recursive model, requiring additional exogenous variables for estimation; however, quantitative data and theoretical understanding of the appropriate exogenous variables, "underlying conditions", are both lacking (Weiss 1971:397). Therefore, I have restricted the hypothetical model to what appear to be the main effects, which correspond to the main effects in the general industrial organization model.

In summary, the general hypothesis is that interlocks are a co-optive device used by economic actors in oligopolistic markets to increase their power over the operation of those markets. This hypothesis will be tested by measuring concentration, interlocks and profits on a representative set of markets, and decomposing their relationships using a standard path analysis.

CHAPTER 4

Operationalization of Industrial Organization Concepts

In the previous chapter, markets were treated as the observations in this study, and concentration, interlocking and profits as attributes of those observations. Interlocks are discussed in Chapters 5-7. In this chapter I discuss the theoretical concept of the market and define the "market area", which is the observation that is actually used; and define indices of concentration and profits on market areas following standard industrial organization procedures. The collection of data for these variables is then discussed, and distributions of the variables are presented. Transformations are performed where necessary to make the indices amenable to analysis, and finally, the measured association between concentration and profits is discussed.

4.1 Markets, Industries and Market Areas

A market is theoretically defined as a set of actors buying and selling a commodity or a set of highly inter-substitutable commodities. Since the whole apparatus of economic theory depends on the concept of competition in the market, it is important that an empirical study of the operation of a market include the actors who are (putatively) competing and exclude those who are not. This is not so easily done. Consider cigarettes. Do filter cigarettes compete with non-filter -- i.e. are the buying, selling and price of filter cigarettes independent of the buying, selling and price of non-filter cigarettes? Clearly, they are related because they are fairly inter-substitutable. What about cigars vs. cigarettes? Would you rather fight than switch? In other words, are there separate cigarette and cigar markets, or one "tobacco products" market? Actually, it is firms, not products, that compete, so the question is, Do cigarette manufacturers compete with cigar manufacturers? The answer is simplified and complicated by the fact that often the same firm produces a "line" of fairly substitutable commodities -- cigarettes, cigars, tobacco. However, the same firm may produce completely unrelated commodities, and very large diversified firms produce hundreds of distinct commodities, thus operating in large numbers of distinct markets, in each of which they compete with different, though possibly overlapping, sets of other firms.

The problem is further complicated by the notion of production substitution.* Just as consumers can satisfy their consumption preferences with a range of commodities, so producers can satisfy their production needs with a range of commodities that have similar production processes. Scherer mentions "screw-machine shops" as an example of a group of shops that produces an incredible variety of commodities <u>using the same production facilities</u>. Although Shop A and Shop B may be producing completely different commodities, and therefore not competing in the strict market sense, either shop can with very little trouble switch its production to the other commodity. Thus in reality the two shops are competitors, in the sense that the conditions of supply, demand and price in the product markets in which each shop operates, affect both shops.

Thus there are two complementary spheres of competition: the commodity, or product, market, in which producers compete to satisfy demand for particular products; and the industry, in which producers with similar production facilities compete to get maximum benefit from their facilities. Fortunately for researchers, the two spheres are generally closely related: commodities with similar uses tend to be produced by similar facilities. Thus "each industry tends to be associated with a particular market or group of markets...[so that] industrial concentration can be studied as a proxy for market concentration" (Statistics

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*The following discussion of markets vs. industries draws on Scherer's discussion (1970:53-54).

Canada 1977:13-14). In other words, the theoretical concept of oligopolistic power in markets can be replaced in empirical studies by the concept of oligopolistic power in industries. An industry characterized by concentration of sales in a few members should have the same characteristics as the market or group of markets which this industry serves, since the members of the industry, by virtue of production substitutability, are effectively operating in all these markets at once.

This phenomenon has allowed the U.S. Census Bureau (and Statistics Canada after it) to devise a classification system (the Standard Industrial Classification, or S.I.C., system) that classifies producers simultaneously into markets and industries with a minimum of distortion. Seven-digit S.I.C. codes identify commodities -- for example, 2844511, "suntan lotions". These commodities are grouped into broader five-digit "product classes" with the same first five digits. All commodities with the same first four digits are grouped into one four-digit industry -- here, 2844, "toilet preparations". Four-digit industries are in turn grouped into 2-digit "industry groups" -- here, 28, "chemicals and allied products".

Thus competition can be studied at any level of fineness for which data are available and at which the investigator feels the concept of inter-substitutability is operative -- i.e. the notion of competition is appropriate.

As Scherer points out, four-digit industries, which concentration studies normally use, are in some cases too broad and in others too narrow to capture the set of actors that are "really" in competition. Thus results of studies using four-digit industries, or any broader classification, may be expected to yield results that underestimate relationships, due to large random errors (Weiss 1971:370).

Although data on concentration and profits at the four digit level are available for Canada, this is an inappropriately fine classification for the present study. Many firms operate in multiple markets and industries. To assign a firm to a particular market or industry, i.e. to claim that it is competing with other firms in that market or industry, when the fraction of its output and profits accounted for by that market or industry may be tiny, will lead to distorted results. This problem is handled in government censuses by the use of the concept of the "establishment". A firm is a rather abstract legal entity that owns various assets, among them the facilities that actually produce commodities. These facilities take the form of "establishments", each establishment being a geographically distinct unit -- a factory, shop, or other site of productive activity (Berkowitz et al. 1979:395). An establishment, with its limited production facilities, usually produces in only one or a limited range of markets. Firms characteristically operate in more markets or industries by owning more establishments. The census assigns establishments, not firms, to S.I.C. categories in calculating sales, costs, wages, etc., so that misallocation occurs only to the extent that establishments span categories.

However, directorship interlocks are necessarily between firms, not establishments, since it is the firm that has the board of directors. Furthermore, firms are in many cases not independent competing actors because they are grouped into "enterprises" -- groups of firms operating under common control. Thus the members of the boards of all firms in an enterprise can be expected to be working as a team, and all of their interlocks outside the enterprise considered to be "the enterprise's interlocks" (this argument is developed in Chapter 5). The multifirm enterprise operates in the sum of the markets or industries operated in by its member firms. How, then, are interlocks to be assigned to markets or industries in a manner comparable with other variables such as concentration and profits, which are assigned at the establishment level?

One solution is to treat all board members as "belonging to" every industry in which the enterprise operates. This appears to have been done by Burt in his study of interlocks across industries (Burt et al. 1979:10-11). However, this strategy is open to the aforementioned problem of misallocation. Even if an enterprise is only peripherally involved in a given industry, all of its interlocks will be given full weight in that industry in computing indices of interlocking -- as much weight as they will be given in an industry where the enterprise may carry on the vast bulk of its activity. However, it is impossible to "weight" interlocks by proportion of activity because data on firms' activity in each S.I.C. category are not available -- and even if they were, the notion of a "fractional interlock" lacks clarity, let alone theoretical justification.

The solution to the problem adopted in this study was also to assign all board members to each industry in which the enterprise operates, but to define industries more broadly, so that problems of misallocation are reduced. An enterprise may operate in many four-digit industries but is less likely to operate across two-digit industry group boundaries -- and where it does operate across industry group boundaries, its presence in each group is more likely to be substantial.

Use of two-digit groupings, mainly forced by the unavailability of four-digit data on a key variable, is fairly common in industrial organization studies. Four-digit concentration and profits data can be aggregated to the two-digit level in such a way as not to destroy their discrimination (Scherer 1970:57; see also Section 4.2 below).

A major statistical drawback of the use of two-digit groups is that the number of observations is drastically reduced. There are over 150 four-digit industries in the logging, mining and manufacturing sectors in Canada, and only 35 market areas (corresponding in coarseness of aggregation to S.I.C. two-digit industry groups--see below). Thus correlation and regression coefficients need to be much larger before one can have the same degree of confidence that they are not simply the result of random error in the variables. For example, in a study of vertical co-optation Burt (1978:22) obtained betas for three variables that had significance levels less than 0.05 for 335 four-digit industries, but when the same data were aggregated to 20 two-digit industry groups, only one beta was significant at less than even the 0.10 level.

This problem is less serious than it might seem, for two reasons. First this study is of the entire population of market areas in these sectors. Thus there is no question of one's confidence in generalizing from a sample to a population. Although the enterprises in each market area are a sample, they are not random, but were chosen to cover the entire population of important firms (see Chapter 5).

However, there remains the possibility that weak associations may be the result of measurement error (including inaccuracies introduced by the aggregation procedure and by the somewhat arbitrary coding decisions made for interlock data -- see Chapters 6-7). The classic solution to this problem is replication. I have tried to "build in" some replication by using multiple indices of all major variables. One can have more confidence in a weak association that is consistent over several different (admittedly not independently measured) indices -- and one is more inclined to take seriously a replicated unexpected result such as a reversed sign on a coefficient.

Use of the broader two-digit categories has another entirely pragmatic justification. Since the interlock data available to me include only a sample totalling 1463 enterprises, there are far too few enterprises in many four-digit industries to have any confidence that the degree of interlocking in the sample repesents the true degree of interlocking in the industry. Even using two-digit industry groups, many groups have rather few enterprises compared to the total number of enterprises actually operating in that industry group. The problem of representativeness is reduced, however, in the broader groups.

Although the level of aggregation used in this study is the two-digit S.I.C., the allocation of four-digit groups is not identical with that used by Statistics Canada. Rather, I have followed the allocations proposed by S. D. Berkowitz, which result not in "industry groups" but in "market areas" (S. D. Berkowitz, forthcoming). These allocations are roughly, and in some cases exactly, similar to the S.I.C.

allocations, but differ in minor respects in some cases. These differences are due to Berkowitz's interpretation of the implications of the Canadian economy input-output table for competition among members of each group.

Although interlock data were available for all sectors of the economy (see Chapter 6), systematic data on concentration and profits (and indeed, well-developed economic theories of oligopolistic competition) were available only for "producer markets"--the logging, mining and manufacturing sectors--so the tests of hypotheses are limited to those three sectors. Consumer and service industries--wholesaling, retailing, transportation, financial services, etc.--are not analyzed in this study.

Since the enterprises for which interlock data were available were not active in all of the four-digit industries included in each market area, data on concentration and profits were aggregated from only those four-digit industries in which the given enterprises were active. For example, market area 10, "rubber industries", includes four-digit S.I.C. categories 1620, 1623, 1624, 1629, 1650. However, interlock data were available only for enterprises operating in S.I.C. 1623 and 1629, so concentration and profits data for market area 10 were aggregated from only these two industries.

A list of all 82 market areas for which interlock data were available, and the three-digit (1960 base) S.I.C.

categories included in each, is given in Appendix A, Table 1. Also included are the four-digit (1970 base) S.I.C. categories included in market areas for which the path analyses could be performed. Two kinds of S.I.C. categories ("1960 base" and "1970 base") are used because the interlock data were classified by the former, and the concentration and profits data by the latter. Correspondences between the old and new S.I.C. categories were taken from the concordance published by Statistics Canada (1973:125).

4.2 Concentration

The degree of concentration of sales in a few firms in a market or industry is conventionally measured by a "concentration ratio". This is the ratio of the combined sales of the x firms with the largest market share to the total sales in the market, where x may be any number thought appropriate -- normally 4 or 8. Comparisons of top-4, top-8, top-20 and other concentration ratios (for U.S. data) have shown that they all have fairly similar power to predict profits, with top-4 generally the best, but it appears that it is primarily co-ordination among the top-4 firms in the industry which must among them control a minimum of something like 50% of industry sales, that leads to oligopoly profits (Weiss 1971: 372, 375; Scherer 1970:52).

Other considerations, discussed below, suggest the use of the Herfindahl index:

$$(4.1)\quad H = \sum_i (S_i^2)$$

where:
S_i = market share of the ith firm.

This index reaches its maximum of 1 only in a pure monopoly and declines toward 0 with increases in the number of firms in the industry and with increases in their equality of market share. Thus it would appear to give more information on structural inequality in the whole industry. Furthermore, theories of oligopolistic pricing developed by Cournot and by Stigler both suggest the use of the Herfindahl index to measure concentration when it is to be associated with profits (Weiss 1971:374). However, in practice the Herfindahl is highly correlated with the top-4 ratio -- Scherer (1970:52) reports a study where the two indices had a correlation of 0.936 over 91 industries, and cites other studies coming to similar conclusions.

Value of shipments data for top-4 and top-8 (among others) and total value of shipments are published at the four-digit level by Statistics Canada (1977:38-86) for 1972. These were converted to concentration ratios for market areas by taking the means over the relevant four-digit industries, weighted by the contribution of each industry to the market area total, the method suggested by Scherer (1970:57):

(4.2) $$RVS4M = \frac{RVS4(1) * VST(1) + RVS4(2) * VST(2) + \ldots}{VST(1) + VST(2) + \ldots}$$

$$= \frac{VS4(1) + VS4(2) + \ldots}{VST(1) + VST(2) + \ldots}$$

where:

RVS4M = top-4 concentration ration for a market area
RVS4(I) = top-4 concentration ratio for industry I,
VST(I) = total value of shipments for industry I,
VS4(I) = value of shipments of top 4 for industry I.

A similar procedure was used to compute weighted mean Herfindahl indices, using Statistics Canada's published Herfindahl indices for four-digit industries (1977:107-111). Values of these three indices of concentration for the market areas analyzed are given in Appendix A, Table 2.

Since analysis of the relative merits of each of these three indices included a comparison of their relationships with indices of profits, discussion of this is presented after the description of the profit indices.

4.3 Profits

There are many different ways to measure the characteristic level of profits in a market or industry, each with its own advantages and disadvantages. What one *wants* to know is whether firms were able to earn monopoly profits on the sale of a particular commodity or on their output in a particular industry. Profits data reported by firms distort this, (a) because they combine profits on all activities of the firm, (b) because of the myriad accounting practices employed -- which may vary randomly or may be intended (usually) to reduce stated profits to escape tax, and (c) because potential monopoly profits may be attenuated by excess costs -- the "easy come, easy go" phenomenon.

Some of these pitfalls are avoided, and other introduced, by the use of "industry price-cost margins" (Collins and Preston 1969) to index profits. This index is based on census data by industry rather than firm-level data, so it avoids the misallocation of all of a firm's profits to each industry. The industry profit level is defined as total industry value of shipments less total costs of production (resulting in gross profit margin) as a percentage of total value of shipments:

$$PCM = (VS - C)/VS \quad (4.3)$$

where:
PCM = price-cost margin
VS = value of shipments
C = costs of production.

The main disadvantage of price-cost margins is that the numerator of the index -- the computed gross profit - includes all the costs that are not included by the census in "costs of production" -- such as the cost of capital, and "head-office" or administrative costs such as advertising, research and development, and general administrative costs. To the extent that these are associated with profits, they will cause overstatement of the association of profits and concentration.

Costs of capital and advertising appear to be the major confounding factors (Scherer 1970:185). Collins and Preston controlled for costs of capital by including an index of this in their regressions. An alternative (but equivalent) method that I prefer was used by Burt in his application of price-cost margins (1978:16-17). Burt "removed" the variation in his PCM's that was due to capital costs by first regressing PCM's on an index of capital costs, then correcting the PCM's using the regression coefficients, with the result that the "corrected price-cost margin" (CPCM) had zero correlation with capital costs. The advantage of this approach is that the path analysis is not cluttered up with correction factors: these have already been removed from the independent variable. Thus:

(4.4) $CPCM = PCM - b(CR - MEAN(CR))$

where:

CPCM = corrected price-cost margin,
PCM = (raw) price-cost margin,
b = regression coefficient of PCM on CR
CR = capital-output ratio, an index of the cost of capital to an industry
= A/O
A = gross book value of depreciable assets,
O = industry output, measured as value of shipments or total sales, etc.

Similar adjustments could be made for other cost items that are included in the PCM; however Collins and Preston's work appears to be well accepted without these additional factors, and studies controlling for them have shown that they are not extremely important (Weiss 1971:367-368).

In this study I have used price-cost margins, corrected for costs of capital according to Burt's method. In addition to industry price-cost margins, I have calculated top-4 and top-8 price-cost margins -- i.e., indices of the profitability of the top-4 and top-8 firms in each industry. One would expect that their profits would be more closely related to top-4 and top-8 concentration than would overall industry profits -- and possibly to interlocking too, if that is concentrated in the top few firms.

Data on sales and costs to calculate PCM's were taken from Statistics Canada's (1977) <u>Industrial organization and concentration...1972</u>. Statistics Canada reports sales net of direct costs except payroll as "value added"; thus, equation 4.3 becomes:

(4.5) $PCM = (VA - L)/VS$

where:

VA = value added
L = payroll
VS = value of shipments
PCM = price-cost margin.

Data on value added and payroll were reported for four-digit industries, and were summed within market areas in a manner similar to that used for value of shipments (see "Concentration" above). PCM's were then calculated using equation 4.5, and are reported in Appendix A, Table 2.

Unfortunately, data on assets by industry (used in computing capital-output ratios) were published by Statistics Canada for 1972 only at the two-digit industry group level, making it impossible to aggregate four-digit industry values into market area figures. Therefore, I simply matched Statistics Canada's two-digit aggregations as closely as possible with my market areas. The result of this matching operation is shown in Appendix A, Table 1. Since Statistics Canada reports industry sales, which are the denominator of the capital-output ratio, both in its report on concentration (1977)--at the four-digit level--and in its report on "Corporation Financial Statistics" (1976) at the two-digit level, I had a choice of matching sales data to (two-digit) assets data or to (four-digit) price-cost margins data. I computed three capital-output ratios (see equation 4.4) using:

(1) aggregated four-digit value of shipments data (see above),

(2) two-digit data on "sales of products" (Statistics Canada 1976:50-64), and

(3) two digit data on summed "sales of products" and "sales of services" (Ibid.).

Values of these three ratios are given in Appendix A, Table 2.

The capital-output ratio based on value of shipments, was discarded because of its bizarre distribution (skewness=

3.7, kurtosis=14.5). The other two ratios were expected to be highly intercorrelated because they differed only in the addition to "sales of products" of the empirically small amount of "sales of services". Both ratios were used as regressors for PCMT, the price-cost margin for each industry, to determine which capital-output ratio explained more variance in PCMT. There was very little difference: the R-squared for CRSP (ratio based on sales of products) was 0.065 and for CRS (based on all sales) was 0.054. The unstandardized regression coefficients were 0.049 and 0.045 respectively, compared with coefficients of 0.077 and 0.064 reported by Burt (1978) for 335 four-digit industries and 20 two-digit groups respectively, and a coefficient of 0.089 reported by Collins and Preston (1969:275) for 243 four-digit industries.

Apparently the unsatisfactory matching has attenuated the relationship. Thus one should expect the resulting corrected price-cost margins to contain some component of industry capital costs. This should cause a slight overstatement of the relationship between concentration and profits. Its effect on the relationship between interlocking and profits cannot be predicted, since we have no evidence on the relationship between interlocking and industry capital costs. If there is no relationship the overstatement of the concentration-profit relationship will have a conservative effect on the test of the hypothesis that interlocks partly explain this relationship. In any case, the amount of variation due to capital costs that is "left in" the profits variable (assuming that Burt's and Collins and Preston's results - from U.S. data -- are relevant) is very small.

Having chosen CRSP, the capital-output ratio based on sales of products, as the index of capital costs, the three PCM's (PCM4: top-4 PCM, PCM8: top-8 PCM, PCMT: industry PCM) were regressed on it to calculate the correction factors. The three unstandardized coefficients were 0.052 (PCM4), 0.048 (PCM8) and 0.049 (PCMT).

The three corrected price-cost margins - top 4, top 8 and overall industry - were then calculated using equation 4.4. Values of these are given in Appendix A, Table 2.

4.4 Examination of concentration and profit indices

Having calculated three indices of concentration and three indices of profits, I then examined the distribution of each, and their intercorrelations in order to determine:

(1) if any of the indices in the two groups were redundant,

(2) if indices of concentration and profits were correlated with the expected strength,

(3) if any of the indices had unusual distributions and/or nonlinear associations with indices in the other group, which could be corrected by transformations.

4.4.1. Redundant indices

Intercorrelations among the six indices are given in Table 4.1. The first conclusion drawn from this table was that the top 8 concentration and profits indices are redundant, as expected. Top 4 and top 8 concentration indices have a correlation coefficient of 0.966, and top 4 and top 8 profits indices have a correlation of 0.994. Furthermore, top 4 concentration has slightly higher correlations than top 8 concentration with top 4, top 8 and total industry profits: 0.125 vs. 0.107, 0.118 vs. 0.106, and 0.149 vs. 0.127 respectively. Similarly, overall industry profits has slightly higher correlations than top 4 and top 8 profits with all three indices of concentration: 0.149 vs. 0.125 and 0.118, 0.127 vs. 0.107 and 0.106, and 0.091 vs. 0.071 and 0.056 respectively. That top 4 concentration is approximately equal to, and a slightly better predictor of profits than, top 8 concentration is suggested in the industrial organization literature (Weiss 1971:372-373; Scherer 1970:52). Since there are no strong theoretical or methodological reasons to distinguish between top 4 and top 8 indices, and an apparent preference in the industrial organization literature for the top 4 concentration ratio, I deleted the two top 8 indices from further analysis. Top 4 profits was also deleted, since it was highly correlated with overall profits (R=0.977), and of

Table 4.1

Intercorrelations among three concentration and three profits indices (N = 35).

	RVS8	HVS	CPCM4	CPCM8	CPCMT
RVS4	0.966*	0.932*	0.125	0.118	0.149
RVS8		0.885*	0.107	0.106	0.127
HVS			0.071	0.056	0.091
CPCM4				0.994*	0.977*
CPCM8					0.978*

Notes:

1. RVS4 = top 4 concentration ratio, value of shipments
   RVS8 = top 8 concentration ratio, value of shipments
   HVS = Herfindahl index, value of shipments
   CPCM4= top 4 corrected price-cost margin
   CPCM8= top 8 corrected price-cost margin
   CPCMT= market area overall corrected price-cost margin.
2. *significance level < 0.01.

no theoretical importance.

Top 4 and Herfindahl concentration indices are conceptually distinct but empirically highly correlated (0.932 for these data). Top 4 concentration measures only the relative market share of the top 4 enterprises; whereas the Herfindahl is a function of the total number of enterprises in the market and the inequality of all their market shares. In view of remarks by Weiss to the effect that economic theories of oligopoly pricing suggest the use of the Herfindahl rather than the top 4 concentration ratio, and his argument in favour of more thorough testing of the Herfindahl index (1971:374-375), and Scherer's comment that the Herfindahl "comes close to being an ideal composite measure [of potential monopoly power]" (1970:52), I retained the Herfindahl index although it was considerably less highly correlated than top 4 concentration with top 4 and overall profits (0.071 vs. 0.125 and 0.091 vs. 0.1[illegible] respectively).

4.4.2 Correlation of profits and concentration

Correlations between concentration and overall industry profits are weakly positive, as Table 4.1 shows, varying between 0.091 and 0.149. With an N of 35, neither of these relationships is statistically significant. These correlations are considerably weaker than associations found for 243 four-digit industries in the U.S. by Collins and Preston. They reported R-squares of 0.07 and 0.10 for simple regressions of profits on concentration for 1958 and 1963 respectively (1969:275), which correspond to correlations of 0.265 and 0.316 respectively. Similarly, Burt reported correlations of 0.243 and 0.324 on 335 four-digit industries and 20 two-digit industry groups respectively for 1967 in the U.S.

4.4.3 Methods to improve the R-squares

It is futile to attempt to specify a relationship that is extremely weak in the first place. Since other investigators found a considerably stronger relationship, I attempted to find causes of attenuation.

Box plots and stem-and-leaf plots (Tukey 1977), and skewness, kurtosis and normality statistics for the two concentration and the profits index are shown in Figure 4.1. Top 4 concentration shows practically no distributional irregularity but a flat distribution. The Herfindahl and profits indices both show skewness to the right (or "upward straggle"). However, the Shapiro-Wilks normality test ("W" statistic) indicates that only the Herfindahl is significantly non-normally distributed: the values of the Herfindahl have only a [illegible].6% probability of being found in a random sample from a comparable normally distributed population (Shapiro and Wilk 1965).

Figure 4.1

Distributional plots and statistics for top 4 concentration, Herfindahl, and corrected price-cost margin ($N = 35$).

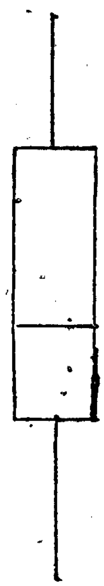
Top 4 concentration

Stem • Leaf

Stem	Leaf
8	5
8	00
7	5566
7	3
6	89
6	134
5	67
5	
4	589
4	0233
3	5689
3	0244
2	
2	
1	589
1	13

(multiply by .01)

Boxplot



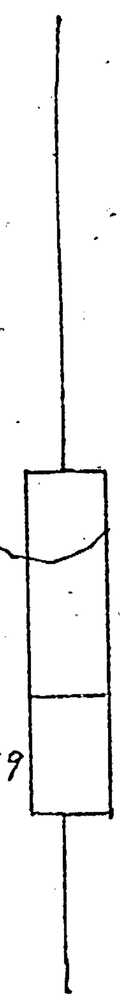
Herfindahl

Stem • Leaf

Stem	Leaf
25	4
24	
23	
22	
21	25
20	05
19	
18	7
17	0
16	
15	
14	08
13	39
12	2
11	47
10	4
9	
8	179
7	69
6	25559
5	13
4	17
3	5
2	
1	0378
0	8

(multiply by .001)

Boxplot



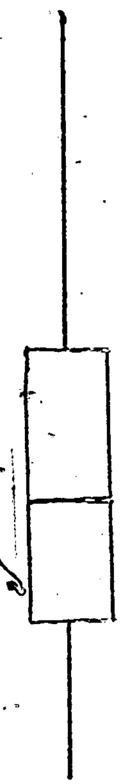
Corrected margin

Stem • Leaf

Stem	Leaf
54	6
52	
50	
48	
46	4
44	74
42	
40	7
38	89
36	289
34	03
32	677
30	1467
28	6
26	0448
24	068
22	1386
20	80
18	
16	1
14	0

(multiply by .001)

Boxplot



	Top 4 concentration	Herfindahl	Corrected margin
Skewness:	−0.050	0.610	0.599
Kurtosis:	−1.046	−0.504	0.366
Shapiro-Wilk W:	0.946	0.935	0.972
(significance):	(0.133)	(0.056)	(0.537)

Square root transformations were computed for the latter two indices in an attempt to reduce the skewness and improve the associations (Tukey 1977:89). Table 4.2 shows skewness, kurtosis, normality statistics and intercorrelations for the raw normality statistics and transformed indices. The square root of the Herfindahl shows a slightly stronger association with profits, and the raw profits index is better than the transformation.

The profits index was then regressed on the two concentration indices in order to find any irregularities in the residuals (Draper and Smith 1966:86-95). Figures 4.2 and 4.3 show plots of the residuals against predicted-profits, with top 4 concentration and the square root of the Herfindahl respectively as regressors.

In both cases the residuals appear to be normally distributed, and the values of the Shapiro-Wilk normality statistic are 0.979 and 0.980 respectively, indicating probabilities of 0.76 and 0.80 respectively that these distributions correspond to samples from normally distributed populations.

Both plots show considerable scatter to the right. Possible outliers were identified by drawing lines at one standard deviation above and below the mean. Burt found outliers by drawing 95% confidence intervals about the regression line (1978:26). However, confidence intervals curve away from the regression line at the extremes (more variance being expected at the extremes). In the present

Table 4.2

Intercorrelations and distributional statistics for raw and transformed concentration and profits indices (N = 35).

	HVS	SQRT (HVS)	CPCMT	SQRT (CPCMT)
HVS4	0.932*	0.961*	0.149	0.120
HVS		0.979*	0.091	0.052
SQRT(HVS)			0.107	0.071
CPCMT				0.996*

	SKEWNESS	KURTOSIS	W' (signif. level)
HVS4	-0.05	-1.05	0.946 (0.133)
HVS	0.61	-0.50	0.935 (0.056)
SQRT(HVS)	0.06	-0.71	0.967 (0.463)
CPCMT	0.60	0.37	0.972 (0.587)
SQRT(CPCMT)	0.21	-0.02	0.989 (0.976)

*Significance level < 0.01.

analysis, I was trying to identify cases of excessive deviation from the predicted value, whether at the extremes or not. In fact, it is most likely that the expected relationship does not hold for extreme values of concentration and profits (see discussion of nonlinearity in Chapter 3 above) -- in a discussion of marginal concentration, Weiss (1971:373) seems to be confident of the relationship only in the top 4 concentration range between 0.3 and 0.7, and 14 of the 35 market areas in this dataset are outside that range.

The residuals for 10 market areas lie beyond one standard deviation for both regressors. Of these ten, four have top 4 concentration above 0.7 (market areas 9, 21, 25, 32) and one has concentration below 0.3 (market area 19 - printing and publishing). Since half of the 10 outliers do not have extreme concentration, and since 9 of the 14 market areas with extreme concentration are not outliers in these regressions, it appears that extreme concentration does not explain the attenuation of the relationship.

An alternative explanation for attenuation is the procedure by which four digit industries were aggregated to market areas, which are approximately as coarse as two digit industries. Other writers have suggested that even four digit industries are too coarse an aggregation to study precisely the relationship of profits and concentration (Weiss 1971:370), and of course two digit industry groups would be worse (Burt et al. 1979:28). Weiss (1971:368) has suggested that two digit industry groups tend especially to

Figure 4.2 Residuals plotted against predicted margins (regression of overall price-cost margins on top 4 concentration).

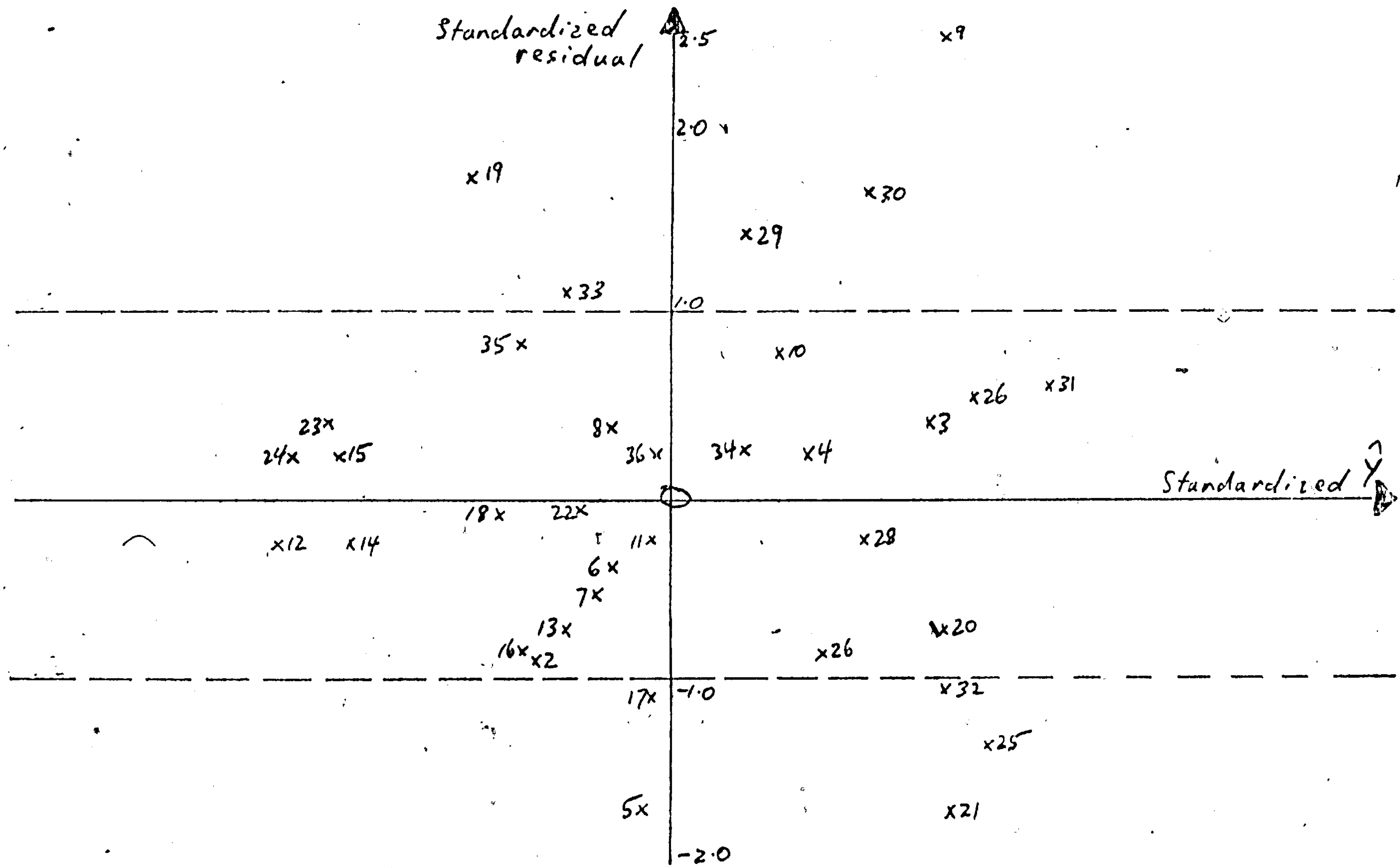
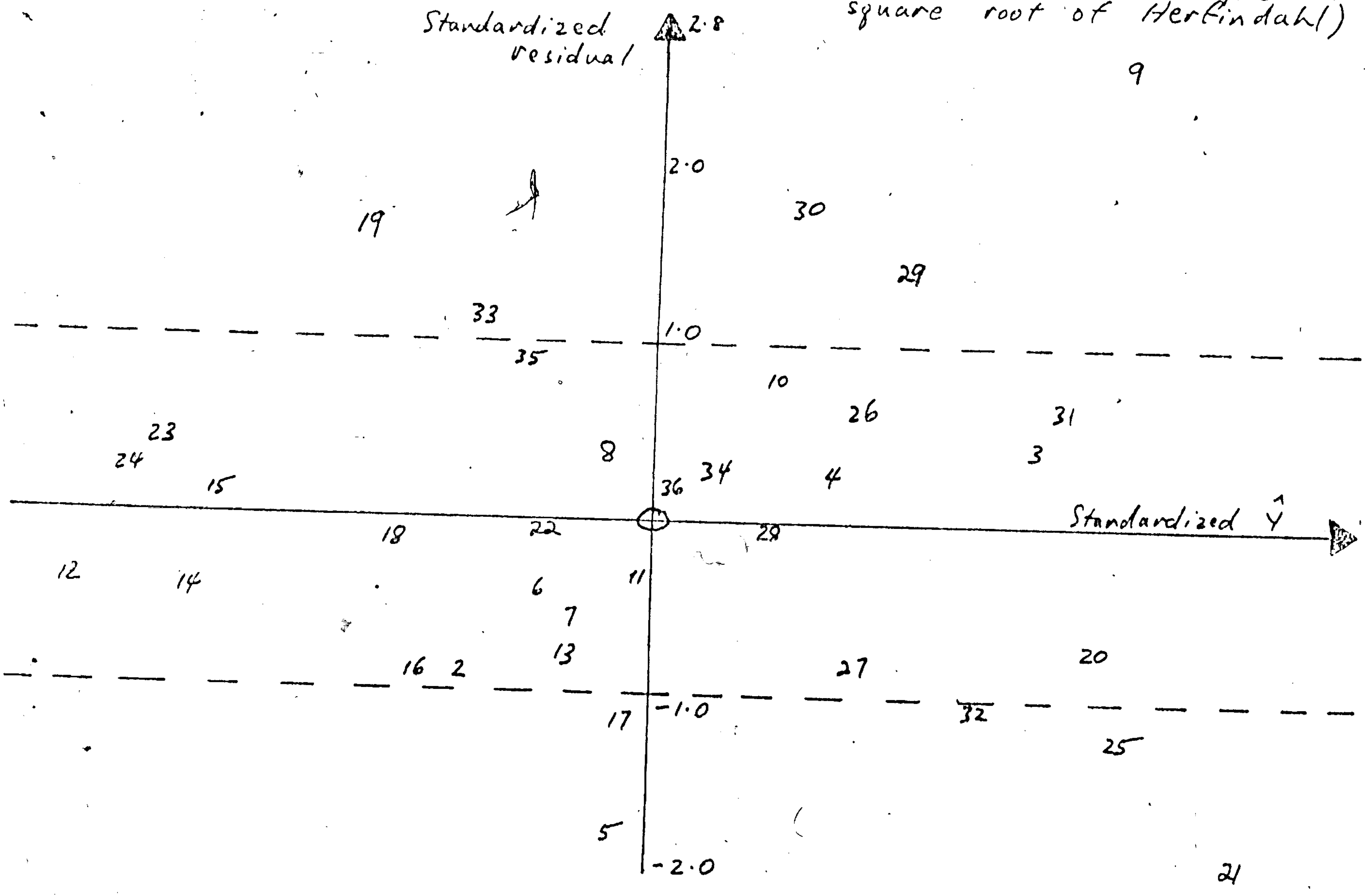


Figure 4.3 Residuals plotted against predicted margins (regression of overall price-cost margins on square root of Herfindahl)



be heterogeneous with respect to profits.

The possibility that some of the market areas were excessively heterogeneous with respect to concentration and/or profits was examined by computing the variance across the four digit industries in each market area. A combined index of heterogeneity of concentration and profits was computed by standardizing the two variances over the 35 market areas and taking the simple mean of the two variances for each market area.

The standardized values of these two variances, sorted by the values of the combined measure of variance, are given in Table 4.3. Of the seven market areas ranking highest on the combined measure, five are outliers in the two regressions discussed above (market areas 9, 25, 19, 30, 21), and with the exception of market area 25 are the highest ranking in terms of absolute value of the residual. Furthermore, four of these five (9, 19, 21, 25) have top 4 concentration ratios outside the range, 0.3 to 0.7. It appears then, that these five market areas -- beverages, printing and publishing, nonmetal mining, primary metal industries other than iron and steel, and automobiles, trucks and parts -- do not have profits corresponding to concentration, because they are inappropriate units of aggregation because of heterogeneity of aggregated four-digit industries, and/or fall outside the range of concentrations ~~for which~~ the relationship is expected to hold, and very likely for additional reasons related to the structures of the industries contained within them. These

Table 4.3

Standardized intra-market-area variances of top 4 concentration, profit margins, and their mean.

MARKET AREA	N FOUR-DIGIT IND'S	VARIANCE (RVS4)	VARIANCE (CPCMT)	MEAN
4 Gold quartz mines	1	0	0	0
10 rubber industries	1	0	0	0
16 Pulp and paper	1	0	0	0
18 Misc. paper	1	0	0	0
23 Misc. metal fabricating	1	0	0	0
24 Machinery mfg.	1	0	0	0
26 Aircraft & parts	1	0	0	0
27 Shipbuilding & repairs	1	0	0	0
29 Communications eqpt.	1	0	0	0
32 Fertilizers	1	0	0	0
33 Paint & varnish	1	0	0	0
12 Clothing	1	0	0	0
2 Logging	5	-0.971	-0.743	-0.857
14 Sawmills	2	-0.965	-0.722	-0.844
17 Paper box & bag	2	-0.901	-0.760	-0.830
36 Toys & sporting goods	3	-0.785	-0.709	-0.747
35 Misc. chemical ind's	2	-0.977	-0.348	-0.663
6 Fish, fruit & vegetables	2	-0.531	-0.760	-0.645
22 Metal fabricating	3	-0.775	-0.503	-0.639
15 Furniture mfg.	7	-0.521	-0.739	-0.630
3 Metal mines	4	-0.557	-0.680	-0.618
34 Industrial chemicals	5	-0.502	-0.648	-0.575
20 Primary iron & steel	2	-0.912	-0.168	-0.540
5 Meat, poultry & dairy	4	-0.673	-0.371	-0.522
11 Textiles	3	-0.379	-0.176	-0.278
31 Petroleum & coal products	7	0.065	-0.496	-0.216
13 Wood products	3	0.397	0.302	0.349
28 Appliances, radio & TV	10	1.274	-0.551	0.361
21 Other primary metals	3	1.502	-0.639	0.431
8 Misc. food	3	1.087	-0.207	0.440
30 Nonmetal mineral products	3	0.108	1.227	0.668
7 Flour, feed, & bakeries	5	0.144	1.250	0.697
19 Printing & publishing	4	0.686	1.142	1.014
25 Autos, trucks & parts	3	-0.279	2.998	1.359
9 Beverages	5	2.569	0.384	1.477
	4	1.697	1.915	1.806

market areas were therefore excluded from the analysis.

4.4.4 Distributions and intercorrelations on 30 market areas

Distributional plots for the concentration and profits indices on the remaining 30 market areas are shown in Figure 4.4. Intercorrelations and normality statistics are shown in Table 4.4. All four indices are tolerably normally distributed but the correlations of profits and concentration are considerably higher, and comparable to, though lower than, those reported by Burt (0.243 on 335 four digit industries, 0.324 on 20 two digit industries) and Collins and Preston (R-squares of 0.07 for 1958 and 0.10 for 1963 on 243 four digit industries). Since the correlation of profits with the square root of the Herfindahl is lower than with the untransformed Herfindahl, the latter was reinstated in the interests of conceptual parsimony.

4.5 Summary

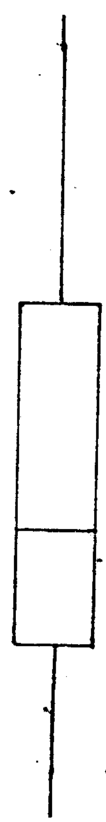
For practical reasons, the theoretical arenas of putative competition -- markets -- were aggregated into 35 market areas, units having approximately the same degree of aggregative coarseness as S.I.C. two digit industry groups. Concentration and profits indices for these units were computed as weighted averages of concentration and profits

Figure 4.4

Distributional plots for Herfindahl, square root of Herfindahl, top-4 concentration, and corrected price-cost margin (N=30).

Stem	Leaf
20	05
19	
18	7
17	0
16	
15	
14	08
13	39
12	
11	47
10	4
9	
8	179
7	69
6	25559
5	13
4	17
3	
2	
1	0378
0	8

Boxplot

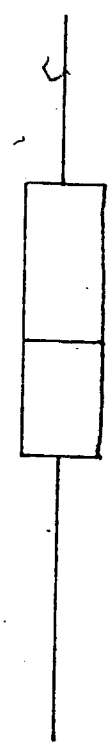


(multiply by 0.01)

(a) Herfindahl

Stem	Leaf
44	73
42	3
40	2
38	5
36	534
34	2
32	27
30	
28	1548
26	36
24	9556
22	61
20	47
18	
16	
14	
12	05
10	04
8	2

Boxplot



(multiply by 0.01)

(b) $\sqrt{\text{Herfindahl}}$

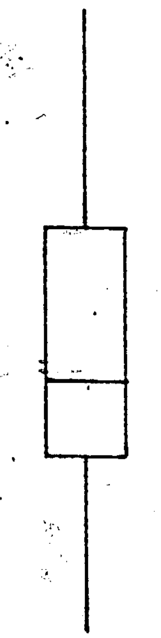
(cont'd)

Figure 4.4 (cont'd)

Stem • Leaf

Stem	Leaf
8	5
8	0
7	56
7	3
6	9
6	134
5	67
5	
4	589
4	0233
3	5689
3	244
2	
2	
1	589
1	13

√Boxplot



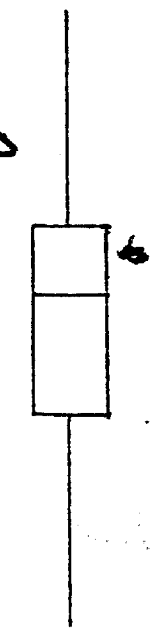
(multiply by 0.1)

(c) Top-4 concentration

Stem • Leaf

Stem	Leaf
44	7
42	
40	7
38	89
36	289
34	03
32	677
30	1467
28	6
26	0448
24	068
22	1386
20	8
18	
16	
14	0

√Boxplot



(multiply by 0.01)

(d) Corrected price-cost margin

for the S.I.C. four digit industries contained within each market area.

Concentration was indexed by the top 4 and top 8 concentration ratios and the Herfindahl index. Profits were indexed by the Collins and Preston price-cost margins, with Burt's correction for capital-output ratios. These corrected price-cost margins were computed for top 4, top 8, and all industry members (within S.I.C. four digit industries).

Top 4 and top 8 profits, and top 8 concentration were found to be redundant. The other indices were found to be tolerably normally distributed, but the square root of the Herfindahl was more highly correlated with profits than the Herfindahl.

Both top 4 concentration and the transformed Herfindahl have much weaker correlations with profits than have previously been reported. This is apparently due in part to the inclusion of five highly atypical and inappropriately aggregated market areas. When these were set aside, correlations between profits and the top 4 concentration ratio and the untransformed Herfindahl index were found to be comparable with, but somewhat lower than, correlations reported by Burt and Collins and Preston.

The top 4 concentration ratio, the Herfindahl index, and the corrected price-cost margins measured on 30 market areas were therefore employed in the tests of the hypotheses developed in Chapter 3.

Table 4.4

Intercorrelations and distributional statistics for selected concentration and profits indices (N = 30).

	HVS	SQRT (HVS)	CPCMT	R-squared CPCMT
RVS4	0.949*	0.962*	0.232	0.054
HVS		0.979*	0.251	0.063
SQRT(HVS)			0.230	0.053

	SKEWNESS	KURTOSIS	W (signif. level)
RVS4	0.093	-0.752	0.962 (0.421)
HVS	0.057	-0.498	0.940 (0.115)
SQRT(HVS)	-0.174	-0.599	0.959 (0.392)
CPCMT	0.070	-0.324	0.987 (0.973)

*Significance level < 0.01.

CHAPTER 5

Operationalization of actors as enterprises

In Chapter 4, I developed indices of concentration and profits for 30 market areas. Measurement of the remaining variable in the model, namely directorship interlocking, is the subject of this and the next two chapters. The "degree of interlocking" is a "structural" variable: i.e. it measures an aspect of the structure of each observation, namely the market area. Each market area contains a certain number (ranging from 14 to 45) of competing units that have informal relationships (here, directorship interlocks) with each other. Thus each observation (market area) in this study is a network, consisting of nodes (actors) and edges (directorship ties). The "degree of interlocking" is a scalar variable that summarizes the structure of these networks as they affect the operation of the market area and are themselves affected by concentration.

In this chapter, I develop the concept of the "enterprise" as the operationalization of the nodes in the networks--the theoretical economic actors. In Chapter 6, I discuss various types of interlocks as the operationalization of the edges in the networks; and Chapter 7 deals with the indices of interlocking based on these operationalized networks.

5.1 The enterprise as the unit of independent economic action

The economic theory of competition in markets is built upon the concept of *independent* competing units. Traditionally, the *firm* has been treated as the empirical independent economic actor (firms of any appreciable size have the legal form of a limited liability joint-stock company, hereafter referred to as a firm, company or corporation). However, there is a significant and growing tendency in modern industrial capitalism for firms to be controlled by other firms, as a result of either the take-over (purchase of shares) of existing firms or the creation of new subsidiaries (Smith 1937 [1776]; Marx n.d. [1867]; Berle and Means 1969 [1932]; Bonbright and Means 1960 [1932]; Larner 1966). Thus the firm has been superseded as the unit of independent economic action by the *enterprise*: a group of firms operating under common control (Berkowitz et al. 1976, 1979a). Firms that are independent of intercorporate control are subsumed as "single-firm enterprises".

The concept of the enterprise as the unit of economic action implies that the actions of all its constituent firms and indeed of the personnel of its constituent firms are simply actions of the enterprise. In effect, the organization of the enterprise into legally separate firms is treated as being no different from the organization of a large firm into several administratively separate divisions (Berkowitz et al. 1976:37; Bonbright and Means 1960 [1932]). In reality, like any collective actor, including the firm, the enterprise is not a perfectly monolithic entity, and the nature of its internal operation is a legitimate subject of study (Bonbright and Means 1960 [1932]; Carrington 1979). However, for the purposes of study of <u>inter-enterprise</u> relationships, questions regarding intra-enterprise functioning can be set aside as outside the domain of inquiry.

The use of the enterprise as the empirical economic actor in markets implies certain specific presumptions regarding the operation of markets and of horizontal interlocking:

(1) Firms that belong to the same enterprise and sell products in the same market do not compete; i.e. they act as though they were the same firm. This presumption has the corollary that in calculating concentration statistics, the market shares of all establishments controlled by each enterprise are added together to compute the market share of each enterprise, the quantity used in calculation of the concentration statistics. This presumption is now widely

accepted; for example, Statistics Canada (1977) has used it in its latest report on industrial concentration in Canada, for 1972:

> The purpose in this report is to group whatever establishment universe is under consideration into enterprises so that all establishments under common control are in the same business enterprise...The presumption is that in this manner the data can be tabulated according to meaningful decision-making entities, that is, the enterprises (Statistics Canada 1977:6).

Thus the concentration statistics used in the present study assume economic action at the enterprise level, since they are based on data taken from this Statistics Canada report.

(2) All of the interlocks formed by any of the firms in an enterprise with firms outside the enterprise are "the enterprise's" interlocks. Thus, in Figure 5.1, enterprises E1 and E2, which are competing in market area X through their member firms F11 and F21, have an interlock via firms F12 and F22. As an interlock between two competing enterprises, this is a <u>horizontal interlock</u>, although it is formed by two non-competing firms. In other words, I presume that <u>any</u> interlock between enterprises competing in a market has anticompetitive ramifications for that market. This follows from the presumption that all the directors of all the firms in an enterprise are "agents" of the enterprise, that in effect the members of the boards of all the firms in an enterprise form a "pool" of potentially co-optive resources that the enterprise, or whoever collectively

control it, can draw upon. Failure to recognize this form of indirectly horizontal interlocking may have contributed to the failure of some other studies of directorship interlocks to find relationships between competition (or its absence) and interlocking.

On the other hand, I presume that there is some difference (in "anticompetitive intensity") between horizontal interlocks between enterprises involving two non-competing firms (F12 and F22 in Figure 5.1) and those involving two competing firms (F11 and F21 in Figure 5.1). I have therefore called the former "indirectly horizontal" interlocks and the latter "directly horizontal" interlocks, and measured and analyzed them separately. This use of the term "indirect" differs from the concept of an "indirect tie" used elsewhere in the social network literature to refer to a tie between two entities that is mediated by a third entity. For example, in Figure 5.2, firm F1 has the latter kind of tie with firm F3 because they have interlocks created by <u>different interlockers</u> (Smith and Jones) with firm F2. In this study I refer to such ties as "P2" ties, following standard network terminology. P2 ties between enterprises that result from interlocks with the same bank (termed "P2 bank-mediated ties") are of special theoretical interest, and are measured and analyzed separately in this study.

Figure 5.1

Indirectly horizontal interlocking

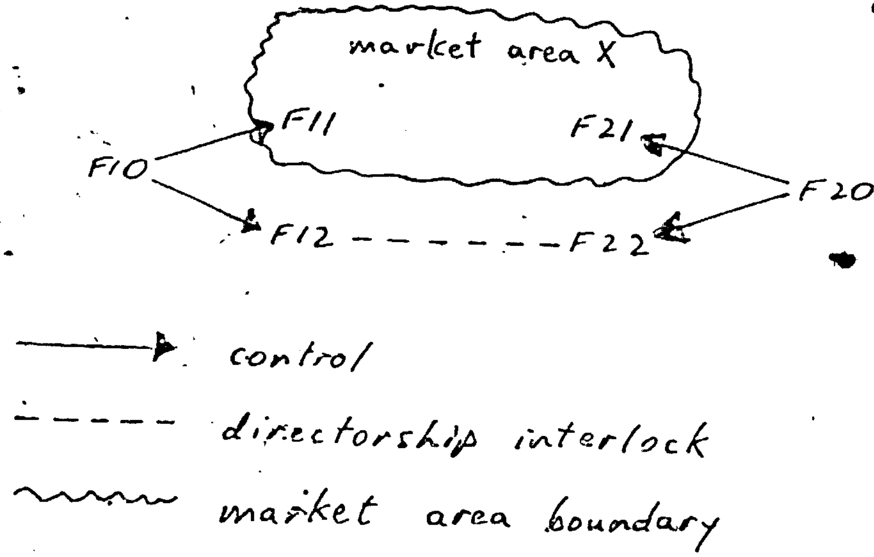
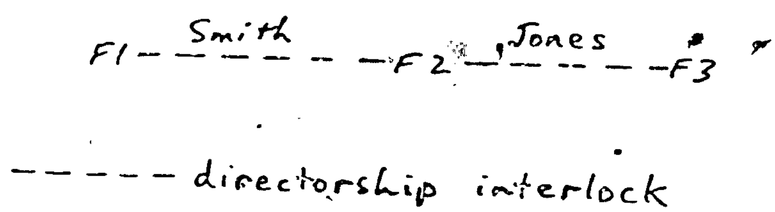


Figure 5.2

P2 interlocking



A further consequence for the study of anticompetitive interlocking of the use of enterprises as actors is that intra-enterprise interlocks are ignored. If two firms are in the same enterprise, their actions are presumed already to be perfectly co-ordinated; thus no co-optive ties can exist between them. (Of course such ties may be taken into account in determining enterprise membership -- see below). Again, failure to exclude intra-enterprise ties, given their relative abundance, may have adversely affected the results of previous studies; instead of variation in anticompetitive interlocking, variation in intra-enterprise management structures would be the major component in an index of interlocking that included these ties.

5.2 Calculation of enterprise membership*

For the reasons given above, it was necessary to determine which firms in the sample formed groups operating under common control, or enterprises. Corporate control is legally a prerogative of ownership: each common share entitles the owner to one vote at shareholders' meetings where company policy is decided and the board of directors, which is empowered to manage the firm (a function it delegates to hired managers) is elected. Thus ownership of more than 50% of the common shares of a firm by one actor--a person, a group, or another firm--confers upon that actor

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*This and the following sections of Chapter 5 are partly based on an earlier report by Berkowitz, Carrington, Kotowitz and Waverman (1979a).

control over policy and management of the firm.

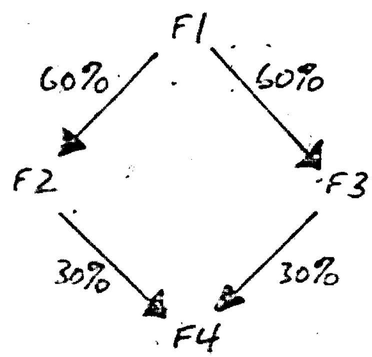
From this definition of control, it follows that control is transitive and additive. By transitivity, I mean that if Firm F1 holds a majority of shares in Firm F2, and therefore controls it, and Firm F2 holds a majority of shares in Firm F3, and therefore controls it, then Firm F1 controls Firm F3. Firm F1 directs all of the actions of firm F2, including its voting of its shareholding in Firm F3. This chain of control has no theoretical limit. In reality, of course, control of something as large and complex as a large firm is not so straightforward; and long chains of control are no doubt subject to various forms of attenuation. However, such chains of control are generally only a few links in length (Berkowitz et al. 1979a).

By additivity, I mean that the shareholdings in a given firm of all the firms in an enterprise are added to determine control. In Figure 5.3, for example, F1 controls F2 and F3, and therefore, controls how the shareholding of each firm in F4 (30%) is voted. Thus, the enterprise (F1, F2, F3) owns 60% of the shares in F4, and controls it.

Setting aside temporarily the property of additivity, enterprise memberships can be determined by computing the transitive closure of the direct control digraph G which results from application of the simple control criterion (share ownership > 50%) to the ownership network. In Figure 5.4, for example, panel (1) shows a section of a typical

Figure 5.3

Transitivity of corporate control and additivity of shareholdings *



x ——→ y % of voting shares in y owned by x

* adapted from S.D. Berkowitz et al. (1979: 399).

intercorporate share ownership network, panel (2) shows the associated direct control digraph, and panel (3) shows the transitive closure, where each maximal complete component is an enterprise.

Some firms own shares in the firm that controls them. For purposes of clustering firms into enterprises, control in either direction is a sufficient criterion; mutual control has no effect on the concept of the enterprise as a collective actor, although it no doubt has ramifications in its internal functioning. In order to use the mathematics of acyclic digraphs, all mutual ownership cycles at any remove (e.g. A-C in Figure 5.4, panels 1,2) are arbitrarily reduced to one-way control (A-C, panel 3).

The computational method is given by Harary et al. (1965: 118-121): add together the successive powers (under Boolean arithmetic) of the control matrix G associated with the direct control digraph, since:

(5.1) $g_{ij}^{n}\# = 1$ (where "#" indicates Boolean arithmetic)

if and only if there is a path of length n from vertex v(i) to vertex v(j), and

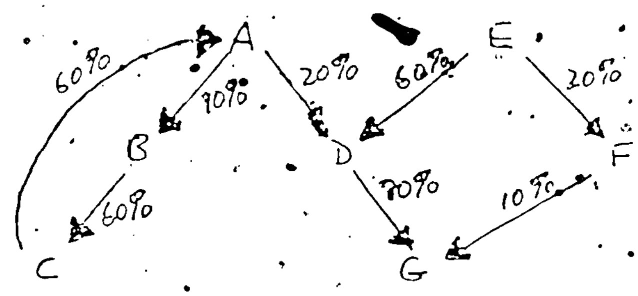
(5.2) $\sum_{k=1}^{n} (g_{ij}^{k})\# = 1$

if and only if there is at least one path of length <= n from vertex v(i) to vertex v(j)

Figure 5.4.

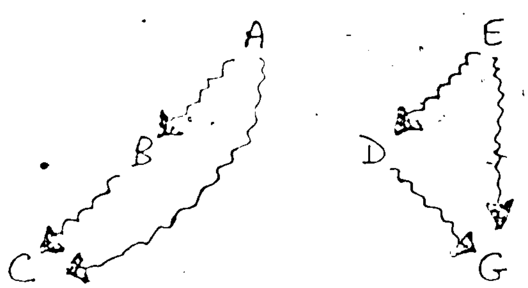
Transitive closure of corporate control

(1) Ownership network



(2) Direct control digraph

(3) Transitive closure of (2)



x ⟶ y % of voting shares in y owned by x

x ⇝ y x controls y

This summation is complete at the (n-1)th power of G where there are n vertices. However, given that the digraph is acyclic, any path of length q (> 1) contains a path of length q-1. Thus it is sufficient to sum successive Boolean powers of the control matrix to the qth power where:

$$(5.3) \quad \left(\sum_{k=1}^{q+1} (G^{k})\right)^{\#} = \left(\sum_{k=1}^{q} (G^{k})\right)^{\#}$$

since, for all m, m>q:

$$(5.4) \quad \left(\sum_{k=1}^{m} (G^{k})\right)^{\#} = \left(\sum_{k=1}^{q} (G^{k})\right)^{\#}$$

(although the (q+1)th power of G may be nonzero, but have paths that duplicate those in the first through qth powers of G). Using equation 5.3 to check for termination of the powering of G is useful for corporate networks, where n may be large but q is generally less than 10.

Strict application of transitive closure fails, however, to take account of the additivity of share ownership within an enterprise (see above). Thus a "stepwise" transitive closure procedure is necessary (see Table 5.1 for an illustration of the procedure applied to the network of Figure 5.3; a mathematical treatment is given in Figure 5.5). At each step i, a control digraph C was computed by applying the control criterion to the cumulative ownership matrix M(i). Cumulative ownership for the (i+1)th step was then computed by adding ownership only where a control path existed to that point. The procedure was terminated at the step where all further control paths stopped.

The result was a cumulative ownership matrix (M3 in Table 5.1) showing the cumulative shareholding by each enterprise in each node of the network. "Enterprise heads" were defined as the firms in which no enterprise owned a controlling shareholding, and "members" as those firms in which an enterprise did hold a controlling shareholding. ("Joint ventures" are discussed below).

5.3 Minority control

The enterprise memberships used in the present study were determined by a slight modification of the above procedure, introduced by Berkowitz et al. (1979a) to take account of minority control.

It is possible to have effective control of a corporation with a shareholding less than an absolute majority. If one actor holds the largest block of shares, and no other shareholder or well-organized group of shareholders holds a block of comparable size, then that actor can normally outvote other shareholders at meetings; controlling the composition of the board of directors, and thus the operation of the firm. Control of the board of directors confers further advantages over other shareholders

Table 5.1

Stepwise transitive closure procedure

(1) Ownership matrix M1:

	F1	F2	F3	F4
	0	0.6	0.6	0
	0	0	0	0.3
	0	0	0	0.3
	0	0	0	0

(2) Control matrix C1:

	F1	F2	F3	F4
	0	1	1	0
	0	0	0	0
	0	0	0	0
	0	0	0	0

(3) Cumulated ownership M2:

	F1	F2	F3	F4
	0	0.6	0.6	0.6
	0	0	0	0.3
	0	0	0	0.3
	0	0	0	0

(4) Cumulated control C2:

	F1	F2	F3	F4
	0	1	1	1
	0	0	0	0
	0	0	0	0
	0	0	0	0

(5) Continue, since C2 > C1.

(6) Cumulated ownership M3:

	F1	F2	F3	F4
	0	0.6	0.6	0.6
	0	0	0	0.3
	0	0	0	0.3
	0	0	0	0

(7) Cumulated control C3:

	F1	F2	F3	F4
	0	1	1	1
	0	0	0	0
	0	0	0	0
	0	0	0	0

(8) Stop, since C3 = C2.

Figure 5.5

Stepwise transitive closure procedure for the determination of enterprise groupings*

Let $D = (V, A, \phi)$ be the ownership network in which:
$V = \{v\}$ is the set of vertices,
$A = \{a\} \subseteq V \times V$ is the set of arcs,
ϕ is a function (the ownership fraction) defined on A such that:
$0 \leq \phi(a) \leq 1$,
p is the control criterion, where $0 < p \leq 1$,
s is the joint venture spread criterion, where:
$0 < s < 1$.

Let M_1 be the value matrix associated with D where:

$$M_1(v_i, v_j) = \phi(a_{ij}).$$

Let λ be a loop-removal function on M such that:

$$\lambda(m(v_i, v_j)) = m(v_i, v_j)(1 - \delta(i,j)) \text{ where:}$$

$$\delta(i,j) = \begin{cases} 1 & \text{if } i = j, \\ 0 & \text{otherwise.} \end{cases}$$

Let β be a "binarizing" function on M such that:

$$\beta(m) = \begin{cases} 1 & \text{if } m > p, \\ 0 & \text{otherwise.} \end{cases}$$

Define M_i $(i > 1)$ recursively as:

$$M_i = \beta(M_{i-1})\lambda(M_1) + \lambda(M_1).$$

Let the final, or target, matrix M^T be defined as M_i where:

$$(M_{i+1}) \quad (M_i).$$

Then define:

1. the set of enterprise heads (or "parents") as:
   $H \quad \{h\} \subseteq V$ where:

   $$\forall w, w \in V, m^T(w,h) \leq n,$$

2. the set of joint venture heads as:
   $J \quad \{j\} \subset V$ where $\exists \{h_1, h_2, \ldots, h_n\} \subset H$ where $n > 1$ and $h_i \neq h_k$

   such that:
   $\forall i, 0 < i \leq n, m^T(h_i, j) > p$, and

   $\forall i, \forall k, 0 < i, k \leq n, i \neq k, |m^T(h_i, j) - m^T(h_k, j)| \leq s$,

3. the set of enterprise members as $E \quad \{e\} \subset V$ where:

   $$\exists h_t \in H \cup J \text{ such that } m^T(h_t, e) > p, \text{ and}$$

   $$\forall h_i \in H \cup J, i \neq t, |m^T(h_t, e) - m^T(h_i, e)| > s.$$

Then $V \quad H \cup J \cup E$ and $H \cap J \quad H \cap E \quad J \cap E \quad \emptyset$.

*Adapted from S.D. Berkowitz et al. (1979:433).

due to privileged access to information, etc. This "minority control" is always open to challenge if a group of competing shareholders with a large enough combined holding arrange to vote together, but such challenges are hard to mount if shareholding is widely scattered. In their original formulation of this now widely-accepted theory, Berle and Means (1969 [1932]) estimated that minority control of large American corporations was possible with as little as 20% of the shares. In a much more recent study, Larner (1966) claims that 10% of the stock is sufficient to control many large U.S. firms.

The problem faced by the researcher who wants to determine enterprise memberships is to separate cases of minority control from cases of minority shareholdings that are not accompanied by control.

Berkowitz et al. argued that minority control of a firm by an enterprise is indicated where the shareholding enterprise has been able to control the composition of the board of directors of the firm in question. Control of the board in turn is indicated by the presence of a substantial number of the owning enterprise's directors on the board of the owned firm - i.e. a substantial number of interlocks between the enterprise and the firm. The obvious operational problem is to determine what combination of shareholding and interlocks constitutes control.

Berkowitz et al. solved this problem by exploring the effects on enterprise memberships of the use of various combinations of ownership and interlocks as criteria of control. On the basis of tests of "robustness", "sensitivity", "inclusiveness", and "efficiency" (1979a:405-410), including comparisons of their heuristic results with data on "acknowledged" minority control provided by Statistics Canada and the Department of Consumer and Corporate Affairs, they concluded that where a minority shareholding of at least 15% and at least two directorship interlocks existed, each directorship interlock could be treated computationally as being worth a 12% shareholding. Thus, three directorship interlocks are needed to indicate control with a bare 15% shareholding (15% + 3*12% = 51%); two interlocks suffice for a shareholding of at least 27% (27% + 2*12% = 51%). Single interlocks were found to have no value as indicators of control, given their abundance and apparently random distribution.

This definition of minority control was incorporated into the stepwise transitive closure procedure for determining enterprise memberships by computing a revised original ownership matrix M', where ownership percentages were increased appropriately; and retaining the >50% control criterion. However, it was now possible for the sum of all "pseudo-shareholding" in a firm to exceed 100%, and for more than one enterprise to hold a controlling pseudo-shareholding in a firm. Firms with this multiple minority control and no clearly dominant owner were treated as "joint ventures" (see Figure 5.5): they, and any firms they controlled, were treated by Berkowitz et al. as separate enterprises with special relationships with their joint parent enterprises.

In the present study, these joint ventured enterprises are treated as separate enterprises, but of course they show strong co-optive ties with their parent enterprises. There are very few joint ventures in the sample, so their treatment is not significant.

5.4 Data

Data on ownership and directorship interlocks among 5306 firms were provided by the "Structural Analysis of the Canadian Economy Project," at the Institute for Policy Analysis, University of Toronto (principal investigators: Professors S. D. Berkowitz, L. Felt, Y. Kotowitz, L. Waverman). The full database from which these data were taken has been described in detail by Berkowitz et al. (1979a, 1979b, 1977, 1976); the following summary draws upon these reports.

The sample of firms included a core of 361 large Canadian public, private and Crown corporations representative of, and including most of the largest firms in, all major sectors of Canadian economic activity (comparable to the widely-used Fortune list of 796 major U.S. firms). This core was then "snowballed" on ownership ties: all firms connected to these firms (as owners or owned) by shareholdings of any size (where reported) and at any remove, were added to the sample.

This procedure included, in principle, foreign firms, where they were connected by ownership at any remove to the core 361 Canadian firms. However, because the principal source of ownership data (see below) included no foreign subsidiaries of Canadian firms, and only the immediate foreign parents of Canadian firms, other foreign connections had to be found using other non-comprehensive sources of data (Berkowitz et al. 1976:27). Thus, although all foreign "parentage" chains were traced, the search could not be exhaustive; and nearly all foreign subsidiaries were excluded. This lacuna probably had little effect on the determination of enterprise memberships, since an intensive effort was made to trace controlling foreign parents at any remove. It may also have had little effect on the study of inter-enterprise interlocking since interlocks between non-controlling foreign affiliates may have little effect in Canada. This possibility could not be verified with these data.

This procedure resulted in a sample of 5306 firms, all of which were tied by shareholding at some remove to at least one of the large 361 firms. This sample was taken to be representative of all major economic activity in Canada. Its use in the present study probably introduced one important bias: given their selection by shareholding, these 5306 are probably much more densely interlocked also by directors than the population of all Canadian firms. Thus the "horizontal interlocking in markets" discussed in this dissertation is limited to interlocking among probably the largest and most heavily interlocked actors in markets. The 14 to 45 enterprises per market area in this sample form a group which, while by no means completely connected, probably contains the functioning core of any co-ordinated oligopolies that exist. Most of the smaller "fringe firms" discussed in the industrial organization literature probably do not appear in this sample. This bias in the <u>sample</u> should not, however, induce any bias in the <u>results</u> of this study, since both concentration and profits, the two correlates of interlocking, were measured over all firms in the markets in the data I have employed (see Chapter 4); and since the sample of 5306 firms used for interlock data should be fairly uniformly representative of major activity in each market area. Further research on a sample of firms including more of the fringe firms is needed to verify this presumption.

Ownership data used to calculate enterprise memberships were taken from Statistics Canada's <u>Inter-Corporate Ownership</u> (1972). Directorship interlock data were taken primarily from the Financial Post's <u>Directory of Directors</u>

(1972). These were supplemented with executive board membership data collected by the Royal Commission on Corporate Concentration (Berkowitz et al. 1976:28-29). While all of these sources have limitations, discussed in detail by Berkowitz et al. (1976:22-29), I judged them to be quite adequate for the purposes of this study, and far superior to the data available to other studies of corporate interlocking.

5.5 Results

Application of the stepwise transitive closure procedure to these 5306 firms produced 1463 enterprises, including 973 single-firm and 490 multi-firm enterprises. The average number of firms in the multi-firm enterprises is 6.91, with a median enterprise size of 5 firms.

Of these 1463 enterprises, 551 could not be assigned to market areas because data on the S.I.C. codes of their member firm(s) were not available in the data base. Almost all of these are foreign single-firm enterprises, quite peripheral to this study. An additional 326 enterprises were eliminated because their member firms have S.I.C. codes (S.I.C. > 800) indicating non-economic activity (e.g. government services) or interstitial to the market areas as defined (see Appendix A, Table 1 for market areas and associated S.I.C. codes).

The remaining 586 enterprises, including nearly all of the original 490 multi-firm enterprises, are distributed over 82 market areas, with an average of 15.4 enterprises (excluding banks) per market area. Many operate in multiple market areas: the average number of market areas per enterprise is 2.6. Although 30 market areas were selected in Chapter 4 for analysis, data on all 82 market areas were used to measure interlocking (see Chapter 6) in order to have as wide as possible a variety of interlock networks on which to explore various definitions of ties.

5.6 Summary

In this chapter, the rationale was explained for treating enterprises rather than firms as actors in markets; and a computational procedure was developed for determining the enterprise memberships of firms, using intercorporate ownership and directorship ties. This procedure was then applied to the data available on a sample of Canadian firms and their foreign affiliates, and the characteristics of the resulting sample of enterprises were described. These enterprises are the nodes of the interlock graphs on which indices of interlocking are defined in Chapter 7. In the next chapter, non-control interlocking between these enterprises is examined in order to define the edges in these graphs.

CHAPTER 6

Operationalization of ties between enterprises*

A directorship/officership tie or interlock exists between two enterprises when a director (i.e. member of the board of directors) or officer (i.e. one of the few top ranks of management, such as president, vice-president, etc.) of a firm in one enterprise is a director or officer of a firm in the other enterprise.

Although the measurement of such ties would appear to be straightforward, it is actually very difficult, and little is known about how to do it properly. However, faulty measurement of interlocks can cause over- or under-estimation of the strength of effects in associational analyses, or misreading of the pattern of interlocks in structural analyses. Failure to deal adequately with the measurement problem may well be a major factor contributing to the weakness or inconclusiveness of the results obtained

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*Most of the research reported in this chapter was done in collaboration with G. H. Heil.

by some previous interlock studies (e.g. Waverman and Baldwin 1975; Carroll et al. 1977; Burt et al. 1979:27).

Directorship interlocks between enterprises are characterized by both multiplexity and multiplicity. By multiplexity I mean qualitative variation: there are different types of interlocks between enterprises (cf. Mitchell 1969 on multiplexity in personal networks). By multiplicity I mean quantitive variation: there are different numbers of each type of interlock between enterprises. Furthermore, for heuristic reasons, different types of ties may be combined into one type of tie--for example, by summing their matrices (see Sections 6.3 and 6.4 below). Then multiplexity is reduced and multiplicity of each type of tie is (generally) increased--although the overall number of ties of all types may remain constant.

This chapter discusses the problems involved in measuring the multiplexity and multiplicity of interlocks and the solutions adopted in this study.

6.1 Quantitative variation

The multiplicity, or number, of each type of tie has two components in its variation. The pair of interlocked firms in the two enterprises may have one or more directors in common; and there may be multiple pairs of interlocked firms in the two enterprises. In Figure 6.1, for example, there are three ties between the two enterprises.

This quantitive variation has been handled in various ways by other researchers (no previous research has dealt with enterprise-level interlocks, so only the problem of multiple ties between firms has arisen). Some researchers have ignored quantity, and treated firms as either tied or not tied (Burt et al. 1979). Others have adopted this binary approach but required at least two interlocks between firms for a tie to be coded as existing (Sonquist and Koenig 1976; Berkowitz et al. 1979a). Others have treated the number of interlocks between pairs of firms as an index of "closeness" (Levine 1972) or the number of interlocks made by a single firm as an (interval-level) attribute of the firm (Waverman and Baldwin 1975; Dooley 1969). Berkowitz (1980) has argued that this assumption that a simple count of interlocks appropriately measures the intensity of the relationship is not well-founded.

In this study I took the position that both the simple existence of one or more interlocks between enterprises and the intensity of the relationship indicated by the number of ties, should be considered as correlates of concentration and profits. However, the simple count seemed an unrealistic index of intensity, since it does not reflect the presumed diminishing significance* of each additional interlock

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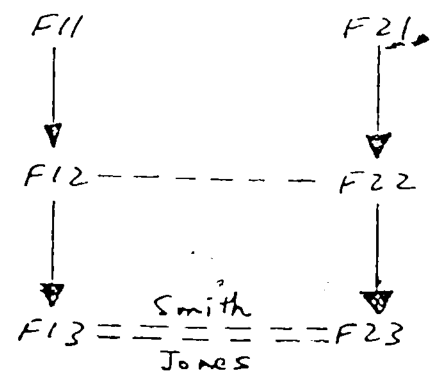
*Cf. the diminishing importance to the mother of each additional child (Goldberg and Coombs 1963) mentioned by McFarland and Brown (1973) in their discussion of the measurement of social distance.

Figure 6.1

Forms of multiple director interlocks between enterprises

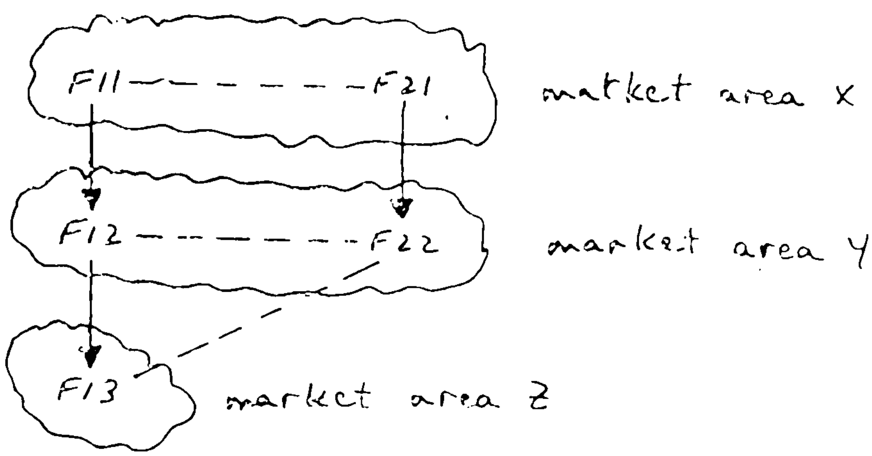


——▶ control

- - - - - director in common

Figure 6.2

Directly and indirectly horizontal interlocking



——▶ control

- - - - director in common

~~~~ market area boundary
~~~~

between the same two enterprises and the crucial importance of the simple "tied/not tied" distinction. Therefore, the range of the real-valued index of intensity was compressed by taking log and limit functions of the number of interlocks, giving the equivalences shown in Table 6.1. These values were then divided by 4 so that they ranged from 0 to 1:

$$(6.1) \qquad V = (\text{MIN}\ (4,\ \text{LOG}_2\ (1 + x)))\ /\ 4$$

where:
V = rescaled tie intensity,
x = number of interlocks.

Of course, this choice of function was arbitrary; however, a systematic comparison of numerous transformations would have overly complexified the research, and was judged to be more appropriately carried out <u>after</u> the present study had established that a relationship did in fact exist among interlocking, concentration and profits.

6.2 Qualitative variation

The qualitative variation, or multiplexity of, interlocks is more complicated. Interlocks vary in the relationship of the interlocker with each firm, and in the market relationship of the firms involved.

The best indicator available of the interlocker's relationship with each firm is his formal title: member of the board of directors, member of the executive board, chairman of the board, president, vice-president, etc. These data are far from ideal, since the meaning of these terms

Table 6.1

Transformation table for intensity of interlocking

$$f(x) = MIN(4, \log_2 (x + 1))$$

Number of interlocks	f (x)
0	0
1	1
2	1.58
3	2
.	.
.	.
7	3
.	.
.	.
15	4
>15	4

varies from firm to firm, but are all that one can obtain, short of extensive surveys, interviews, and exercise of intuition. And the constant component across firms in their meaning probably far outweighs the variable component.

These formal titles were reduced to three categories. These are, in order of presumed intensity of tie to the firm: officers, who are generally salaried, full-time employees of the firm; members of the executive board, who are charged by the board of directors to act for the board on a day-to-day basis; and members of the board of directors, whose involvement with the firm may constitute as little as attending one or a few meetings a year (Berkowitz et al. 1976:28). Waverman and Baldwin (1975) have established that almost all officers who form interlocks are also directors. Executive board members are always directors and are sometimes also officers. Thus the two most intense affiliations are practically always accompanied by the least intense. In other words, there are four kinds of corporate directors: those who are also officers, those who are also executive board members, those who are also both of these, and those who are simply directors. I therefore treated each of the three types of affiliations held by an interlocker as a separate affiliation; a single person could have up to three ties with a firm. This ensured that the <u>counted</u> <u>number</u> of interlocks between firms reflected the intensity of the interlocker's association with each firm. If, for example, he was an officer and director of one firm, and director (only) of the other firm, he created two interlocks between the firms. If he was director and executive board member of both, he created 4 interlocks (subject to the rescaling discussed above of the sum of all these interlocks for the pair of enterprises).

Data on executive board memberships are difficult to obtain and to interpret. As the committee of the board of directors empowered to act for it on a day-to-day basis, the executive board may be seen as the small, active core of the board. Firms with relatively small boards of directors do not have executive boards; in effect, the whole board is its own executive committee (Berkowitz et al. 1976b:28-29). Executive board memberships are not reported by the *Directory of Directors* and are reported incompletely by company reports (*Ibid.*). Berkowitz et al. collected executive board data by assuming that firms with a board size of seven or fewer members (the mean board size for their sample of firms was approximately seven) had no executive board, and supplementing their documentary sources for firms with larger boards with a mailed survey of firms carried out for them by the Royal Commission on Corporate Concentration.

They then tested the hypothesis that executive board members are particularly important in *intra*-enterprise control by comparing enterprise groupings computed on combined ownership and executive board membership ties with groupings computed on combined ownership and (undifferentiated) directorship ties. They concluded that executive board ties were _inferior_ to undifferentiated directorship ties for identifying intercorporate control (Berkowitz et al. 1978:405:410).

This research has two implications for the treatment of executive board ties in the present study. The fact that executive board ties produced some significantly _different_ enterprise groupings from undifferentiated directorship ties suggests that executive board members do perform functions that are different from those of simple directors. Executive board members are apparently not primarily involved in intra-enterprise control, but they may be involved in inter-enterprise co-optation. Practically, however, the fact that executive board membership is identical with simple membership in the board of directors for half the firms in the sample (those with small boards) may conceal variation in the other half, and cause results based on executive board ties to be very similar to those for directorship ties. However, there is certainly a _prima facie_ case for initially differentiating the two types of tie.

Given three possible affiliations with each of two firms, there are nine possible types of relationships between firms by virtue of the interlocker's affiliation with each (see Table 6.2). Since each of these nine represents a qualitatively unique relationship between firms, they were coded separately. Thus for each of the 82 market areas, 9 graphs were coded, each with the enterprises in that market area as nodes and one of the types of affiliation-pairs as edges. The method used to reduce these to a more manageable number is described in Section 6.3.

Directorship interlocks between enterprises also vary in the market relationship of the firms and enterprises involved. A <u>horizontal</u> tie is a tie between two <u>enterprises</u> that sell in the same market area. In Chapter 5, a distinction was made between <u>directly</u> horizontal ties, where the two interlocked <u>firms</u> operate in the same market area, and <u>indirectly</u> horizontal ties, where at least one of the interlocked <u>firms</u> is outside the market area. In Figure 6.2, both enterprises are involved in market area X. When competition in this market area is considered, enterprises E1 and E2 have a directly horizontal tie made by firms F11 and F12, and indirectly horizontal ties made by firms F12-F22 and F13-F22. However, when market area Y is under consideration, the F12-F22 tie is a <u>directly</u> horizontal tie and the F11-F21 tie is indirectly horizontal. The distinction is made in this way because interlocks where both firms are in the market area are expected to have special significance for (anti-)competition in that market area.

By the same logic, interlocks involving two firms that are <u>both</u> outside the market area (e.g. F12-F22 and F13-F22

Table 6.2

Types of relationships between interlocked firms by virtue of the interlocker's affiliations

	Affiliation with firm 2		
Affiliation with firm 1	Executive board	Board of directors	Officer
Executive board	EE	ED	EO
Board of directors	DE	DD	DO
Officer	OE	OD	OO

Table 6.3

Types of interlocks between enterprises by virtue of the market relationships of the interlocked firms

		Market relationship of firm 2	
		In market	Outside market
Market rel'nship of firm 1	In market	II	IO
	Outside market	OI	OO

with respect to market area X) are expected to have the least significance for competition in the market area. Thus interlocks between enterprises fall into four categories by virtue of the market relationships of the firms involved (Table 6.3), and a particular interlock may fall into different categories in considering its effect in different market areas.

The combination of these four categories of market relationships with the nine categories of affiliation-pairs results in a multiplexity of 36 categories of interlocks between enterprises, each having its own distinct graph, for each market area. Since this number of categories was unmanageable (especially since each category had 2 graphs -- one with binary-valued edges and one with real-valued edges), an attempt was made in the interests of parsimony to reduce them by eliminating redundant graphs.

6.3 Reduction of interlock graphs

In the multivariate analysis of attributes of populations, the standard method for reducing a large number of theoretically related and empirically associated variables is the family of techniques known as factor analysis. Factor analytic techniques enable one to derive one or a few new variables, called factors, that are linear combinations of the original variables, and that adequately reflect the variation that is common to all the original variables or to subsets of them. In factor analysis the common "variation" that is reflected by the derived factors is variation in the quantity of various attributes possessed by members of the population.

A related notion is used in the network analysis of social structures. Here the variation under consideration is variation in the patterns of ties among members of a population. Where members of a population have identical patterns of ties for two or more types of tie, the types of tie are treated as one type of tie. This principle, termed the "axiom of quality" (Boorman and White 1976:1393), was originally proposed by Lorrain and White and justified on grounds that may be summarized as: "it is not necessary to distinguish in the abstract what is nowhere concretely distinguished"(1971:51).

In practice, one rarely finds two empirical types of tie with identical patterns on a population, just as one rarely finds two scalar variables with identical distributions on a population. Therefore we extended the axiom of quality to a weaker version: where two types of tie have similar patterns on a population they may be adequately represented by a single type of tie. This weakening of an impractically restrictive condition to a more useful version is analogous to the weakening of Lorrain and White's (1971) original formulation of the structural equivalence of entities that made blockmodelling possible as a practical method of social research: instead of requiring that nodes of a graph have *identical* patterns of ties in order to be treated as the same node, blockmodel analysis requires only that nodes have *similar* patterns of ties (White et al. 1976; Arabie et al. 1978; Carrington and Heil 1979).

Thus the 36 types of tie defined in Section 6.2 were reduced in number by creating new types of tie, each representing a subset of the original types of tie that were similar to one another and different to those in the other subsets.

Since the present study is concerned only with *intra*-market-area ties, similarity of types of tie was assessed within each market area, rather than on the entire population of enterprises as a whole. Computing similarity within market areas has two important incidental advantages: (1) the consistency of the computed similarities can be assessed over 82 market areas--in effect there are 82 replications of the procedure, and (2) it is much easier, given the limitations of available computer memory, and uses less computer resources (and therefore money) to do arithmetic 82 times ~~separately~~ on 36 matrices, averaging about 25 nodes each (a total number of elements of about 82 x 36 x 25 x 25 = 1,845,000) than once on 36 matrices with the entire population of 586 nodes (a total number of elements of about 36 x 586 x 586 = 12,362,256).

Factor analysis as a method for combining types of interlocks was rejected for two reasons: (1) since the obttained factors would have been combinations of the original types of interlock, it would have been difficult to have given substantive interpretations to these factors, if they were in fact found to be associated with concentration and profit margins, and (2) since the particular linear combinations of types of tie would have been different for each market area, it would have been difficult to have compared them across market areas. Instead, we decided to cluster the types of interlock so that they would not be converted to abstract factors, and because clusterings could be compared fairly easily across market areas.*

There are a large number of techniques available for clustering (for recent reviews see Bailey 1975; Everitt 1974; Cormack 1971). Because of the large number of clusterings to be performed, and the considerable cost of running many computer clustering procedures and our limited resources, we chose the very simple and fast, but tolerably accurate, McQuitty hierarchical "elementary linkage analysis" method (McQuitty 1957; Heil 1974).

Thus the problem of reducing the original 36 types of interlocks to a smaller number of combined types of interlocks was defined as the problem of clustering 36

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*See Nunnally (1967:364-365) for the similarity of factor analysis and clustering.

entities (each entity being a graph or matrix reporting the occurrence of a particular type of interlock among the enterprises in a market area) into a relatively few internally similar groups, and repeating this procedure on the 82 market areas, comparing the 82 obtained clusterings for consistency; then forming a new type of combined-interlock from each clustered group by combining the interlocks it contained in some way that was consistent over all 82 market areas.

In order to cluster the 36 types of interlock in each market area, it was necessary to compute the similarity between pairs of matrices representing pairs of types of interlock, building a 36 x 36 inter-interlock similarity matrix which could be clustered (similar to the correlation matrix that is input to factor analytic procedures). The similarity of two matrices was defined as the correlation between them, computed using the obvious extension to real-valued matrices of Katz and Powell's (1953) method for computing the "conformity" of two binary-valued matrices (see also Carrington et al. 1980). The two n x n matrices are unravelled, forming two vectors of length n-squared, and the correlation between the vectors is computed from the usual Pearson product-moment formula, except that matched pairs of elements are omitted from the calculation if either element is an "undefined" element of its matrix; in the present study, all main diagonal elements are undefined.

Application of this procedure would have yielded a 36 x 36 matrix of correlations among the 36 interlock matrices--which could then have been clustered--for each market area. However, because of the very considerable overlap (due to data collection procedures) between executive boards and boards of directors and the empirical overlap between officerships and directorships, we expected that the major structural variation would occur across the four enterprise market relationhips rather than across the nine affiliation pairs. If this were true, it would have the important practical implication that we could cluster affiliation-pairs <u>within</u> each of the four market-relationships -- three, actually, since the "in-out" graph was the transpose of the "out-in" graph. This would involve considerably fewer computations, and therefore cost less, since it would necessitate the calculation of intercorrelations and clusterings on only three 9 x 9 sets of elements per market area rather than one 36 x 36 set.

This expectation was checked by performing a full 36 x 36 clustering on four market areas selected as representative of the diversity of types of industrial organization in the 30 market areas included in the logging, mining and manufacturing sectors: (2) logging, (10) rubber, (12) clothing, and (25) automobiles, trucks and parts. In all four market areas the coarsest clustering was into the four market-relationships, confirming our expectation.

Therefore, the procedure applied to each of the 82 market areas was to compute and cluster a 9 x 9 inter-interlock matrix of affiliation-pairs (EE, ED, EO, DE,...OO) for each of the three market-relationships -- IN-IN, IN-OUT added to OUT-IN (i.e. the symmetric sum of the transposes), and OUT-OUT -- and a fourth 9 x 9 "grand" correlation matrix based on the sums of these three sets of matrices. This resulted in four possible clusterings of the 9 affiliation-pairs for each of the 82 market areas.

The consistency of the clusterings over the 82 market areas was then assessed by comparing (only) the clusterings based on the "grand" summed matrices. The 82 market areas were first clustered into groups with similar patterns of intercorrelations of types of interlocks by a further application of the McQuitty procedure: an 82 x 82 correlation matrix was constructed by computing, as above, the intercorrelations of each pair of "grand" 9 x 9 correlation matrices for individual market areas; this 82 x 82 matrix was then clustered using McQuitty's method. At the coarsest level, this produced five groups of market areas. Individual market area clusterings on the "grand" matrices were then examined for consistency within and across the five groups.

These clusterings, divided into the five groups, are shown in Table 6.4. They show a fairly consistent overall pattern. There are two main clusters -- EE, ED, DD; DE, and

Table 6.4

Coarsest McQuitty clusterings of interlocks based on affiliations of interlocker (market areas grouped by similarity of inter-interlock correlation matrices)

Key to numerical codes for types of interlocks:

		Affiliation with firm 2		
		E	D	O
Affil'n with firm 1	E	1	2	3
	D	4	5	6
	O	7	8	9

Market area	Clusters		
Group 1			
29	1 2 4 5 6 8	3 7 9	
26	all in one cluster		
82	1 2 4 5 6 8	3 7 9	
49	all in one cluster		
25	1 2 3 4 5 6 9	7 8	
30	all in one cluster		
63	all in one cluster		
Group 2			
59	1 2 4 5	3 6 9	7 8
37	1 2 4 5 8	3 6 7 9	
2	1 2 4 5 7 8	3 6 9	
15	all in one cluster		
77	1 2 4 5	3 6 9	7 8
65	1 3 4 6 7	2 5 8 9	
8	1 2 4 5 7 8 9	3 6	
40	1 2 4 5 6 8	3 7 9	
21	1 2 4 5 6 8	3 7 9	
43	1 2 4 5 6 8	3 7 9	
24	1 2 4 5	3 7 9 6 8	

(cont'd)

Table 6.4 (cont'd)

Market area	Clusters		
Group 3			
55	1 2 4 5 6 9	7 8	
56	1 2 4 5 7 8 9	3 6	
42	1 2 4 5 8	3 6 7 9	
54	1 2 3 4 5 6 9	7 8	
67	1 2 3 4 5 6 9	7 8	
31	1 2 3 4 5 6 9	7 8	
44	all in one cluster		
53	1 2 4 5 7 8	3 6 9	
17	1 2 4 5 6 9	7 8	
7	all in one cluster		
3	1 2 4 5	3 6 9	7 8
20	1 2 4 5 8	3 6 7 9	
9	1 2 4 5 7 8	3 6 9	
78	1 2 4 5 6 8	3 7 9	
22	1 2 4 5 7 8	3 6 9	
19	1 2 4 5	3 6 7 8 9	
75	1 2 4 5	3 6 9	7 8
74	1 2 4 5	3 6 7 8 9	
14	1 2 4 5	3 6 9	7 8
61	1 2 4 5	3 6 7 8 9	
46	1 2 4 5 8	3 6 7 9	
38	2 4 5 6 8	1 3 7 9	
28	1 2 4 5	3 6 7 8 9	
27	1 2 4 5 7 8	3 6 9	
33	2 4 5 8	1 3 6 7 9	
79	1 2 4 5	3 6 9	7 8
45	all in one cluster		
Group 4			
35	2 4 5 6 8	1 3 7 9	
60	1 2 4 5 6 8	3 7 9	
1	2 8	1 3 7 9	4 5 6
11	1 2 4 5	3 6 9	7 8
47	1 2 4 5 6 8	3 7 9	
70	2 4 5 6 8	1 3 7 9	
72	all in one cluster		

(cont'd)

Table 6.4 (cont'd)

Market area	Clusters		
Group 5			
80	1 2 5 8 9	3 4 6 7	
10	1 2 5 8 9	3 4 6 7	
41	all in one group		
68	2 4 5 6 8	1 3 7 9	
39	1 2 4 5	3 6 9	7 8
58	3 4 5 6	1 9	2 7 8
36	all in one group		
57	all in one group		
50	all in one group		
73	3 4 6 7	1 9	2 5 8
71	2 4 5 6	1 3 7 8 9	
32	2 3 4 5 6 7 8	1 9	
12	all in one group		
51	all in one group		
18	all in one group		
62	1 2 4 5 6 8	3 7 9	
48	2 4 5 6 8	1 3 7 9	
69	all in one group		
66	4 5 6	1 3 7 9	2 8
13	1 2 3 4 5 6 9		7 8
6	all in one group		
23	1 2 4 5 6 8	3 7	
16	1 2 4 5 7 8	[illegible] 9	
5	all in one group		
81	1 2 4 5 [illegible] 8	3 6 9	
52	1 2 4 5 7 8	3 6 9	
34	2 4 5 6 8	1 3 7 9	
64	1 2 4 5 7 8	3 6 9	
76	1 2 4 5	3 6 9	7 8
4	1 2 4 5 7 8	3 6 9	

EC, DC, OE, OD, OO -- with some variation in the EO, DO, OE, and OD ties.

The clusterings are not surprising. Ties involving E and D affiliations were expected to be similar because of the data-collection overlap. Ties excluding D affiliations (i.e. EO, OE, OO) should be different from the others because officerships and executive board memberships both indicate a strong tie between person and firm. Their structural similarity, and difference from the ties involving D affiliations, suggests that they perform a similar interlocking function, and one that is different from that of the interlocks involving D affiliations. Of course this is only <u>suggested</u> by the structural evidence: it would have to be verified by examination of the qualities and correlates of the different types of ties. Such research was not attempted in this study.

In view of these results, the nine types of ties were first reduced using the equation:

(6.2) $E = D$,

resulting in four types of ties -- DD, DO, OD, and OO -- DO being the transpose of OD. However, since the intended method of reduction was to sum the clustered matrices, and the matrices based on ties involving O affiliations are much sparser than those involving D and E affiliations (see Table 6.5), the DO and OD matrices were clustered with the OO matrices in order to reduce the sparsity of the graphs on which the indices of interlocking would be computed.

This created two affiliation-pair types of ties, the sums of the EE, ED, DE and DD matrices -- labelled "DD" ties -- and the sums of the EO, DO, OE, OD and OO matrices -- labelled "DD/DO" ties -- on each of three market-relationships -- IN-IN, IN-OUT + OUT-IN, and OUT-OUT. A further reduction was achieved by summing the IN-OUT + OUT-IN and OUT-OUT matrices. This was justified on grounds of parsimony, and by the fact that there was no particular theoretical distinction between the two types of indirectly horizontal ties, but a crucial distinction between directly ("IN-IN") and indirectly horizontal ties. Thus the final result of the combining of ties was four types of ties: directly horizontal DD and DO/OO ties, and indirectly horizontal DD and DO/OO ties. For each of these a real-valued matrix was computed for each of the 30 selected market areas by summing the relevant matrices from among the original 36 matrices and dividing by the number of summed matrices, so that the elements of the four real-valued matrices still had values between 0 and 1. Corresponding binary matrices were computed by setting all elements greater than 0 to 1.

6.4 Financial interlocks

Many writers have noted the importance of banks in the functioning of industrial capitalist economies and in the networks of relationships among the actors in these economies. Directorship ties between industrial corporations

Table 6.5

Mean densities over 82 market areas of

9 different types of ties

Firms' market relations	Interlocker's affiliations DD	DO/OD	OO	TOTAL
<u>Ties with banks included</u>				
IN-IN	0.02195	0.00632	0.00148	0.00902
IN-OUT/OUT-IN	0.03998	0.01279	0.00233	0.01697
OUT-OUT	0.02397	0.00558	0.00163	0.00909
TOTAL	0.03147	0.00937	0.00195	0.01304
<u>Ties with banks excluded</u>				
IN-IN	0.00775	0.00259	0.00140	0.00358
IN-OUT/OUT-IN	0.01101	0.00392	0.00160	0.00511
OUT-OUT	0.03754	0.00800	0.00173	0.01362
TOTAL	0.01683	0.00461	0.00159	0.00691

and banks have been interpreted as evidence of bank domination of industry, or of the merger of financial and industrial capital into self-financing groups, or as evidence that banks serve as intermediaries between mutually problematic industrial firms that are not directly connected (i.e. distinct members of the same bank board sit on the boards of firms in competing enterprises, creating a "bank-mediated P2 tie" between the enterprises). Since this study was primarily concerned with the effect of horizontal interlocking on competition, I was interested mainly in the banks as intermediaries between competing enterprises. However, I was also interested in the effect of the simple bank-industrial firm ties as a kind of control variable: if many bank-industrial ties did not create bank-mediated ties between competing industrial enterprises, then the boards of directors of banks could not be seen primarily as meeting-places for representatives of competing enterprises.

The following types of bank-related ties were defined, and corresponding real-valued matrices for each of the DD and DC/OC affiliation-pair groups computed, on the 30 selected market areas (see Figure 6.3):

(1) "Directly horizontal bank ties": ties between the chartered banks and firms operating in the market area ("horizontal" is somewhat of a misnomer here, but is used to maintain consistency with with the previous industrial-industrial tie definitions);

(2) "Indirectly horizontal bank ties": ties between bank-controlled enterprises and firms <u>outside</u> the market area but belonging to enterprises operating in the market area;

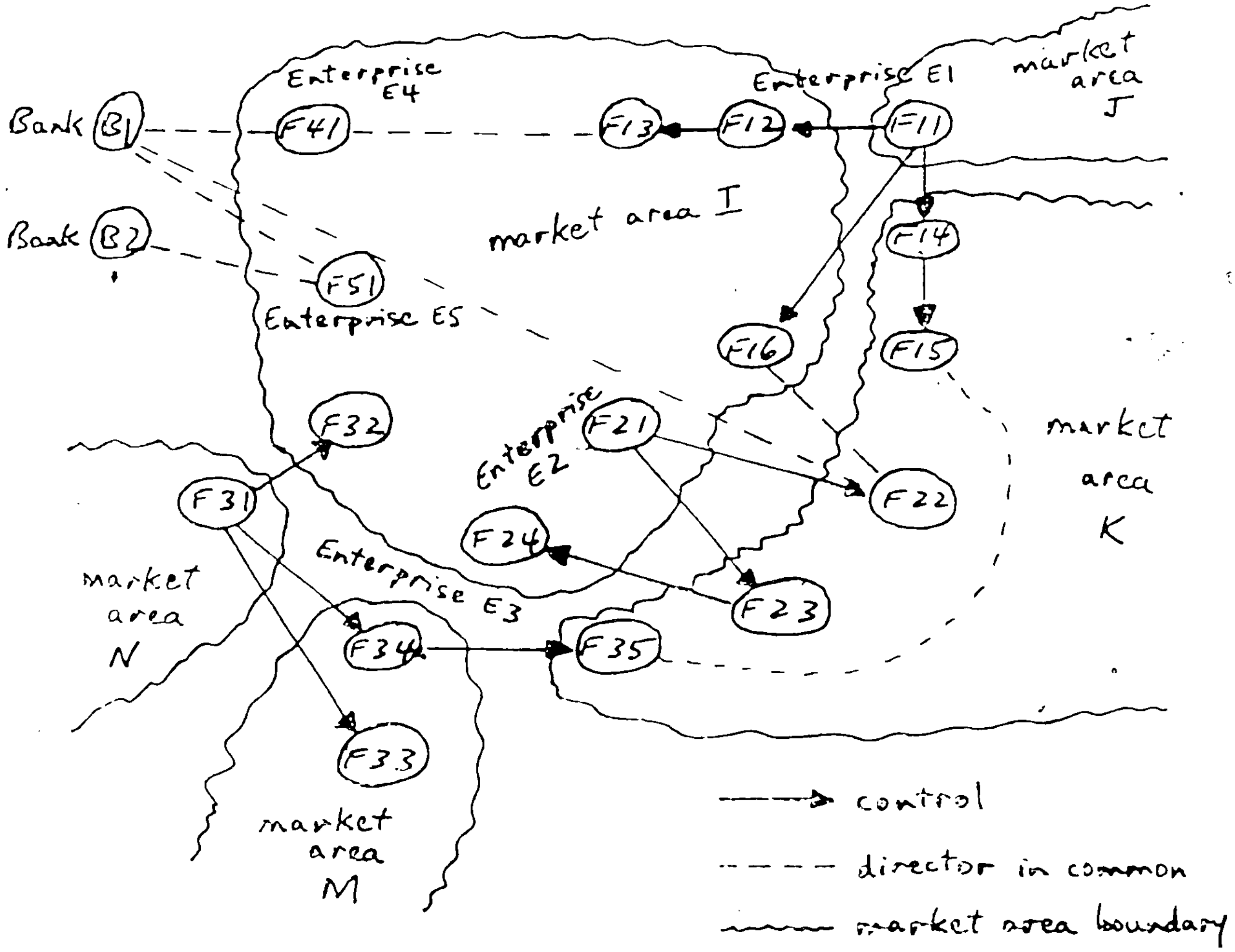
(3) "Directly horizontal bank-mediated P2 ties": P2 bank-mediated ties between firms in the market area;

(4) "Indirectly horizontal bank-mediated ties": P2 bank-mediated ties between firms belonging to enterprises operating in the market area, where at least one of the P2 interlocked firms is outside the market area.

Matrices for types (1) and (2) above were created by adding the nine chartered banks as nodes, and their interlocks with enterprises in the market area as edges (rescaled as in equation 6.1 above to values between 0 and 1), to the relevant previously computed matrices. Since direct interlocks between banks are prohibited, the 9 x 9 submatrix for bank-bank ties was empty. Matrices for types (3) and (4) above were computed by setting all nonbank ties in the matrices for (1) and (2) above to 0 (to eliminate nonbank enterprises as intermediaries), then squaring these matrices to compute P2 ties and retaining only the submatrix for each that involved nonbank-nonbank P2 ties. Elements of these matrices were rescaled to values between 0 and 1

Figure 6.3

Types of interlocks with respect to market relationships



Types of tie (re: m.a. I)	Enterprises	Firms
1. Directly horizontal	E4 - E1	F41 - F13
2. Indirectly horizontal	E1 - E3 E1 - E2	F15 - F35 F16 - F22
3. Directly horizontal bank	B1 - E4 B1 - E5 B2 - E5	B1 - F41 B1 - F51 B2 - F51
4. Indirectly horizontal bank	B1 - E2	B1 - F22
5. Bank-mediated P2 directly horiz.	E4-E5	F41-F51
6. Bank-mediated P2 indirectly horizontal	E4-E2 E5-E2	F41-F22 F51-F22

using:

(6.3) f(V) = MIN.(1,V).

Finally, these four types of ties involving banks were combined with the directly and indirectly horizontal ties between enterprises to create the following six combined types of ties ("TOT'S"):

(1) Directly horizontal ties between enterprises,

(2) TOT (1) plus indirectly horizontal ties between enterprises,

(3) TOT (1) plus directly horizontal bank ties,

(4) TOT (2) plus directly and indirectly horizontal bank ties,

(5) TOT (3) plus directly horizontal bank-mediated P2 ties,

(6) TOT (4) plus directly and indirectly horizontal bank-mediated P2 ties.

For each of these six TOT's, a real-valued matrix for each of the DD and DD/OC affilation-pair-groups was constructed for each market area by summing the relevant matrices and computing the function in equation 6.3 above. Binary-valued versions of these 12 matrices were computed by setting elements greater than 0 to 1.

6.5 Summary

This chapter has described the construction of 12 real-valued and 12 binary-valued matrices measuring different types of interlocks on each of the 30 market areas selected in Chapter 4. These 12 types of interlocks were defined by first defining 36 types of horizontal interlocks, reducing these to 4 types by combining types with similar graphs, and then adding 8 corresponding types of ties involving banks. These 24 matrices per market area form the basis for the computation of scalar indices of interlocking described in the next chapter.

CHAPTER 7

Operationalization of Degree of Interlocking

Chapters 5 and 6 described the methods by which 12 real-valued and 12 corresponding binary-valued director interlock relations were defined on each of 30 market areas. This chapter describes the derivation and computation of indices measuring six dimensions of the degree of interlocking for each of the 24 types of tie; and the reduction of these 144 indices to 12 indices which were used in the tests of the hypotheses described in Chapter 8. Reduction in the number of indices was accomplished by discarding redundant indices, a redundant index of interlocking being defined as that member of a pair of alternate indices having the lower correlation with the profits index.

7.1 Indices of interlocking

The general hypothesis of this study is that interlocks are one means by which enterprises in oligopolistic markets co-ordinate their efforts to jointly maximize profits. Thus the oligopoly is hypothesized to be an instance of the general sociological notion of a group of actors faced with a task to carry out that requires co-ordination -- i.e., communication of information, a decision-making mechanism, and enforcement of the decisions that are made.

The measurement problem is to isolate and measure that aspect of interlocking that is presumed to be associated with group co-ordination. Since no research has been done on co-ordination through corporate interlocks, I have referred to the literature on co-ordination in other kinds of social networks in order to derive indices for this study.

Mitchell (1969) has reviewed the British anthropological network research and isolated two aspects of personal networks that appear to be related to group integration and resulting individual behaviour.

The <u>density</u> of ties (corresponding to the graph theoretic notion of <u>completeness</u>) is the proportion of pairs of actors in the group who are tied (ties are treated in this formulation as nondirected):

(7.1) $DN = 2A/NN(NN-1)$

where:

- DN = density
- A = actual pairs of actors who are tied (i.e. actual number of edges)
- NN = number of actors in the group. ("NN" is used here to distinguish the number of nodes in a graph from "N" -- the number of cases in a sample or population).

Density of egocentric networks has been used by Bott (1957) and others to explain ego's attitudes and behaviour. Because of its immediate intuitive appeal and conceptual simplicity, and because it is likely to be related to almost any other conceivable notion of connectedness, density was used in this study as one index of interlocking. For real-valued ties, density was computed as in equation 7.1, but the value of A ranged from 0 to 1. Thus a network would have to have all possible ties made, and at maximum intensity, to have a density index of 1.

It is fairly well accepted in the industrial organization literature that it is co-ordination among the few firms with the largest market shares that affects profit levels. The actions of the "fringe" firms with small market shares will usually have little effect on prices, as long as the top few firms control the lion's share of the market (Scherer 1970:186). This view is supported by studies that have compared the associations of various concentration ratios with profits and found that top 4 and top 8 ratios are as good or better at predicting profits as the ratios including more firms (Weiss 1971:372). Thus it is plausible that it is only the interlocking among the top few firms that is important in oligopolistic co-ordination.

Market share data for individual firms are kept confidential, so one cannot be sure which are the top few firms in each market. However, *if* it is true that they are the firms that need most to interlock in order to co-ordinate their actions, then they should form a connected subgraph in the network. Since subgraphs formed by fringe firms are expected to be essentially chance phenomena, since these firms have nothing to gain by co-ordinating their (small) market shares, it is at least plausible that the top few firms will form the largest connected subgraph in the network.

In order to test the possibility that interlocking among the top few firms was the major determinant of profits, the largest connected subgraph in each network was determined and the density of ties in this subgraph computed. Since there is also reason to believe that the number of firms in this subgraph may affect profits -- a smaller group being easier to co-ordinate than a larger one -- the number of firms in the subgraph was also used as a predictor of profits.

The interlock network for each market area was partitioned into its maximal connected subgraphs by the method of raising the (binary) adjacency matrix to successive powers (Harary et al. 1965:134-138; computational method is given in Chapter 5 above).

It seems plausible that density of interlocking should affect co-ordination--the more ties that exist, the more channels of communication and influence are available.

However, as Mitchell points out, the structure of the ties should also affect the integration or effectiveness of the group. For a given density of ties (<1), these ties may be arranged in more or less effective patterns. Mitchell argues that compactness, or the average length of the paths between actors, is the primary factor determining integration in networks. This seems plausible in view of the well-known tendency for information to deteriorate when it is transmitted through intermediaries: presumably the fewer intermediaries there are between pairs of actors, the more effective their mutual transmission of information and influence.

Compactness can only be measured on a connected graph: the distance between two nodes that are not connected directly or through intermediaries is undefined. Thus it was only possible to measure compactness in the largest connected subgraph, presumed to be formed by the top few firms.

The formula used for compactness was Beauchamp's (1965) average relative centrality:

```
(7.2)  CP = ((NN-1)/(N))*(SUM(1/SUM(D(I,J))))
                              I     J
where:
      CP = compactness
      NN = number of nodes in the graph,
   D(I,J) = distance between nodes I and J.
```

In a graph with binary-valued edges, the distance between two nodes is equal to the number of edges in the shortest path between them (their "geodesic"). This was calculated by raising the adjacency matrix M to successsive boolean powers ("#" in the following equations indicates boolean arithmetic):

(7.3) $D(I,J) = K$

where K is the smallest integer for which:

$$M^{K}\#(I,J) = 1.$$

There is no standard way to measure distance between nodes in a network with real-valued edges. The appropriate index of distance must be derived from the meaning of the real-valued edges, with the caveat that "one must be careful to use an operation appropriate to the value system for the network and to the interpretation envisaged" (Harary et al. 1965:365).

In this case the real-valued distance between nodes represents the difficulty of mutual communication and influence. For a direct tie this is reasonably measured by the reciprocal of the tie intensity, V (defined in Sections 6.1 to 6.4, and equations 6.1 and 6.2, of Chapter 6 above): If nodes A and B have (only) a direct tie of intensity V = 0.5, their distance is 2.0. This preserves the relationship of distance and tie strength used in binary-valued graphs: where the tie has strength 1, the distance is 1/1 = 1.

In a binary-valued graph, the distance between two nodes joined by intermediaries is simply the number of edges in a shortest path (geodesic) between them. The existence of multiple geodesics does not reduce their computed distance. Thus in Figure 7.1, A and C have a distance of 2, as do D and F. Though this arithmetic may be justified for binary graphs, it seems less so for real-valued graphs, where the value of each edge represents the decay of whatever is being transmitted; presumably transmission should be improved by multiple channels. For example, in Figure 7.2, D and F should be better co-ordinated than A and C. In order to be able to "add" multiple paths, indirect distance was defined as the reciprocal of indirect closeness, and closeness through multiple paths was treated as additive. Closeness of directly tied nodes was of course defined as the tie intensity, V. In order to avoid including looped paths in computations of closeness -- e.g., in Figure 7.2, we do not consider the looped path D--E1--F--E2--D--E1--F to contribute to closeness -- closeness betwen a node and itself at any remove was defined as 0, and only the paths of shortest length (where length is the number of edges regardless of their values) were summed to compute closeness. This had the drawback of excluding long, strong paths such as D--E5--E6--F in Figure 7.1; however, this corresponded to my intuition that information or influence should "flow through" only the shortest path(s).

Figure 7.1

Indirect distances in binary-valued graphs

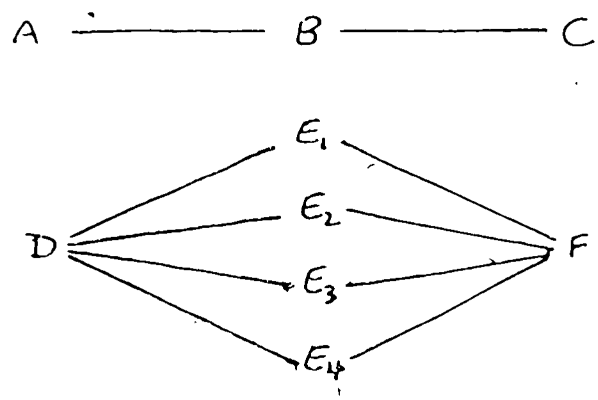
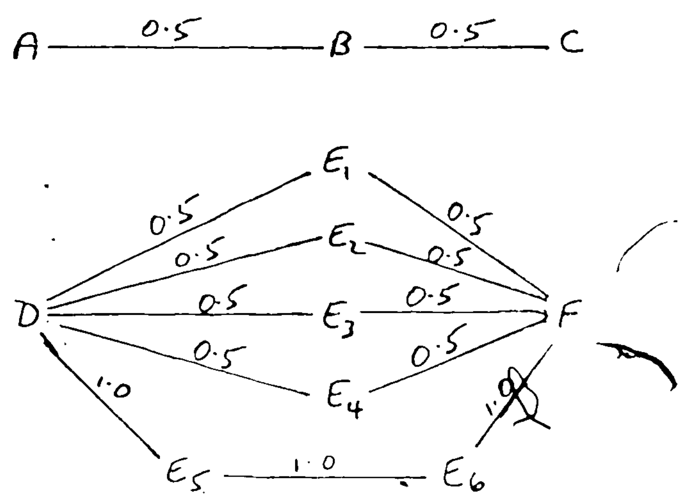


Figure 7.2

Indirect distances in real-valued graphs



The closeness of two nodes by virtue of each indirect path -- i.e., the value of that path -- was computed as the product of the values of the edges, divided by path length. Edges were multiplied rather than added because of the idea of decay of transmission through the edges: if nodes A and B have a (direct) tie of strength 0.5, then this is assumed to mean 0.5 of A's transmission of information or influence reaches B. Similarly 0.5 of B's transmission reaches C, in Figure 7.2. Furthermore, as in binary-valued graphs, there is a decay in the transmission as it is relayed by B (in Figure 7.1, the distance from A to C is computed as 2, not 1; i.e., only 0.5 of A's transmission reaches C, although none is lost in the 1-valued edges). Thus:

(7.4) V(A,B; X1, X2...Xk)

= V(A,X1)*V(X1,X2)*...V(Xk,B)/(k+1)

where:

V(A,B; X1,X2...Xk) = value of path of length k+1 between A and B mediated by nodes X1,X2...Xk.

And where there are M shortest paths of length (k+1) between A and B:

(7.5) D(A,B) = (k+1)/MIN(1,V1(A,B)+V2(A,B)+...+VM(A,B))

where:
D(A,B) = distance between A and B
= reciprocal of their closeness
VI(A,B)= value of Ith shortest path between A and B.

The denominator is computed as the minimum of 1 and the sum of the path values in order to maintain comparability with the arithmetic of binary distance: no matter how large the sum of the path values, they cannot exceed the value of one path consisting of all 1-valued edges. Thus in Figure 7.2: D(A,B) = 2/0.25 = 8, and D(D,F) = 2/1 = 2.

This is only one somewhat arbitrary way of defining real-valued distance; other measures could have been computed and compared with this one. However, I judged that this would overly complexify the research design.

The distance matrix, D, for real-valued graphs was therefore calculated by simultaneously raising both the (binary valued) adjacency matrix A, and the (real-valued) value matrix V, to successive powers. Each pair of nodes (I,J) has a shortest path length, k; i.e., the minimum value of R such that:

$$A^{R}(I,J) = 1.$$

Then:

$$(7.6)\quad D(I,J) = k/MIN(1, V^{k}(I,J)).$$

These values of D(I,J) were substituted in equation 7.2 to calculate the compactness of each real-valued network.

Freeman (1979:227) has identified a third aspect of connectedness in a graph that is expected to be related to "efficiency...in solving problems": centralization, or the degree to which a single node dominates the graph. Freeman cites research by Leavitt demonstrating that the degree to which one point is central is indeed related to group effectiveness. The rationale, of course, is that a group is effective to the degree that it has a well-defined leader. This conception is in direct opposition to that implicit in the use of graph density and compactness, which assume the equal importance of every node.

It seems plausible that leadership may be important in oligopolies, both because of its importance generally in group functioning and because of the importance of the theory of price leadership in explaining oligopolistic pricing (Scherer 1970: 164-173). If prices in oligopolies are indeed set by a leader, then surely pricing decisions and their enforcement could better be carried out if the leader dominated the channels of communication and influence.

In order to verify the importance of centralization, it was used as an index of interlocking. Freeman (1979: 227-232) provides three indices of centralization, all based on the extent to which one node is more central than all others; the three indices differ in the kind of centrality that is being compared. The simplest kind of centrality is centrality of degree (indegree and outdegree are the same in symmetric graphs): to what extent does one node have more direct ties than other nodes? Another form of centrality is "betweenness: to what degree does one node occur in the shortest paths between other nodes? Finally, there is centralization of closeness (or compactness): to what extent is one node closer to other nodes? "Closeness" is of course the property of a node that was averaged to determine compactness: Mitchell uses the term "reachability". Thus centralization of closeness can only be measured on a connected subgraph.

Of these three indices of centralization, the first and third were used. I was not at all convinced that centralization of "betweenness" contributed to oligopolistic co-ordination. Centralization of degree was computed for both the full graph, annd the largest connected subgraph. Centralization of closeness could be computed only for the subgraph.

Freeman's formula for centralization of degree is:

$$(7.7)\quad CD = \sum_{I} (DG(P^*) - DG(P(I)))/(NN*(NN-3)+2)$$

where:

CD = centralization of degree,
DG(P(I)) = degree of node P(I),
P* = node with the greatest degree
NN = number of nodes in the graph
(Freeman 1979:230).

For real- or binary-valued symmetric graphs, the degree of a node is simply the sum of all edges connected to it; if the (real- or binary-valued) value matrix of the network is V, then the degree of node P(I) is:

$$(7.8)\quad DG(P(I)) = \sum_{J} (V(P(I),P(J)).$$

Freeman's formula for centralization of closeness is:

```
(7.9)  CC = ((SUM(C(P*) - C(P(I)))) (2NN-3))/(NN*(NN-3)+2)
             I
```

where:

```
     CC = centralization of closeness,
C(P(I)) = closeness of P(I) to all other nodes
          (see equation 7.10),
     P* = node with greatest closeness
          (see equation 7.11),
     NN = number of nodes in the graph
                    (Freeman 1979:231).
```

The closeness of a node P(I) to all other nodes -- i.e., its centrality in terms of closeness or reachability -- is:

```
(7.10) C(P(I)) = (NN-1)/(SUM(D(P(I),P(J))))
                             J
```

where:

```
     NN = number of nodes in the graph,
  D(X,Y)= distance between nodes X and Y
        = reciprocal of their closeness
          (see equation 7.3 for binary-valued
          graphs, and equation 7.6 for
          real-valued graphs).
```

The most central node, P*, is the P(I) such that:

```
(7.11) C(P(I)) = MAX (C(P(J)).
                  J
```

7.2 Identification of redundant indices

The 144 indices of interlocking derived in Section 7.1 above varied on five dimensions:

a) Graph connectedness: index computed on

1) full graph (density, centralization of degree)
2) largest connected subgraph (density, centralization of degree, compactness, centralization of compactness).

b) Level of measurement:
1) real-valued ties
2) binary-valued ties.

c) Type of index:
1) density
2) centralization of degree
3) compactness
4) centralization of compactness

d) Type of tie (see Chapter 6):
1) directly horizontal ties only (i.e., between firms in the market area)
2) directly and indirectly (i.e., involving at least one enterprise member outside the market area) horizontal ties
3) directly horizontal and bank ties with enterprise members in the market area.
4) directly and indirectly horizontal, and bank ties with enterprise members within and outside the market area.
5) ties in category (3) above, plus bank-mediated (P2) horizontal ties (between enterprise members in the market area).
6) ties in category (4) above, plus bank-mediated (P2)

directly and indirectly horizontal ties.

e) Affiliations of interlockers (see Chapter 6):

1) director and possibly also executive board member of each firm ("DD")

2) officer of at least one of the two interlocked firms; possibly (and probably) also a director ("DO/OO").

For the sake of brevity, indices of interlocking are referred to in this chapter by a seven-character code of the following form (all individual indices of interlocking are defined in Table 7.1 and Appendix C below):

xyyzznn

where:

x is the level of measurement:

R = real-valued,

B = binary-valued;

yy is the graph connectedness:

FG = full graph,

LC = largest connected component;

zz is the type of index:

DN = density,

CP = compactness,

CD = centralization of degree,

CC = centralization of closeness;

nn is the type of tie (TOT) and interlocker's affiliations:

01 = DD affiliations on TOT 3,

02 = DO/OO affiliations on TOT 3,

04 = DD affiliations on TOT 4,

05 = DO/OO affiliations on TOT 4,

07 = DD affiliations on TOT 1,

08 = DO/OO affiliations on TOT 1,

10 = DD afiliations on TOT 2,

11 = DO/OO affiliations on TOT 2,

13 = DD affiliations on TOT 5,

14 = DO/OO affiliations on TOT 5,

16 = DD affiliations on TOT 6,

17 = DO/OO affiliations on TOT 6

(missing numbers identify indices not used in this study).

Thus, for example, the name RFGDN11 identifies the index of density of real-valued director-officer or officer-officer ties on TOT 2 (directly and indirectly horizontal ties) for the full graph.

Some of these dimensions of variation (type of tie, type of index, graph connectedness) were included in order to determine which category of index had more effect on profits. Others (level of measurement, affiliations of interlockers) were included to increase the chances of measuring interlocking in such a way as to capture its expected associations with profits. In order to reduce the unwieldy number of indices, I selected the categories of indices in the latter two dimensions that were most strongly correlated with profits.

The average levels of correlations of categories of indices in the former three (theoretically and substantively significant) dimensions were also examined for strong differences, although the intention was to keep (for the eventual hypothesis-testing) indices that represented all categories in these three dimensions.

It is well known that selection of indices on the basis of zero-order correlations with another variable is hazardous because a correlation may be misleadingly low (1) because of a suppressor variable, (2) or where there is a strong but non-linear relationship between the two variables. Problem (1) was handled by considering the effect of possible suppressor variables where categories of indices had low correlations with the profits variable. Problem (2) was avoided by checking for non-linear associations -- both by checking the distributions of the indices of interlocking, and by testing the residuals from simple regressions of the profits variable on each index of interlocking.

7.2.1 Distributions of indices of interlocking

Because of the large number of indices of interlocking, it was not feasible to examine the distribution or regression residuals for each index in detail. Instead, summary statistics were computed for each test, to give a rough indication of occurrences of non-linearity.

The major distributional irregularity of a fairly normally distributed variable that can contribute to a non-linear relationship is excessive skewness. Thus a skewness statistic was calculated for each index of interlocking. The values of this statistic are given in the "SKRAW" column of Table 7.1. Almost all of these values are positive, and a good number have large values (e.g., greater than 1.0), indicating considerable skew to the right.

Skewness appears to be especially high for indices based on types of ties excluding bank ties. These are by far the sparsest matrices (see Chapter 6). Examination of the actual values of the interlocking indices suggested that skewness was highest for sparse matrices because:

(1) in several matrices, especially those excluding bank ties, there were no ties at all, thus density and centralization of degree were equal to 0 for these cases, the mean was therefore "pulled down" near 0, and the remaining cases tended to straggle upward.

TABLE 7.1

SKEWNESS OF INDICES OF INTERLOCKING--RAW AND TRANSFORMS *

INDX	CONNECT	LEVMEAS	TYPINDEX	BANKS	MKTREL	AFFILS	SKRAW	SKMISS	SKLOGM	SKRECIPM	SKLOGXP1	SKRECXP1
RFGDN01	FULL	REAL	DENSITY	IN	ININ	DD	1.38246	1.38248	0.03458	-2.0755	1.36516	1.34801
RFGDN02	FULL	REAL	DENSITY	IN	ININ	DD/OO	0.83000	0.83000	0.41152	-0.5795	0.83243	0.82889
RFGDN04	FULL	REAL	DENSITY	IN	ALL	DD	1.41435	1.41435	-0.08662	-2.1240	1.35838	1.30326
RFGDN05	FULL	REAL	DENSITY	IN	ALL	DD/OO	1.77337	1.77337	0.46015	-1.1431	1.74664	1.72024
RFGDN07	FULL	REAL	DENSITY	OUT	ININ	DD	3.41063	2.05045	-0.20509	-1.7580	3.34864	3.28753
RFGDN08	FULL	REAL	DENSITY	OUT	ININ	DD/OO	1.88094	0.26264	-0.66646	-1.5393	1.87593	1.87096
RFGDN10	FULL	REAL	DENSITY	OUT	ALL	DD	2.90236	2.83741	0.00293	-2.4838	2.81611	2.72896
RFGDN11	FULL	REAL	DENSITY	OUT	ALL	DD/OO	3.57187	3.56153	0.18226	-1.8480	3.46280	3.39340
RFGDN13	FULL	REAL	DENSITY	P2IN	ININ	DD	1.59102	1.59102	0.17419	-2.1050	1.56827	1.54577
RFGDN14	FULL	REAL	DENSITY	P2IN	ININ	DD/OO	1.03087	1.03087	0.17016	-0.5798	1.02586	1.02089
RFGDN16	FULL	REAL	DENSITY	P2IN	ALL	DD	1.24217	1.24217	-0.22603	-2.3899	1.18528	1.12803
RFGDN17	FULL	REAL	DENSITY	P2IN	ALL	DD/OO	1.74272	1.74272	0.42433	-1.2765	1.71287	1.68343
RFGCD01	FULL	REAL	CENTDEG	IN	ININ	DD	1.27873	1.27873	-0.07641	-1.5876	1.20467	1.13202
RFGCD02	FULL	REAL	CENTDEG	IN	ININ	DD/OO	1.05599	1.05599	0.25551	-0.6511	1.03190	1.00803
RFGCD04	FULL	REAL	CENTDEG	IN	ALL	DD	0.88617	0.88617	0.03160	-1.1144	0.81186	0.73784
RFGCD05	FULL	REAL	CENTDEG	IN	ALL	DD/OO	0.98421	0.98421	0.28685	-0.3809	0.95061	0.91704
RFGCD07	FULL	REAL	CENTDEG	OUT	ININ	DD	2.01672	0.91477	-0.23969	-1.1088	1.93394	1.85015
RFGCD08	FULL	REAL	CENTDEG	OUT	ININ	DD/OO	1.72077	0.45334	-0.55877	-1.2916	1.68774	1.65586
RFGCD10	FULL	REAL	CENTDEG	OUT	ALL	DD	0.78764	1.00034	0.03955	-1.0513	0.66981	0.59242
RFGCD11	FULL	REAL	CENTDEG	OUT	ALL	DD/OO	1.09965	1.41508	0.10941	-0.7635	1.00283	0.90982
RFGCD13	FULL	REAL	CENTDEG	P2IN	ININ	DD	1.63213	1.63213	0.31904	-1.4212	1.54409	1.45666
RFGCD14	FULL	REAL	CENTDEG	P2IN	ININ	DD/OO	1.59952	1.59952	0.42530	-0.6185	1.55436	1.50998
RFGCD16	FULL	REAL	CENTDEG	P2IN	ALL	DD	0.54292	0.54292	-0.22013	-1.2482	0.45249	0.36421
RFGCD17	FULL	REAL	CENTDEG	P2IN	ALL	DD/OO	1.35857	1.35857	0.45607	-0.3343	1.29771	1.23849
BFGDN01	FULL	BINARY	DENSITY	IN	ININ	DD	1.33587	1.33587	0.15004	-1.4440	1.30012	1.26497
BFGDN02	FULL	BINARY	DENSITY	IN	ININ	DD/OO	0.89090	0.89090	0.22514	-0.4730	0.80242	0.87395
BFGDN04	FULL	BINARY	DENSITY	IN	ALL	DD	0.89906	0.89906	-0.14768	-1.5576	0.79388	0.69028
BFGDN05	FULL	BINARY	DENSITY	IN	ALL	DD/OO	1.45063	1.45063	0.07216	-0.1274	1.39020	1.33074
BFGDN07	FULL	BINARY	DENSITY	OUT	ININ	DD	2.63379	1.65161	-0.45001	-2.4894	2.70090	2.69029
BFGDN08	FULL	BINARY	DENSITY	OUT	ININ	DD/OO	2.10065	0.83212	-0.58007	-1.1710	2.08100	2.06175
BFGDN10	FULL	BINARY	DENSITY	OUT	ALL	DD	2.67008	2.66033	0.49041	-2.3259	2.42571	2.183[illegible]
BFGDN11	FULL	BINARY	DENSITY	OUT	ALL	DD/OO	1.98530	1.91137	0.18151	-1.4314	1.85063	1.72387
BFGDN13	FULL	BINARY	DENSITY	P2IN	ININ	DD	1.55247	1.55247	0.25165	-1.5802	1.50113	1.45033
BFGDN14	FULL	BINARY	DENSITY	P2IN	ININ	DD/OO	1.20290	1.20290	0.37876	-0.4096	1.18799	1.17323
BFGDN16	FULL	BINARY	DENSITY	P2IN	ALL	DD	0.47522	0.47522	-0.87166	-2.4773	0.31507	0.15916
BFGDN17	FULL	BINARY	DENSITY	P2IN	ALL	DD/OO	1.62500	1.62500	0.55816	-0.6763	1.51218	1.40500
BFGCD01	FULL	BINARY	CENTDEG	IN	ININ	DD	0.42295	0.42295	-0.45601	-1.3259	0.33317	0.24448
BFGCD02	FULL	BINARY	CENTDEG	IN	ININ	DD/OO	1.16286	1.18288	0.49056	-0.3318	1.12850	1.07534
BFGCD04	FULL	BINARY	CENTDEG	IN	ALL	DD	1.88664	1.88664	1.09797	0.3925	1.64714	1.42754
BFGCD05	FULL	BINARY	CENTDEG	IN	ALL	DD/OO	1.12667	1.12667	0.46096	-0.2166	0.98932	0.85341
BFGCD07	FULL	BINARY	CENTDEG	OUT	ININ	DD	1.50217	0.34405	-0.69953	-1.2793	1.42401	1.33576
BFGCD08	FULL	BINARY	CENTDEG	OUT	ININ	DD/OO	1.61316	0.13849	-0.56049	-1.0516	1.57063	1.53041
BFGCD10	FULL	BINARY	CENTDEG	OUT	ALL	DD	1.10160	1.43869	0.03942	-1.5063	0.74969	0.41264
BFGCD11	FULL	BINARY	CENTDEG	OUT	ALL	DD/OO	1.08793	1.17794	0.26511	-0.5301	0.86769	0.69463
BFGCD13	FULL	BINARY	CENTDEG	P2IN	ININ	DD	1.00504	1.00504	0.36340	-1.1146	0.86954	0.77216
BFGCD14	FULL	BINARY	CENTDEG	P2IN	ININ	DD/OO	1.63871	1.63871	0.77542	-0.1769	1.55517	1.47404
BFGCD16	FULL	BINARY	CENTDEG	P2IN	ALL	DD	0.17454	0.17454	-0.38713	-0.9059	0.01234	-0.14209
BFGCD17	FULL	BINARY	CENTDEG	P2IN	ALL	DD/OO	1.53926	1.53926	0.71639	-0.0306	1.32893	1.11384
RLCDN01	LCC	REAL	DENSITY	IN	ININ	DD	-0.07374	-0.07374	-0.48369	-0.3267	-0.12584	-0.17817
RLCDN02	LCC	REAL	DENSITY	IN	ININ	DD/OO	0.82646	0.82646	-0.97355	-2.2560	0.44340	0.09699
RLCDN04	LCC	REAL	DENSITY	IN	ALL	DD	1.49665	1.49665	0.42540	-0.4071	1.40963	1.3[illegible]
RLCDN05	LCC	REAL	DENSITY	IN	ALL	DD/OO	1.10259	1.10259	0.53010	-0.3315	1.07623	1.05004
RLCDN07	LCC	REAL	DENSITY	OUT	ININ	DD	1.39666	0.88304	-0.71090	-1.7822	1.25693	1.13293
RLCDN08	LCC	REAL	DENSITY	OUT	ININ	DD/OO	1.67664	1.18407	0.14473	-0.6739	1.41650	1.234[illegible]
RLCDN10	LCC	REAL	DENSITY	OUT	ALL	DD	1.79072	1.87383	0.26503	-0.8815	1.37340	1.00904
RLCDN11	LCC	REAL	DENSITY	OUT	ALL	DD/OO	1.11081	1.02117	0.02184	-1.3045	0.90004	0.7[illegible]
RLCDN13	LCC	REAL	DENSITY	P2IN	ININ	DD	0.29078	0.29078	-0.35142	-0.9441	0.17929	0.073[illegible]
RLCDN14	LCC	REAL	DENSITY	P2IN	ININ	DD/OO	1.02594	1.02594	-0.70939	-1.9585	0.64362	0.293[illegible]

* [illegible]

TABLE 7.1 (cont'd)

SKEWNESS OF INDICES OF INTERLOCKING--RAW AND TRANSFORMS*

INDX	CONNECT	LEVMEAS	TYPINDEX	BANKS	MKTREL	AFFILS	SKRAW	SKMISS	SKLOGM	SKRECIPM	SKLOGXP1	SKRECXP1
RLCDN16	LCC	REAL	DENSITY	P2IN	ALL	DD	1.27376	1.2738	0.5117	-0.1271	1.19799	1.1240
RLCDN17	LCC	REAL	DENSITY	P2IN	ALL	DO/OO	1.04128	1.0411	0.4380	-0.0459	1.00750	0.9742
RLCCP01	LCC	REAL	COMPACT	IN	ININ	DD	0.79923	0.7992	-1.0289	-4.6238	0.70314	0.6155
RLCCP02	LCC	REAL	COMPACT	IN	ININ	DO/OO	0.29419	0.2942	-1.3634	-2.8809	0.00562	-0.2366
RLCCP04	LCC	REAL	COMPACT	IN	ALL	DD	1.70024	1.7002	-0.3216	-2.0601	1.61895	1.5397
RLCCP05	LCC	REAL	COMPACT	IN	ALL	DO/OO	3.06186	3.0619	0.3437	-1.9845	3.02573	2.9898
RLCCP07	LCC	REAL	COMPACT	OUT	ININ	DD	1.47873	-0.0197	-1.0593	-2.2675	1.35522	1.2470
RLCCP08	LCC	REAL	COMPACT	OUT	ININ	DO/OO	1.77168	0.8589	-0.4766	-1.6684	1.51600	1.3391
RLCCP10	LCC	REAL	COMPACT	OUT	ALL	DD	2.05531	1.9412	-0.3526	-2.8598	1.71763	1.4297
RLCCP11	LCC	REAL	COMPACT	OUT	ALL	DO/OO	1.24464	0.9259	-1.1033	-4.8577	1.08038	0.9369
RLCCP13	LCC	REAL	COMPACT	P2IN	ININ	DD	0.56014	0.5601	-0.9120	-3.5258	0.45274	0.3436
RLCCP14	LCC	REAL	COMPACT	P2IN	ININ	DO/OO	0.27413	0.2741	-1.2539	-2.2765	-0.02310	-0.2719
RLCCP16	LCC	REAL	COMPACT	P2IN	ALL	DD	1.31068	1.3107	-0.5158	-2.1167	1.22018	1.1380
RLCCP17	LCC	REAL	COMPACT	P2IN	ALL	DO/OO	2.66033	2.6603	0.5086	-1.7799	2.63482	2.6094
RLCCD01	LCC	REAL	CENTDEG	IN	ININ	DD	0.13692	0.9991	-0.2664	-1.4329	-0.08531	-0.3412
RLCCD02	LCC	REAL	CENTDEG	IN	ININ	DO/OO	1.13267	1.1549	-0.1198	-1.1973	0.91146	0.7367
RLCCD04	LCC	REAL	CENTDEG	IN	ALL	DD	0.73015	0.7302	0.1379	-0.6296	0.66300	0.5961
RLCCD05	LCC	REAL	CENTDEG	IN	ALL	DO/OO	0.44565	0.4456	0.0624	-0.3408	0.41796	0.3903
RLCCD07	LCC	REAL	CENTDEG	OUT	ININ	DD	2.81613	-0.8704	0.6205	0.2829	2.59418	2.4009
RLCCD08	LCC	REAL	CENTDEG	OUT	ININ	DO/OO	2.84986	0.3782	-0.2578	-0.8510	2.76415	2.6968
RLCCD10	LCC	REAL	CENTDEG	OUT	ALL	DD	1.05791	1.6433	0.4720	-0.6321	0.76492	0.5137
RLCCD11	LCC	REAL	CENTDEG	OUT	ALL	DO/OO	1.74414	1.6493	0.2972	-0.7977	1.42206	1.1496
RLCCD13	LCC	REAL	CENTDEG	P2IN	ININ	DD	-0.45012	0.2176	-0.6803	-1.7886	-0.63049	-0.8037
RLCCD14	LCC	REAL	CENTDEG	P2IN	ININ	DO/OO	1.21986	1.2382	-0.1109	-1.1756	0.98363	0.7957
BLCCD16	LCC	REAL	CENTDEG	P2IN	ALL	DD	0.38267	0.3827	-0.1752	-0.9010	0.29925	0.2169
RLCCD17	LCC	REAL	CENTDEG	P2IN	ALL	DO/OO	0.86219	0.8622	0.1798	-0.4935	0.60198	0.7426
RLCCC01	LCC	REAL	CENTCP	IN	ININ	DD	1.10417	1.2488	-0.3168	-3.3975	0.79887	0.4650
RLCCC02	LCC	REAL	CENTCP	IN	ININ	DO/OO	1.09626	0.0479	-0.4984	-1.2629	0.97614	0.8656
RLCCC04	LCC	REAL	CENTCP	IN	ALL	DD	1.09634	1.0963	-0.1390	-1.6139	0.94624	0.8017
RLCCC05	LCC	REAL	CENTCP	IN	ALL	DO/OO	1.49428	1.4943	-0.2453	-2.3284	1.40217	1.3128
RLCCC07	LCC	REAL	CENTCP	OUT	ININ	DD	2.90022	0.2562	-0.1003	-0.5437	2.70589	2.5203
RLCCC08	LCC	REAL	CENTCP	OUT	ININ	DO/OO	2.91230	-1.6433	-1.8308	-1.9324	2.83525	2.7642
RLCCC10	LCC	REAL	CENTCP	OUT	ALL	DD	1.35729	1.0698	-0.5108	-2.6092	1.10229	0.8769
RLCCC11	LCC	REAL	CENTCP	OUT	ALL	DO/OO	1.60114	0.7993	-1.1256	-3.9441	1.31242	1.0988
RLCCC13	LCC	REAL	CENTCP	P2IN	ININ	DD	0.54132	0.8713	-0.2774	-1.7871	0.21906	-0.1047
RLCCC14	LCC	REAL	CENTCP	P2IN	ININ	DO/OO	1.17395	0.2543	-0.3663	-1.3342	1.02325	0.8847
RLCCC16	LCC	REAL	CENTCP	P2IN	ALL	DD	0.68229	0.6823	-0.4213	-1.7603	0.52101	0.3693
RLCCC17	LCC	REAL	CENTCP	P2IN	ALL	DO/OO	2.08918	2.0892	-0.0369	-2.2260	1.96107	1.8330
BLCDN01	LCC	BINARY	DENSITY	IN	ININ	DD	0.85737	0.8574	0.0416	-0.8490	0.60780	0.3603
BLCDN02	LCC	BINARY	DENSITY	IN	ININ	DO/OO	-0.63619	-0.6362	-1.4239	-2.7749	-0.82601	-1.0615
BLCDN04	LCC	BINARY	DENSITY	IN	ALL	DD	0.39649	0.3985	-0.0873	-0.5336	0.29614	0.1986
BLCDN05	LCC	BINARY	DENSITY	IN	ALL	DO/OO	0.57657	0.5766	-0.1351	-0.8347	0.44592	0.3172
BLCDN07	LCC	BINARY	DENSITY	OUT	ININ	DD	0.97897	-0.9971	-1.5778	-1.9853	0.89547	0.8225
BLCDN08	LCC	BINARY	DENSITY	OUT	ININ	DO/OO	1.13409	-1.1167	-1.4066	-1.7224	1.05901	0.9936
BLCDN10	LCC	BINARY	DENSITY	OUT	ALL	DD	0.35902	0.3987	-0.2406	-0.9093	0.07014	-0.2511
BLCDN11	LCC	BINARY	DENSITY	OUT	ALL	DO/OO	0.07718	-0.0324	-0.8741	-2.1955	-0.17963	-0.4267
BLCDN13	LCC	BINARY	DENSITY	P2IN	ININ	DD	0.69155	0.6916	-0.0415	-1.0012	0.40918	0.2253
BLCDN14	LCC	BINARY	DENSITY	P2IN	ININ	DO/OO	-0.65369	-0.6537	-1.1024	-1.8948	-0.78661	-0.9448
BLCDN16	LCC	BINARY	DENSITY	P2IN	ALL	DD	0.30449	0.3045	-0.2033	-0.7063	0.17550	0.0496
BLCDN17	LCC	BINARY	DENSITY	P2IN	ALL	DO/OO	0.15956	0.1596	-0.3680	-0.9319	0.05354	-0.0543
BLCCP01	LCC	BINARY	COMPACT	IN	ININ	DD	0.74338	0.7434	0.2823	-0.2050	0.56909	0.3922
BLCCP02	LCC	BINARY	COMPACT	IN	ININ	DO/OO	-0.77038	-0.7704	-1.1758	-1.7172	-0.91439	-1.0780
BLCCP04	LCC	BINARY	COMPACT	IN	ALL	DD	0.64955	0.6496	0.3761	0.1398	0.55235	0.4602
BLCCP05	LCC	BINARY	COMPACT	IN	ALL	DO/OO	0.23048	0.2305	-0.0331	-0.2902	0.14663	0.0636
BLCCP07	LCC	BINARY	COMPACT	OUT	ININ	DD	0.80963	-1.1101	-1.4541	-1.7706	0.73804	0.6797
BLCCP08	LCC	BINARY	COMPACT	OUT	ININ	DO/OO	0.98216	-1.3116	-1.6157	-1.9728	0.93306	0.6964
BLCCP10	LCC	BINARY	COMPACT	OUT	ALL	DD	-0.46321	0.3007	-0.0717	-0.5008	-0.93094	-1.3896
BLCCP11	LCC	BINARY	COMPACT	OUT	ALL	DO/OO	-0.51441	-0.3085	-0.8014	-1.3472	-0.74840	-0.9430

*See notes at end of table

TABLE 7.1 (cont'd)

SKEWNESS OF INDICES OF INTERLOCKING--RAW AND TRANSFORMS*

INDX	CONNECT	LEVMEAS	TYPINDEX	BANKS	MKTREL	AFFILS	SKRAW	SKMISS	SKLOGM	SKRECIPM	SKLOGXP1	SKRECXP1
BLCCP13	LCC	BINARY	COMPACT	P2IN	ININ	DD	0.62927	0.6293	0.1669	-0.4804	0.46255	0.2760
BLCCP14	LCC	BINARY	COMPACT	P2IN	ININ	DO/OO	-0.69591	-0.6959	-0.9154	-1.1829	-0.78233	-0.8765
BLCCP16	LCC	BINARY	COMPACT	P2IN	ALL	DD	-0.60090	-0.6009	-0.7963	-1.0022	-0.66845	-0.7363
BLCCP17	LCC	BINARY	COMPACT	P2IN	ALL	DO/OO	0.38143	0.3814	0.0957	-0.1981	0.28624	0.1904
BLCCD01	LCC	BINARY	CENTDEG	IN	ININ	DD	0.88110	1.1771	0.5668	-0.4140	0.45193	-0.0327
BLCCD02	LCC	BINARY	CENTDEG	IN	ININ	DO/OO	0.75159	-0.1217	-0.6920	-1.7128	0.58550	0.4398
BLCCD04	LCC	BINARY	CENTDEG	IN	ALL	DD	2.05894	2.0589	1.0604	0.3403	1.67628	1.3360
BLCCD05	LCC	BINARY	CENTDEG	IN	ALL	DO/OO	0.44752	0.4475	-0.5091	-2.0672	0.23165	-0.0025
BLCCD07	LCC	BINARY	CENTDEG	OUT	ININ	DD	2.75329	0.7628	0.4843	0.0617	2.47376	2.2483
BLCCD08	LCC	BINARY	CENTDEG	OUT	ININ	DO/OO	2.66769	-2.0000	-2.0000	-2.0000	2.79263	2.7205
BLCCD10	LCC	BINARY	CENTDEG	OUT	ALL	DD	0.59435	0.7543	-0.0674	-1.4222	0.26154	-0.0177
BLCCD11	LCC	BINARY	CENTDEG	OUT	ALL	DO/OO	0.63567	-0.4240	-0.8710	-1.7642	0.50762	0.3786
BLCCD13	LCC	BINARY	CENTDEG	P2IN	ININ	DD	0.30704	1.1287	0.4826	-0.3841	-0.20985	-0.6769
BLCCD14	LCC	BINARY	CENTDEG	P2IN	ININ	DO/OO	0.91597	0.3737	0.1625	-0.1105	0.69259	0.4956
BLCCD16	LCC	BINARY	CENTDEG	P2IN	ALL	DD	1.17786	1.1779	0.3739	-0.3885	0.67987	0.6017
BLCCD17	LCC	BINARY	CENTDEG	P2IN	ALL	DO/OO	0.10320	0.1032	-0.4499	-0.9949	-0.07132	-0.2434
BLCCC01	LCC	BINARY	CENTCP	IN	ININ	DD	0.45714	1.0350	0.4603	-0.3237	-0.04117	-0.5533
BLCCC02	LCC	BINARY	CENTCP	IN	ININ	DO/OO	0.64983	-0.1426	-0.3562	-0.5621	0.49282	0.3577
BLCCC04	LCC	BINARY	CENTCP	IN	ALL	DD	1.92215	1.9221	0.9965	0.1844	1.57614	1.2531
BLCCC05	LCC	BINARY	CENTCP	IN	ALL	DO/OO	0.18831	0.1883	-0.3365	-0.9317	0.03164	-0.1302
BLCCC07	LCC	BINARY	CENTCP	OUT	ININ	DD	2.54731	0.3726	-0.2864	-1.1112	2.32668	2.1571
BLCCC08	LCC	BINARY	CENTCP	OUT	ININ	DO/OO	2.89862	-2.0000	-2.0000	-2.0000	2.82527	2.7511
BLCCC10	LCC	BINARY	CENTCP	OUT	ALL	DD	0.20376	0.7208	0.3216	-0.0844	-0.08316	-0.3026
BLCCC11	LCC	BINARY	CENTCP	OUT	ALL	DO/OO	0.53122	-0.3749	-0.5320	-0.8155	0.39167	0.2609
BLCCC13	LCC	BINARY	CENTCP	P2IN	ININ	DD	-0.12337	1.0299	0.6805	0.3432	-0.61187	-1.0254
BLCCC14	LCC	BINARY	CENTCP	P2IN	ININ	DO/OO	0.76242	0.2737	0.1040	-0.1214	0.56058	0.3415
BLCCC16	LCC	BINARY	CENTCP	P2IN	ALL	DD	1.08221	1.0822	0.4953	-0.1618	0.87097	0.5555
BLCCC17	LCC	BINARY	CENTCP	P2IN	ALL	DO/OO	0.07688	0.0789	-0.4896	-1.0566	-0.11096	-0.2976

*See notes at end of table

Table 7.1 (cont'd)

Notes:

INDX:	index of interlocking
CONNECT:	connectedness of graphs
FULL:	full graph
LCC:	largest component
LEVMEAS:	level of measurement of raw interlocks
REAL:	real-valued
BINARY:	binary-valued
TYPINDEX:	type of index of interlocking
DENSITY:	density
CENTDEG:	Freeman's centralization of degree
COMPACT:	Beauchamp's compactness
CENTCP:	Freeman's centralization of compactness
BANKS:	treatment of ties with banks
IN:	bank ties included in graphs
OUT:	bank ties (and banks) excluded from graphs
P2IN:	bank ties and bank-mediated P2 ties between enterprises included in graphs
MKTREL:	relationship to this market area of interlocks included in graphs
ININ:	only directly horizontal ties (i.e. formed by <u>firms</u> that are both in the market area) included
ALL:	directly and indirectly horizontal ties included
AFFILS:	affiliations with interlocked <u>firms</u> of the person creating the interlock
DD:	director, and possibly also executive board member, of both firms
DO/OO:	officer of at least one of the firms; any of officer, director or executive board member of the other firm
SKRAW:	skewness of untransformed index over all 30 market areas
SKMISS:	skewness of untransformed index over market areas where index is greater than 0
SKLOGM:	skewness of LOG(index) over market areas where index is greater than 0
SKRECIPM:	skewness of reciprocal of index over market areas where index is greater than 0
SKLOGXP1:	skewness of LOG(index + 1) over all 30 market areas
SKRECXP1:	skewness of 1/(index + 1) over all 30 market areas

(2) in sparse matrices, the largest connected subgraph tends to be very small --often only two or three nodes. Consequently, the two indices of centralization tend to have many values clustered near 0, since there is little stratification of nodes in a two or three node graph with symmetric ties.

Since cases with interlock indices with values of 0 were expected to conform poorly with the general hypothesis, a new set of indices was created whose values were only defined where they were greater than 0. Here the intention was to present one set of results "for interlocking in general" and another set "for interlocking where it exists above a threshold level (0)" -- anticipating that for some (sparse) types of interlocks (especially directly horizontal ties), the general hypothesis would hold only in that subset of market areas where the ties existed above a threshold level. The distributions of these new indices are shown in the "SKMISS" column of Table 7.1. Although skewness is reduced appreciably for a few indices, especially those excluding bank ties (e.g. RFGDN06, RFGCD07, RFGCD08, etc.), treating 0-valued indices as "missing" has not appreciably affected the overall tendency to positive skewness.

Because of the variety of skewness values, several transformations of the indices of interlocking were calculated, in order to compare their effects on skewness. Skewness of log(x) and 1/x are shown as "SKLOGM" and "SKRECIPM" respectively in Table 7.1. Since these transformations are undefined for x=0, they were computed on the indices of interlocking where cases with 0 values were excluded. In order to include all cases, the transformations log (x+1) and 1/(x+1) were also computed on all cases; their skewness statistics are shown in Table 7.1 as "SKLOGXP1" and "SKRECXP1" respectively.

Examination of these four columns of the table reveals that log(x) is successful in a large number of cases in reducing skewness to close to 0, or below 0. Since the profits and concentration indices are all slightly positively skewed, the negative skewness values for log(x) for some indices seem undesirable, but the many slight positive skewness values indicate that log(x) may be more linearly related with profits for many indices.

7.2.2 Residuals from regressions of profits on interlocking

Anscombe and Tukey (1963) have identified two common patterns of residuals that indicate the inadequacy of the linear regression model assumed by the use of the simple correlation coefficient to measure association. These patterns are shown in Figure 7.3, where residuals are plotted against predicted Y. In an adequate linear regression, the residuals should have pattern (1); pattern (2) indicates that variation in Y increases with the value of Y, suggesting a variable transformation, and pattern (3) indicates a curvilinear relationship, necessitating the addition of nonlinear terms in the regression (Draper and

Smith 1966:89-91).

Because of the large number of indices of interlocking, it was not feasible to examine in detail the plot of the residuals from a regression of profits on each index. However, Anscombe and Tukey (1963:150-152) have provided simple summary statistics for each pattern: Pattern (2) is identified by a nonzero value of:

```
                            2
(7.12)  h  =  (SUM(e(I)  *(YHAT(I) - YBAR)))/RMS*H
                I
```

where:

```
      e(I)  = Ith residual,
   YHAT(I)  = Ith predicted value of Y,
      YBAR  = mean of observed Y,
       RMS  = residual mean square
            = (residual sum of squares)/dfR
       dfR  = residual degrees of freedom
         H  = ((N-1)/N)*SSC
       SSC  = sum of squares for model.
```

A "rough" [sic] significance test of the difference of h from 0 can be constructed by comparing the ratio of h and its standard error to a table of critical values for t:

```
(7.13)  se(h)  = SQRT(2v/(v+2)*H)
```

where:

```
        se(h)  = standard error of h
            v  = residual degrees of freedom
               = dfR
            H is defined as in 7.12.
```

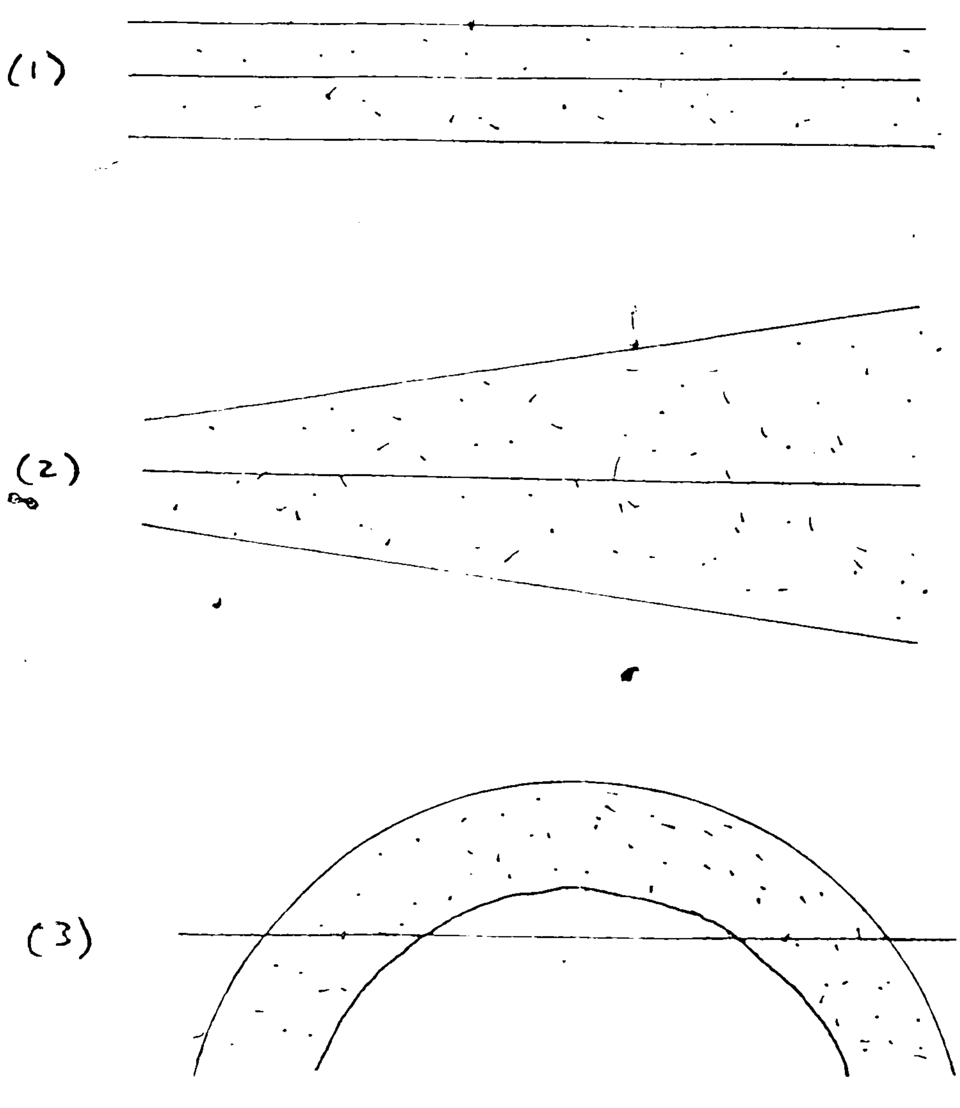
```
(7.14)       t  = h/se(h)
```

Thus if |t| > 2.753 (the 0.01 level of t for df=28) then h

Figure 7.3

Patterns of residuals from linear regression*

(residuals plotted against predicted Y.)



* Adapted from N. Draper and H. Smith, Applied Regression Analysis, p. 89.

is significantly (at the 0.01 level) different from 0.

Pattern (3) is identified by a nonzero value of:

$$(7.15)\quad T12 = \underset{I}{SUM}\ (e(I)*(YHAT(I))^{2})$$

where:

$e(I)$ = Ith residual term,
$YHAT(I)$ = Ith predicted Y.

T12 is a less sophisticated but computationally much simpler version provided by Draper and Smith (1965:93) of Anscombe and Tukey's k statistic (1963:150). The main drawback of T12 is that there is no way to compute the significance of its difference from 0.

Values of h, of t for the significance test of h, and of T12 were computed for regressions of the profits index on all raw and log(x) indices of interlocking. Values of the Shapiro-Wilk W, testing for normality, were also computed; and in all cases, W indicated normality at a very high level of significance. Values of |t(h)| were all very small, ranging from 0.0 to 0.14 for the raw indices and from 0.0 to 0.20 for the log indices. All of these t values are less than the 0.7 level of t for df=26; i.e. the probability that h is not significantly different from 0, and that the residuals therefore do not have pattern (2), ranges from 0.7 to 1.0. Values of T12 were also extremely small, all being less than 0.01. Although no significance test was made, these appear to indicate no appreciable curvilinearity.

On the basis of these tests, I concluded that the raw and log indices of interlocking did not have significantly non-linear relationships with profits that would invalidate the use of the correlation coefficient. Since the third set of indices of interlocking, the untransformed indices with zero values excluded, were closely related to the two sets of indices whose residuals were tested, and their distibutions were close to those of the raw indices, I presumed that this set also had no significant nonlinear relationship with the profits index.

7.2.3 Correlations of interlocking and profits

The zero-order correlations of all indices of interlocking -- raw, zero-values excluded, and log -- with overall corrected price-cost margins were computed and analyzed to determine which categories of indices were strongly or weakly associated with profits.

Results of an analysis of variance and breakdown of means by category of the 144 correlations in each of the three groups are shown in Table 7.2. Clearly the outstanding difference is between indices computed on the full graph for each market area and those computed on the largest connected subgraph. This is especially clear when the density and centralization of degree indices are broken down into full graph and largest subgraph categories in Table 7.3.

Table 7.2

ANOVA and means breakdown for 3 sets of correlation coefficients of profits with interlocking (N=144).

Dimension	Raw degree of intlking F	Zero values excluded F	Log degree of intlking F
Connectedness	249.6*	180.9*	175.1*
Level of measurement	1.6	0.0	0.1
Type of index	6.3*	13.5*	12.1*
Type of tie (TOT)	3.4'	1.3	3.8'
Affiliations	7.0*	46.2*	36.0*

Notes:

*Significance level < 0.01.
'Significance level < 0.05.

(cont'd)

Table 7.2 (cont'd)

Category means breakdown

Dimension (category)*	N	Raw degree of intlking	Zero values excluded	Log degree of intlking
All	144	0.053	0.065	0.051
Connectedness				
Full graph	48	0.165	0.220	0.203
Largest component	96	-0.059	-0.090	-0.100
Level of measurement				
Binary	72	0.062	0.065	0.054
Real	72	0.044	0.065	0.048
Type of index				
Density	48	0.093	0.147	0.130
Cent. of degree	48	0.035	0.023	0.009
Compactness	24	-0.044	-0.007	-0.026
Cent. of closeness	24	-0.068	-0.171	-0.171
Type of tie (TOT)				
1. directly horiz.	24	-0.031	0.012	-0.050
2. TOT 1 + indir. horiz.	24	0.011	0.133	0.128
3. TOT 1 + direct bank	24	0.070	0.030	0.025
4. TOT 2 + dir,indir bk	24	0.151	0.151	0.144
5. TOT 3 + dir. P2 bk	24	0.063	0.011	0.018
6. TOT 4 + dir,indir P2 bk	24	0.054	0.054	0.043
Affiliations				
DD	72	0.072	0.143	0.120
DO/OO	72	0.034	-0.013	-0.017

*Defined in Chapter 7, Section 7.2.

Table 7.3

Category means breakdown by type of index of correlations with profits for 3 groups of interlock indices

Type of index	N	Raw	Zero excluded	Log
FULL - density	24	0.226	0.296	0.284
LC - density	24	-0.041	-0.002	-0.024
FULL - cent. of degree	24	0.154	0.226	0.197
LC - cent. of degree	24	-0.083	-0.179	-0.179
LC - compactness	24	-0.044	-0.007	-0.026
LC - cent. of closeness	24	-0.068	-0.171	-0.171

Notes:

FULL: computed on ties in the full graph
LC: computed on ties in the largest component

All four indices computed on the largest connected subgraph have unexpected negative correlations with profits. If interlocking in the "central clique" were more important to profits (as was hypothesized), then these four indices would have had larger positive correlations than the indices computed on the full graph. At the very least, one would expect them to have correlations approximately equal to those for the full graph. If the average correlations for the subgraph indices had been approximately zero, or had been variously weakly positive and negative, one could conclude that the largest connected subgraph was an inappropriate set of nodes for the association with profits -- that membership in the subgraph and/or its interlocks were essentially stochastic. But the consistency of the negative correlations across four indices and three groups of indices strongly suggests that this result reveals some pattern.

Unexpectedly weak or negative zero-order correlations may be caused by a suppressor variable. In view of the aforementioned drastic reduction in the number of nodes in the largest connected subgraphs compared to the full graphs, I hypothesized that the number of nodes in the subgraph was a suppressor variable. This is plausible if (1) interlocking in the central clique decreases with increased clique size,* and (2) profits increase as the size of the central clique

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*This follows from the plausible assumption that each enterprise can maintain interlocks with only a limited number of its competitors, regardless of the number of enterprises in the market area. This is contrary to Mayhew increases. Assumption (2) is implausible -- the ease of co-ordination, and therefore profit levels, should decrease as the size of the group increases. Thus the effect of the size of the largest subgraph should reinforce a positive association between interlocking in the central clique and profits.

However, if one makes the further assumption that the size of the central clique is strongly positively related to the density of ties in the full graph, which is known to be positively associated with profits, the result is the model shown in Figure 7.4. Here the density of ties in the full graph has a positive effect directly on profits, but a negative indirect effect: increased density causes increased central clique size, which reduces the level of interlocking in the central clique, which reduces profit levels. In other words, as interlocks in the full graph become more dense, the size of the crucial central clique, which must be co-ordinated by interlocks, grows, leading to difficulties in co-ordination and reducing profits -- reducing the positive effect on profits of the overall density of interlocks in the market area. Figure 7.4 models one of the problems faced by any would-be cartel: on the one hand, as many sellers of the commodity as possible must be included,

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and Levinger's (1976) argument that density of interaction is expected to increase with population size in "human aggregates"--but their model, based on consideration of random graphs, assumes that each person has a very large capacity for interactions.

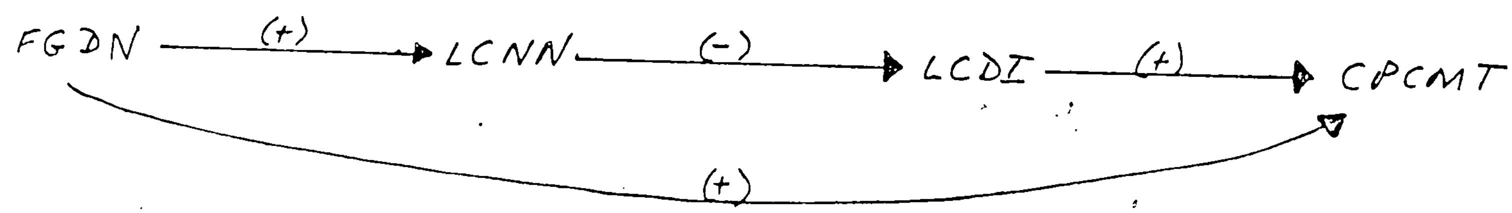
so that the cartel has a "corner on the market"; on the other hand, problems of co-ordination increase with the size of the group.

One result of this process modelled in Figure 7.4 would be suppression of the relationship between profits and interlocking in the central clique, since its direct positive effect on profits would be offset by its (spurious) negative relationship with profits resulting from their mutual (but opposite in effect) relationship with interlocking in the full graph.

This more elaborate model could be tested as part of the path analysis to test the general hypothesis of the study. However, before doing so, its plausibility was checked by computing zero-order correlations between interlocking in the central clique and the size of the central clique, and between density of interlocking in the full graph and the size of the central clique. If the former correlations were positive or the latter negative, the model could not be correct; if they were as hypothesized, the model's plausibility would be confirmed. Because of the strong similarity in patterns of results to this point for the three kinds of interlock indices -- raw, zero-values excluded, and log -- analysis of correlations with the size of the central clique was limited to the raw indices. However, correlations were also computed with the square of the size of the central clique, since co-ordination problems

Figure 7.4

Path model for full graph and subgraph predictors of corrected price-cost margins



FGDN: full graph density of interlocks,

LCNN: number of nodes in largest connected component,

LCDI: degree of interlocking in largest connected component,

CPCMT: corrected price-cost margin.

in a group (and co-optive interlocking) could be expected to increase with the square of the number of nodes.

A breakdown of the average correlations with these indices of the size of the central clique is shown in Table 7.4. The density of ties in the full graph does indeed strongly influence the size of the central clique, which in turn has the hypothesized negative association with density and compactness in the central clique, but not with either index of centralization. On reflection, this result seems reasonable: the larger the subgraph, the more "fringe" nodes are present (i.e., the more stratified the nodes), and the greater the relative centrality of the dominant node. Thus the model of Figure 7.4 appears to be a plausible explanation for the average negative correlations with profits of density and compactness in the central clique, but not for the two centralization indices.

The dimension of the interlock indices that has the next strongest relationship with variations in their correlations with profits is the affiliations of the interlocker. Indices based on director-director ("DD") ties have an average correlation with profits of 0.072, compared to 0.034 for indices based on director-officer or officer-officer ("DO/OO") ties (Table 7.2). This difference is even more pronounced for the "zero-values excluded" and log indices. This relationship was examined more closely by controlling for the other dimensions on which the indices

Table 7.4

Summary of correlations of interlocking indices with size of central clique and its square

Type of index	N	LCNN	$LCNN^2$
FULL - density	24	0.495	0.403
LC - density	24	-0.331	-0.299
LC - cent. of degree	24	0.177	0.104
LC - compactness	24	-0.220	-0.192
LC - cent. of closeness	24	0.085	0.027

Notes:

FULL: computed on ties in the full graph
LC: computed on ties in the largest component
LCNN: number of nodes in the largest component

varied, in order to test whether the relationship was consistent over all subcategories of indices. Because of the similarity in pattern of the relationship over the three kinds of indices -- raw and two transformations -- the breakdown was performed on the raw index only. Because the reliability of the subgraph-based indices as criteria was in doubt, both because of their negative correlations with profits and because of their dependence, demonstrated above, on full graph density, a separate breakdown was performed for the full graph-based indices only.

The results of this breakdown are shown in Table 7.5. For full graph indices, the difference between director-director ("DD") and director-officer or officer-officer ("DO/OO") indices is considerably smaller (0.199 vs. 0.182) than for all indices (0.072 vs. 0.034). However, director-director ("DD") indices have average correlations higher than or approximately equal to director-officer or officer-officer ("DO/OO") indices, for five out of six types of index (the correlations for the density of the largest subgraph are somewhat more negative for "DD" than for "DO/OO"). Similarly, director-director ("DD") indices have higher correlations than "DO/OO" indices for real- and binary-valued ties. However, there is a very pronounced difference over the six types of tie. For the three types of tie (TOT's 2,4,6) including indirectly horizontal ties (i.e., ties where at least one interlocking firm is outside the market area), the "DO/OO" indices have substantially higher correlations with profits than the director-director ("DD") indices. One can only speculate as to why this is so. Perhaps a fair number of the indirectly horizontal director-director ("DD") ties are indeed the result of chance; whereas the "DO/OO" ties, involving at least one officer of an interlocked firm, are more likely to be evidence of collusion. In any case, the obvious conclusion is that "DO/OO" indices should be used in these three cases, and director-director ("DD") indices in the other three, to test the general hypotheses.

A third conclusion drawn from Table 7.2 was that the distinction between binary and real-valued measurement of interlocks had little effect on size of correlations (F=1.6, not significant, in the analysis of variance of correlations), although the binary-valued ties had, on average, somewhat higher correlations for the untransformed interlock indices (0.62 vs. 0.44). Apparently, either (1) in reality, the mere presence or absence of a tie between enterprises, not its "strength," is the important factor in co-optation, and therefore, profit levels, or (2) the chosen method of measuring strength of ties, involving a sequence of somewhat arbitrary transformations, did not accurately measure that aspect of strength of ties that actually affects profits.

Before accepting this conclusion, a closer analysis of binary vs. real-valued indices was performed, similar to the

Table 7.5

Comparison of average correlations with profit margins of DD and DO/OO indices of interlocking, controlling for other dimensions of interlock indices*

	Full graph only			All indices		
Index	N	DD	DO/OO	N	DD	DO/OO
All	48	0.199	0.182	144	0.072	0.034
Type of index						
FG DN	24	0.225	0.227	24	0.225	0.227
FG CD	24	0.173	0.136	24	0.173	0.136
IC DN				24	-0.052	-0.031
IC CD				24	-0.037	-0.130
IC CP				24	-0.047	-0.040
IC CC				24	-0.033	-0.103
Type of tie (TOT)						
1.	8	0.149	-0.090	24	0.049	-0.112
2.	8	0.101	0.176	24	0.006	0.016
3.	8	0.378	0.307	24	0.102	0.037
4.	8	0.194	0.212	24	0.126	0.176
5.	8	0.280	0.262	24	0.126	0.0
6.	8	0.090	0.174	24	0.020	0.087
Level of measurement						
Binary	24	0.206	0.201	72	0.068	0.056
Real	24	0.191	0.163	72	0.075	0.012

*Indices are defined in Chapter 7, Section 7.2.

breakdown used to select between director-director ("DD") and "DO/OO" indices. However, this breakdown was based on only the 72 indices remaining after selection of director-director ("DD") vs. "DO/OO" indices, and a separate breakdown was performed for the 24 remaining full graph indices.

The results of this breakdown are shown in Table 7.6. The mean correlation with profits over the 72 remaining indices is slightly higher for indices based on real-valued graphs than for the binary graphs (0.063 vs. 0.058); on full graph indices, binary indices have a higher mean correlation, but the difference is tiny. Indices based on binary graphs have slightly higher mean correlations for all types of index except subgraph density and compactness, but these differences are difficult to assess since the means are negative. However, there are clear and consistent differences when the indices are broken down by type of tie: for those excluding bank ties (TOT's 1 and 2), indices based on real valued ties have consistently higher mean correlations, and for those including bank ties, indices based on binary valued ties have higher mean correlations.

Apparently, it is the mere presence or absence of bank ties that is related to profits, but the strength of ties with competing enterprises -- i.e., the number of interlocked firms and the number of interlocks between pairs of firms -- is more strongly related to profits than their mere existence. Again, an explanation of this difference must be highly speculative. Perhaps interlocks with

Table 7.6

Comparison of average correlations with profit margins of indices of interlocking based on real- and binary-valued graphs, controlling for type of index and type of tie*

	Full graph only			All indices		
	N	Binary	Real	N	Binary	Real
All	24	0.245	0.228	72	0.058	0.063
Type of index						
FG DN	12	0.263	0.243	12	0.263	0.243
FG CD	12	0.227	0.213	12	0.227	0.213
IC DN				12	-0.044	-0.017
IC CD				12	-0.028	-0.029
IC CP				12	-0.056	-0.004
IC CC				12	-0.013	-0.027
Type of tie (TOT)						
1.	4	0.119	0.179	12	0.009	0.080
2.	4	0.140	0.219	12	-0.049	0.052
3.	4	0.387	0.370	12	0.038	0.034
4.	4	0.312	0.219	12	0.181	0.119
5.	4	0.319	0.242	12	0.113	0.028
6.	4	0.195	0.116	12	0.055	0.064

*Indices are defined in Chapter 7, Section 7.2.

competitors are metered much more precisely than with banks.
The immediate conclusion is that for indices based on each type of tie, the level of measurement category with the highest mean correlation is the appropriate one for the final hypothesis testing.

7.2.4 Further deletion of redundant indices

The number of indices had at this point been reduced to 36 -- 6 types of index on each of 6 types of tie -- for each of which there were 3 transformations -- raw, zero value excluded, and log. A redundant index was now redefined as that member of a pair of highly intercorrelated indices whose correlation with the profits index was lower and/or which was less desirable on other grounds.

Intercorrelations were computed among the untransformed values of all 36 indices, and are shown in Table 7.7. Correlations of the three transformations of the 36 indices with the profits index are shown in Table 7.8. All pairs of indices whose intercorrelation was greater than approximately 0.75 were compared on their correlation with profits, and the index with the larger value was selected unless there was a special reason to select the other index. Comparisons of highly intercorrelated indices are shown in Table 7.9.

With a few exceptions, these comparisons reveal very strong and simple patterns. For each type of index, the indices based on TOT's 3 and 4 (3= direct horizontal ties

TABLE 7.7

INTERCORRELATIONS OF 36 SELECTED INTERLOCK INDICES OVER 30 MARKET AREAS.

CORRELATION MATRIX*

	RFGDN07	RFGDN11	RFGCD07	RFGCD11	BFGDN01	BFGDN05	BFGDN13	BFGDN17	BFGCD01
RFGDN07	1.00000	0.54439	0.95247	0.41405	0.63883	0.68844	0.55114	0.59348	0.50575
RFGDN11	0.54439	1.00000	0.52818	0.89168	0.42188	0.64368	0.36298	0.58549	0.34840
RFGCD07	0.95247	0.52818	1.00000	0.43417	0.64581	0.57535	0.58548	0.53576	0.48630
RFGCD11	0.41405	0.89168	0.43417	1.00000	0.33110	0.55517	0.29206	0.54245	0.26436
BFGDN01	0.63883	0.42188	0.64581	0.33110	1.00000	0.67368	0.97370	0.68033	0.85683
BFGDN05	0.68844	0.64368	0.57535	0.55517	0.67368	1.00000	0.56925	0.93600	0.58109
BFGDN13	0.55114	0.36298	0.58548	0.29206	0.97370	0.56925	1.00000	0.62585	0.81443
BFGDN17	0.59348	0.58549	0.53576	0.54245	0.68033	0.93600	0.62585	1.00000	0.56367
BFGCD01	0.50575	0.34840	0.48630	0.26436	0.85683	0.58109	0.81443	0.56367	1.00000
BFGCD05	0.38504	0.15858	0.21628	0.04110	0.31544	0.74673	0.22431	0.66286	0.22451
BFGCD13	0.37551	0.34084	0.46005	0.30329	0.89762	0.45174	0.90392	0.51887	0.85906
BFGCD17	0.56089	0.28699	0.49223	0.23621	0.46143	0.76495	0.42337	0.85941	0.35716
RLCDN07	0.64003	0.27718	0.70598	[illegible]	0.24644	0.24872	0.20961	0.21138	0.11475
RLCDN11	-0.02327	0.06452	0.00828	0.30208	-0.26453	-0.16823	-0.25737	-0.17591	-0.26222
RLCCP07	0.62411	0.26431	0.67311	0.21293	0.20330	0.24268	0.16046	0.19119	0.08005
RLCCP11	-0.01943	0.00743	0.00071	0.21730	-0.23991	-0.19855	-0.29184	-0.23217	[illegible]
RLCCD07	0.40940	0.79127	0.49201	0.62841	0.40338	0.38059	0.39404	0.39772	0.37239
RLCCD11	-0.09293	0.15538	-0.05696	0.30449	-0.06277	0.00736	-0.04996	0.10414	0.09756
RLCCC07	0.34627	0.73712	0.41045	0.56603	0.31295	0.33834	0.28966	0.32799	0.31414
RLCCC11	-0.13762	0.08035	-0.12791	0.28949	-0.15720	-0.03073	-0.16110	0.03115	0.02101
BLCDN01	-0.24034	-0.27549	-0.26350	-0.26081	-0.62630	-0.32760	-0.63543	-0.46103	-0.76786
BLCDN05	0.01729	-0.05464	-0.09826	-0.25012	-0.16564	0.05564	-0.25597	-0.14606	-0.27152
BLCDN13	-0.26360	-0.31907	-0.31379	-0.36637	[illegible]	-0.36469	-0.55142	-0.50843	[illegible]
BLCDN17	-0.03351	-0.07843	-0.11627	-0.27558	[illegible]	0.15890	-0.07612	0.20197	-0.22912
BLCCP01	-0.22604	-0.25327	-0.27513	-0.26932	-0.60778	-0.32127	-0.61529	-0.46382	-0.72969
BLCCP05	0.01142	-0.06618	-0.08879	-0.29148	-0.14240	0.08263	-0.20953	-0.05333	-0.27261
BLCCP13	-0.25531	-0.29827	-0.28901	-0.34574	-0.50140	-0.38214	-0.48642	-0.51213	-0.62590
BLCCP17	0.13867	-0.02966	0.08473	-0.19716	0.03413	0.27072	0.04152	0.38508	-0.15355
BLCCD01	-0.20504	-0.11588	-0.28473	-0.13656	-0.15231	-0.14637	-0.16652	-0.13526	0.10944
BLCCD05	-0.06200	-0.34396	-0.16478	-0.51014	-0.31418	-0.09666	-0.35701	-0.23873	-0.41938
BLCCD13	-0.06662	0.06293	-0.08157	0.07426	0.19695	0.05573	0.17243	0.09763	0.32440
BLCCD17	0.22448	-0.19252	0.17185	-0.32512	-0.13956	0.10736	-0.14528	0.13320	-0.29449
BLCCC01	-0.26069	-0.09251	-0.33353	-0.10771	-0.14271	-0.14031	-0.16362	-0.10826	0.11972
BLCCC05	-0.19067	-0.39683	-0.26060	-0.55923	-0.27346	-0.15947	-0.30569	-0.26130	-0.43190
BLCCC13	-0.06194	0.05951	-0.05883	0.06983	0.22715	0.08533	0.19493	0.13739	0.34902
BLCCC17	0.16555	-0.23736	0.08975	-0.36578	-0.05774	0.17698	-0.08729	0.16512	-0.21652

*Variables are defined in Table 7.1

TABLE 7.7 (cont'd)

INTERCORRELATIONS OF 36 SELECTED INTERLOCK INDICES OVER 30 MARKET AREAS.

CORRELATION MATRIX*

	BFGCD05	BFGCD13	BFGCD17	RLCDN07	RLCDN11	RLCCP07	RLCCP11	RLCCD07	RLCCD11
RFGDN07	0.36504	0.37551	0.56089	0.64003	-0.02327	0.62411	-0.01943	0.40940	-0.09293
RFGDN11	0.15658	0.34084	0.28099	0.27718	0.06452	0.26431	0.00743	0.79127	0.15536
RFGCD07	0.21628	0.46005	0.49223	0.70598	0.00828	0.67311	0.00071	0.49201	-0.05695
RFGCD11	0.04110	0.30329	0.23621	0.22991	0.30208	0.21293	0.21730	0.62841	0.36445
BFGDN01	0.31544	0.69762	0.46143	0.24644	-0.26453	0.20330	-0.26991	0.40338	-0.06277
BFGDN05	0.74873	0.45174	0.76485	0.24872	-0.16823	0.24268	-0.19855	0.39059	0.00736
BFGDN13	0.22431	0.90392	0.42397	0.20981	-0.25737	0.16046	-0.29164	0.39404	-0.04996
BFGDN17	0.00286	0.51887	0.85941	0.21138	-0.17591	0.19118	-0.23217	0.39772	0.10414
BFGCD01	0.22451	0.85906	0.35716	0.11475	-0.26222	0.08006	-0.28062	0.37239	0.09756
BFGCD05	1.00000	0.06664	0.75718	0.09009	-0.21802	0.11121	-0.20078	-0.04172	-0.18580
BFGCD13	0.06664	1.00000	0.27890	0.12536	-0.21391	0.07269	-0.25118	0.45455	0.08107
BFGCD17	0.75718	0.27890	1.00000	0.27612	-0.14844	0.26680	-0.17915	0.16282	0.05268
RLCDN07	0.09009	0.12536	0.27612	1.00000	0.27105	0.99637	0.26666	0.19746	-0.03353
RLCDN11	-0.21802	-0.21391	-0.14844	0.27105	1.00000	0.28050	0.98952	-0.08529	0.15231
RLCCP07	0.11121	0.07269	0.26680	0.99637	0.28050	1.00000	0.26058	0.15030	-0.05263
RLCCP11	-0.20078	-0.25118	-0.17915	0.26666	0.98952	0.26058	1.00000	-0.13562	0.06456
RLCCD07	-0.04172	0.45455	0.16282	0.19746	-0.08529	0.15030	-0.13562	1.00000	0.25334
RLCCD11	-0.18580	0.08107	0.05268	-0.03353	0.15231	-0.05263	0.06456	0.25334	1.00000
RLCCC07	[illegible]	0.36543	0.09594	0.20704	-0.02597	0.16414	[illegible]	0.97104	0.32715
RLCCC11	[illegible]	-0.04168	-0.00951	-0.06684	0.17442	-0.09958	0.09770	0.17036	0.97036
BLCDN01	0.07777	-0.75266	-0.27040	-0.12762	0.13441	-0.08943	0.19531	-0.38308	-0.33634
BLCDN05	0.34984	-0.34601	-0.10617	-0.06254	-0.10343	-0.03175	-0.02152	-0.15690	-0.41936
BLCDN13	0.00335	-0.69127	-0.33754	-0.13642	0.06420	-0.09708	0.13344	-0.40657	-0.37600
BLCDN17	0.43238	-0.20970	0.30762	-0.05601	-0.19492	[illegible]	-0.15795	-0.12040	-0.30547
BLCCP01	0.06355	-0.73799	-0.29260	-0.14923	0.13179	[illegible]	0.13201	-0.36146	-0.31772
BLCCP05	-0.42304	-0.33296	0.04469	-0.02165	-0.22163	[illegible]	-0.14066	-0.18361	-0.43572
BLCCP13	-0.01617	-0.60436	-0.36791	-0.12886	-0.06997	-0.09477	0.13715	-0.35901	-0.34040
BLCCP17	0.49762	-0.13399	0.59570	0.11965	-0.24095	0.12827	-0.23033	-0.09405	-0.14641
BLCCD01	-0.21669	-0.13042	-0.19964	-0.31062	-0.01704	-0.29675	-0.01873	-0.13172	-0.11603
BLCCD05	0.46329	-0.49016	0.02203	-0.03623	-0.13720	0.00126	-0.10063	-0.35776	-0.42839
BLCCD13	-0.13436	0.34635	-0.02947	-0.13473	0.11049	-0.14681	-0.08247	0.11433	-0.22359
BLCCD17	0.51699	-0.32070	0.53028	-0.23557	-0.13910	[illegible]	-0.03756	-0.19926	-0.22276
BLCCC01	-0.23661	-0.06491	-0.20166	-0.38961	-0.03029	-0.37706	-0.03764	-0.09657	-0.16906
BLCCC05	0.37579	-0.39971	-0.05283	-0.15313	-0.21424	-0.11545	[illegible]	-0.42510	-0.46316
BLCCC13	-0.11691	0.37393	0.01176	-0.12073	0.11626	-0.13287	0.05554	0.10530	-0.21600
BLCCC17	0.61701	-0.26737	0.49603	0.12334	-0.32636	0.14757	-0.28072	-0.30424	-0.30159

*Variables are defined in Table 7.[illegible]

TABLE 7.7 (cont'd)

INTERCORRELATIONS OF 36 SELECTED INTERLOCK INDICES
OVER 30 MARKET AREAS.

CORRELATION MATRIX*

	BLCCC07	BLCCC11	BLCDN01	BLCDN05	BLCDN13	BLCDN17	BLCCP01	BLCCP05	BLCCP13
BFGDN07	0.34827	-0.13762	-0.24034	0.01729	-0.26360	-0.03351	-0.22604	0.01142	-0.25531
BFGDN11	0.73712	0.08035	-0.27549	-0.05464	-0.31907	-0.07543	-0.25327	-0.06616	-0.29627
BFGCD07	0.41045	[illegible]	-0.28350	-0.09826	-0.31379	-0.11627	-0.27513	-0.08879	-0.28901
BFGCD11	0.36663	[illegible]	[illegible]	-0.25012	-0.30037	-0.27588	-0.26932	-0.29148	-0.34574
BFGDN01	0.31895	[illegible]	[illegible]	-0.16564	-0.56371	-0.05345	-0.60776	-0.14240	-0.50148
BFGDN05	0.33834	[illegible]	[illegible]	0.05564	-0.38469	0.15830	-0.32127	0.08263	-0.38214
BFGDN13	[illegible]	[illegible]	[illegible]	-0.25597	-0.55142	-0.07612	-0.61529	-0.20953	-0.48642
BFGDN17	0.32799	[illegible]	[illegible]	-0.14606	-0.50843	0.20167	-0.46362	-0.05333	-0.51213
BFGCD01	0.34414	[illegible]	[illegible]	-0.27152	-0.68693	-0.22912	-0.72969	-0.27261	-0.62590
BFGCD05	-0.03419	[illegible]	0.09777	0.34984	0.00335	0.43238	0.06355	0.42304	-0.01617
BFGCD13	0.36543	[illegible]	-0.76266	-0.34601	-0.69127	-0.20970	-0.73799	-0.33298	-0.60436
BFGCD17	0.09594	[illegible]	-0.27040	-0.10617	-0.33754	0.30762	-0.29260	0.04469	-0.36791
BLCDN07	0.20704	-0.08684	-0.12762	-0.06254	-0.13642	-0.05601	-0.14923	-0.02165	-0.12686
BLCDN11	-0.02597	0.17442	0.13441	-0.10343	0.06420	-0.19492	0.13179	-0.22163	0.06997
BLCCP07	0.16414	-0.09958	-0.08943	-0.03175	-0.09708	-0.04090	-0.11135	0.01134	-0.09477
BLCCP11	-0.07638	0.09770	0.19531	-0.02152	0.13344	-0.15795	-0.19201	-0.14050	0.13715
BLCCD07	0.97104	0.17838	-0.38308	-0.15890	-0.40657	-0.12040	-0.36146	-0.18381	-0.35961
BLCCD11	0.32718	0.97030	-0.33634	-0.41932	-0.37600	-0.30849	-0.31764	-0.43572	-0.34645
BLCCC07	1.00000	0.27712	-0.34595	-0.10080	-0.37605	-0.11088	-0.32468	-0.16424	-0.33200
BLCCC11	0.27712	1.00000	-0.21708	-0.30288	-0.26622	-0.25280	-0.19672	-0.35785	-0.24325
BLCDN01	-0.34595	-0.21708	1.00000	0.64050	0.92245	0.30971	0.99341	0.58673	0.90081
BLCDN05	-0.10080	-0.30288	0.64050	1.00000	0.56349	0.68250	0.63468	0.91873	0.56360
BLCDN13	-0.37868	-0.26622	0.92245	0.56349	1.00000	0.26708	0.93569	0.55288	0.98834
BLCDN17	-0.11088	-0.25280	0.30971	0.68250	0.26705	1.00000	0.28182	0.78025	0.22941
BLCCP01	-0.32468	-0.19672	0.99341	0.63466	0.93569	0.28182	1.00000	0.57630	0.92254
BLCCP05	-0.16424	-0.35785	0.58673	0.91873	0.55288	0.78025	0.57630	1.00000	0.53479
BLCCP13	-0.33200	-0.24325	0.90081	0.56360	0.98834	0.22941	0.92254	0.53479	1.00000
BLCCP17	-0.13027	-0.20859	0.18565	0.41329	0.14145	0.87316	0.15041	0.61996	0.09169
BLCCD01	-0.10380	0.19661	-0.17764	-0.12929	-0.07047	-0.06505	-0.11837	-0.21799	-0.07060
BLCCD05	-0.30681	-0.33448	0.73617	0.81244	0.69280	0.59255	0.72059	0.84666	0.67558
BLCCD13	0.12155	0.23713	-0.45893	-0.17330	-0.54269	-0.09443	-0.44903	-0.33525	-0.49598
BLCCD17	-0.21899	-0.21273	0.45668	0.46014	0.37687	0.63029	0.42001	0.60059	0.33633
BLCCC01	-0.07475	0.23812	-0.25023	-0.18852	-0.14833	-0.06263	-0.19860	-0.26606	-0.15284
BLCCC05	-0.41995	-0.41831	0.67490	0.71654	0.66279	0.55703	0.65593	0.61964	0.65059
BLCCC13	0.11051	0.22485	-0.51415	-0.20652	-0.59915	-0.08420	-0.51132	-0.33354	-0.56234
BLCCC17	-0.33450	-0.27623	0.45024	0.50154	0.42692	0.59654	0.41936	0.65653	0.39260

*Variables are defined in Table 7.1

TABLE 7.7 (cont'd)

INTERCORRELATIONS OF 36 SELECTED INTERLOCK INDICES OVER 30 MARKET AREAS.

CORRELATION MATRIX*

	BLCCP17	BLCCD01	BLCCD05	BLCCD13	BLCCD17	BLCCC01	BLCCC05	BLCCC13	BLCCC17
BFGDN07	0.13867	-0.20504	-0.06200	-0.08662	0.22448	-0.26069	-0.19667	-0.06194	0.16555
BFGDN11	-0.02966	-0.11588	-0.34396	0.06293	-0.19252	-0.09251	-0.39663	0.05951	-0.23736
BFGCD07	0.06473	-0.28473	-0.16478	-0.08157	0.17155	-0.33353	-0.26060	-0.05663	0.08975
BFGCD11	-0.13716	-0.13656	-0.51014	0.07425	-0.32512	-0.10771	-0.35923	0.06959	-0.35576
BFGDN01	0.03413	-0.15231	-0.31418	0.19895	-0.13956	-0.14271	-0.27346	0.22715	-0.05774
BFGDN05	0.27072	-0.14637	-0.09666	0.05573	0.10736	-0.14031	-0.15547	0.08532	-0.17096
BFGDN13	0.04152	-0.16652	-0.35701	0.17243	-0.14528	-0.16362	-0.30569	0.19493	-0.08728
BFGDN17	0.36565	-0.13526	-0.23673	0.09763	0.13320	-0.10826	-0.26130	0.13734	0.16512
BFGCD01	[illegible]	0.10944	-0.41938	0.32440	-0.29449	0.11972	0.43150	0.34962	-0.21602
BFGCD05	0.49762	-0.21889	0.46329	-0.13436	0.51099	-0.23601	0.37879	-0.11691	0.61701
BFGCD13	-0.13399	-0.13042	-0.49016	0.34635	-0.32070	-0.09491	-0.3[illegible]	0.37343	-0.26737
BFGCD17	0.39570	-0.19964	0.02203	-0.02947	0.33026	-0.20160	-0.05263	0.01176	0.49605
BLCDN07	0.11965	-0.31062	-0.03623	-0.13472	0.23557	-0.38981	-0.15310	-0.12073	0.12331
BLCDN11	-0.24095	-0.01704	-0.16720	0.11049	-0.13910	-0.03029	-0.21424	0.11[illegible]	-0.3[illegible]
BLCCP07	0.12627	-0.29675	0.00126	-0.14661	0.25254	-0.37706	-0.11545	-0.13267	-0.14757
BLCCP11	-0.23039	-0.01875	-0.10063	0.06247	-0.09758	-0.03784	-0.12564	0.03574	-0.26074
BLCCD07	0.09405	-0.13172	-0.35776	0.11433	-0.19926	-0.09657	-0.44510	0.10630	-0.30424
BLCCD11	-0.19641	0.11603	-0.42838	0.22667	-0.22276	0.16906	-0.45316	0.21600	-0.3[illegible]
BLCCC07	-0.13027	-0.10380	-0.30661	0.12155	-0.21885	-0.07475	-0.41995	0.11051	-0.33[illegible]
BLCCC11	-0.20659	0.19661	-0.33448	0.23713	-0.21273	0.23512	-0.[illegible]16[illegible]	0.22485	-0.37[illegible]
BLCDN01	0.16565	-0.17764	0.73617	-0.45693	0.45666	-0.25023	0.67450	-0.51415	0.4[illegible]
BLCDN05	0.41329	-0.12929	0.61244	-0.17336	0.46014	-0.16852	0.71654	-0.56652	0.50154
BLCDN13	0.14145	-0.07047	0.69260	-0.54269	0.37667	-0.14333	0.65[illegible]	-0.59916	0.46[illegible]
BLCDN17	0.67316	-0.06505	0.59255	-0.07443	0.63029	-0.08263	0.55700	-0.56426	0.55054
BLCCP01	0.15041	-0.11637	0.72059	-0.44903	0.42001	-0.19960	0.65843	-0.51132	0.4197[illegible]
BLCCP05	0.61998	-0.21799	0.64600	-0.33525	0.66685	-0.26606	0.61964	-0.55354	0.56505
BLCCP13	0.09169	-0.07060	0.67568	-0.49535	0.53635	-0.15264	0.60505	-0.56234	0.3[illegible]
BLCCP17	1.00000	-0.19771	0.48097	-0.20235	0.61039	-0.21561	0.44327	-0.16232	0.73365
BLCCD01	-0.19771	1.00000	-0.26542	0.59576	-0.36288	0.97694	-0.24142	0.55740	-0.25950
BLCCD05	0.48097	-0.26542	1.00000	-0.43157	0.72091	-0.33254	0.90142	-0.40662	0.76932
BLCCD13	-0.20235	0.59576	-0.43157	1.00000	-0.35760	0.63412	-0.35757	0.38927	-0.37177
BLCCD17	0.61039	-0.36288	0.72091	-0.35760	1.00000	-0.42649	0.58620	-0.39139	0.69315
BLCCC01	-0.21561	0.97694	-0.33254	0.63412	-0.42649	1.00000	-0.25948	0.61165	-0.31021
BLCCC05	0.44327	-0.24142	0.90142	-0.35757	0.58620	-0.25948	1.00000	-0.34004	0.71342
BLCCC13	-0.16232	0.55740	-0.40662	0.38927	-0.39139	0.61165	-0.34004	1.00000	-0.38528
BLCCC17	0.73365	-0.25950	0.76932	-0.37177	0.69315	-0.31021	0.71342	-0.38528	1.00000

*Variables are defined in Table 7.1

TABLE 7.8

CORRELATIONS WITH CORRECTED PRICE-COST MARGINS OF 36 SELECTED INTERLOCK INDICES AND THEIR TRANSFORMS.

INDEX	CONNECT	LEVMEAS	TYPINDEX	BANKS	MKTREL	AFFILS	DICPCMT	DIMCPCMT	LDICPCMT
BFGCD01	FULL	BINARY	CENTDEG	IN	ININ	DD	0.40586	0.36761	0.40586
BFGCD05	FULL	BINARY	CENTDEG	IN	ALL	DD/OO	0.27965	0.25102	0.27965
RFGCD07	FULL	REAL	CENTDEG	OUT	ININ	DD	0.15103	0.35937	0.60349
RFGCD11	FULL	REAL	CENTDEG	OUT	ALL	DD/OO	0.19974	0.50339	0.42114
BFGCD13	FULL	BINARY	CENTDEG	P2IN	ININ	DD	0.37012	0.36349	0.37012
BFGCD17	FULL	BINARY	CENTDEG	P2IN	ALL	DD/OO	0.16725	0.16301	0.16725
BFGDN01	FULL	BINARY	DENSITY	IN	ININ	DD	0.36852	0.38336	0.36852
BFGDN05	FULL	BINARY	DENSITY	IN	ALL	DD/OO	0.34466	0.37165	0.34466
RFGDN07	FULL	REAL	DENSITY	OUT	ININ	DD	0.20626	0.36378	0.62867
RFGDN11	FULL	REAL	DENSITY	OUT	ALL	DD/OO	0.22398	0.51816	0.35057
BFGDN13	FULL	BINARY	DENSITY	P2IN	ININ	DD	0.26730	0.34269	0.26730
BFGDN17	FULL	BINARY	DENSITY	P2IN	ALL	DD/OO	0.22263	0.24017	0.22263
BLCCC01	LCC	BINARY	CENTCP	IN	ININ	DD	-0.09662	-0.16196	-0.16006
BLCCC05	LCC	BINARY	CENTCP	IN	ALL	DD/OO	0.06409	0.00611	0.06409
RLCCC07	LCC	REAL	CENTCP	OUT	ININ	DD	-0.00443	0.28028	0.32578
RLCCC11	LCC	REAL	CENTCP	OUT	ALL	DD/OO	-0.12850	-0.07099	-0.05217
BLCCC13	LCC	BINARY	CENTCP	P2IN	ININ	DD	0.22263	0.25015	0.22597
BLCCC17	LCC	BINARY	CENTCP	P2IN	ALL	DD/OO	0.03429	0.03674	0.03429
BLCCD01	LCC	BINARY	CENTDEG	IN	ININ	DD	-0.09660	-0.11446	-0.16063
BLCCD05	LCC	BINARY	CENTDEG	IN	ALL	DD/OO	0.01446	-0.01166	0.01446
RLCCD07	LCC	REAL	CENTDEG	OUT	ININ	DD	0.01383	0.55270	0.52323
RLCCD11	LCC	REAL	CENTDEG	OUT	ALL	DD/OO	-0.04961	0.14550	0.14808
BLCCD13	LCC	BINARY	CENTDEG	P2IN	ININ	DD	0.22734	0.26931	0.22104
BLCCD17	LCC	BINARY	CENTDEG	P2IN	ALL	DD/OO	-0.03340	-0.03563	-0.03340
BLCCP01	LCC	BINARY	COMPACT	IN	ININ	DD	-0.17343	-0.17884	-0.17343
BLCCP05	LCC	BINARY	COMPACT	IN	ALL	DD/OO	0.17417	0.17615	0.17417
RLCCP07	LCC	REAL	COMPACT	OUT	ININ	DD	0.06140	0.30571	0.34831
RLCCP11	LCC	REAL	COMPACT	OUT	ALL	DD/OO	0.03980	0.11969	0.12142
BLCCP13	LCC	BINARY	COMPACT	P2IN	ININ	DD	-0.18276	-0.17940	-0.18276
BLCCP17	LCC	BINARY	COMPACT	P2IN	ALL	DD/OO	-0.05572	-0.05346	-0.05572
BLCDN01	LCC	BINARY	DENSITY	IN	ININ	DD	-0.17847	-0.18844	-0.17847
BLCDN05	LCC	BINARY	DENSITY	IN	ALL	DD/OO	0.20992	0.17814	0.20992
RLCDN07	LCC	REAL	DENSITY	OUT	ININ	DD	0.00065	0.31837	0.34639
RLCDN11	LCC	REAL	DENSITY	OUT	ALL	DD/OO	0.02609	0.13481	0.12559
BLCDN13	LCC	BINARY	DENSITY	P2IN	ININ	DD	-0.22713	-0.22547	-0.22713
BLCDN17	LCC	BINARY	DENSITY	P2IN	ALL	DD/OO	-0.00482	-0.03254	-0.00482

plus bank ties with firms in the market area; 4= ties of type 3 plus indirect horizontal ties plus bank ties with firms outside the market area) are highly correlated with the corresponding indices based on TOT's 5 and 6 (5= ties of type 3 plus P2 bank-mediated ties between firms in the market area; 6= ties of type 4 plus P2 bank-mediated ties between firms both within and outside the market area), and have slightly higher correlations with the profit margins variable: e.g., BFGDN01* vs. BFGDN13; BFGCD01 vs. BFGCD13, etc. (In Table 7.9 some of the members of these pairs and their correlation with the other member -- e.g., BFGCD05, 0.757 -- are shown in parentheses because they in turn were also judged to be redundant. BFGCD05, for example, is also highly correlated with BFGDN05, and has a lower correlation with corrected price-cost margins ("CPCMT")--0.280 vs. 0.345). Apparently, then, the inclusion of bank-mediated P2 ties in the graphs slightly <u>reduces</u> the power of the graph to explain variation in profits. The only exceptions are BLCCC13 and BLCCD13, with radically higher correlations with corrected price-cost margins ("CPCMT") than their partners, BLCCC01 and BLCCD01; these were treated as anomalies and ignored. All of the ties based on graphs including P2 bank-mediated ties were therefore excluded from further consideration.

The second obvious pattern is the high correlation between pairs of indices based on the same type of tie, and

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*See Table 7.1 for definitions of indices of interlocking.

the consistency in which one type of index had higher correlations with profits than the other. For example, each of the four full graph density indices (BFGDN01, BFGDN05, RFGDN07, RFGDN11) based on the four remaining types of tie (TOT's 3, 4, 1, 2 respectively) is highly correlated with the corresponding one of the four centralization of degree indices (BFGCD01, BFGCD05, RFGCD07, RFGCD11), and in three of four cases the density index is more highly correlated with the profits variable. Similarly for the four subgraph compactness vs. density indices. In the last group, the correlations between corresponding indices are again high, but for two types of tie (TOT's 3 and 4), centralization of closeness indices have higher correlations with profits, and for the other two TOT's, centralization of degree indices have higher correlations with profits.

Given such strong patterns with so few exceptions, I had some confidence in using this intercorrelation-correlation procedure to select a subset of indices for further analysis. The 12 indices in the left-hand column of Table 7.9 were therefore selected.

Of the 8 of these indices based on the largest connected subgraphs, and having very weak correlations with the profits index, 5 have negative correlations with the size of the subgraph (see Table 7.10). For these indices one would expect that the weakness of the correlation with profits is partially due to the suppressor effect of

Table 7.9

Selection of interlock indices from highly intercorrelated pairs by comparing their correlations with corrected price-cost margins*

Selected index	R (CPCMT)	Rejected index	R (CPCMT)	Inter-correl'n.
BFGDN01	0.369	BFGDN13	0.267	0.974
		BFGCD01	0.406	0.657
		BFGCD13	0.370	0.898
(BFGCD01		BFGCD13		0.859)
BFGDN05	0.345	BFGDN17	0.223	0.936
		BFGCD05	0.280	0.749
		BFGCD17	0.167	0.765
(BFGCD05		BFGCD17		0.757)
BFGDN07	0.206	BFGCD07	0.151	0.952
BFGDN11	0.224	BFGCD11	0.200	0.892
BLCCP01	-0.173	BLCCP13	-0.183	0.923
		BLCDN01	-0.178	0.993
		BLCDN13	-0.227	0.936
(BLCDN01)		BLCDN13		0.922)
BLCCP05	0.174	BLCCP17	-0.056	0.620
		BLCDN05	0.210	0.919
		BLCDN17	-0.005	0.780
(BLCDN05		BLCDN17		0.683)
BLCCP07	0.061	BLCDN07	0.051	0.996
BLCCP11	0.040	BLCDN11	0.026	0.990
BLCCC01	-0.097	BLCCC13	0.222	0.612
		BLCCD01	-0.097	0.977
		BLCCD13	0.227	0.634
(BLCCD01		BLCCD13		0.596)
BLCCC05	0.064	BLCCC17	0.034	0.713
		BLCCD05	0.014	0.901
		BLCCD17	-0.033	0.586
(BLCCD05		BLCCD17		0.721)
BLCCD07	0.014	BLCCC07	-0.014	0.971
BLCCD11	-0.050	BLCCC11	-0.129	0.970

*Indices are defined in Table 7.1.

subgraph size (see Figure 7.4 above).

The other 3 indices based on subgraphs are characterized by large numbers of market areas with no ties at all. Two of these indices have only 12 market areas containing ties; the other has 22 (Table 7.10). When the null market areas are excluded from computation of the correlations with profits, the correlations are dramatically higher for the former two indices (0.348 vs. 0.061, 0.523 vs 0.014) and somewhat higher for the third (0.148 vs. -- 0.050). This effect is also apparent for the two full graph indices based on the same two TOT's: the correlation with profits for RFGDN07, with only 12 non-null market areas, rises from 0.206 to 0.629 when the null market areas are excluded, and the correlation for RFGDN11 rises from 0.224 to 0.351. Thus, unless further specification changes this relationship, it appears that indices based on these two types of tie (the "07" indices are based on TOT 1: direct ties between firms operating in the market area; the "11" indices are based on ties between enterprises formed by firms within and outside the market area -- both TOT's exclude bank ties) are poor predictors of profits over all market areas, but much better predictors of profits in the market areas where they exist. This point is perhaps worth underlining: _in market areas where these ties exist_ (12 for directly horizontal ties; 22 for indirectly horizontal ties), _the degree of horizontal interlocking between competing enterprises appears to be strongly associated with_

Table 7.10

Characteristics of 12 selected indices of interlocking

	R (CPCMT)			N	R
	Raw	Log	Null mktareas excluded	non-null cases	(LCNN)
RFGDN01	0.369	0.383	0.369	30	0.693
RFGDN05	0.345	0.372	~~0.344~~	30	0.164
RFGDN07	0.206	0.364	0.629	12	0.382
RFGDN11	0.224	0.518	0.351	22	0.464
RLCCP01	-0.173	-0.179	-0.173	30	-0.704
RLCCP05	0.174	0.178	0.174	30	-0.709
RLCCP07	0.061	0.306	0.349	12	0.133
RLCCP11	0.040	0.120	0.121	22	-0.289
RLCCC01	-0.097	-0.162	-0.180	30	-0.132
RLCCC05	0.064	0.066	0.064	30	-0.643
RLCCD07	0.014	0.523	0.523	12	0.505
RLCCD11	-0.050	0.146	0.148	22	0.189

Notes:

Indices are defined in Table 7.1.
ICNN: number of nodes in the largest component.
R(x): Pearson coefficient of correlation with x.

market area profit levels. In order to test this conclusion further, the path analyses reported in Chapter 8 were performed on these subsets of market areas (N=12 and N=22) in addition to the full 30 market areas.

For all twelve indices, the log transformations were either less highly correlated with profits than the raw indices (on 12, 22, and 30 market areas) or were only very marginally better correlated (see Table 7.10). Therefore, in the interests of parsimony, the log transformations were excluded from further analysis.

Thus the set of indices used in the path analyses includes 12 raw indices computed on all 30 market areas, and also on the 12 market areas where directly horizontal ties exist, and on the 22 market areas where indirectly or directly horizontal ties exist. The raw indices consist of three types of indices on each of four types of ties: full graph density, largest subgraph compactness, and largest subgraph centralization, on TOT's 1-4: (1) directly horizontal ties, (2) directly and indirectly horizontal ties, (3) type 1 ties plus bank ties with market members, (4) type 1 and 2 ties plus bank ties with market members and non-members.

7.3 Summary

In this chapter, indices of interlocking were derived, computed, compared and selected. Four types of index -- density, compactness, centralization of degree, and centralization of closeness -- were discussed, and formulae derived for application to the corporate networks measured in Chapter 6. Procedures were described for identifying the largest connected component of a graph, since two of the indices were defined only on connected graphs.

This resulted in 432 indices of interlocking -- the original index and 2 transformations on each of 6 types of indices on each of 24 types of tie. Reduction of these to a manageable number for the path analytic tests of the main hypotheses was accomplished mainly by comparing pairs of alternate indices with respect to the size of their correlation with corrected price-cost margins, and selecting the member of the pair with the higher correlation.

In order to be confident of the validity of the zero-order correlations with profits, skewness statistics for the distributions of the interlock indices were examined, and the residuals from simple regressions of profits on each index of interlocking were checked for normality using the Shapiro-Wilk W statistic, and for patterns indicating nonlinearity by the Anscombe-Tukey h statistic and a modified form of their k statistic.

Most indices based on the largest connected component had very weak positive, or negative, correlations with profits. This was attributed to the effect of the size of the component as a suppressor variable, and a path model was proposed embodying this hypothesis. Zero-order correlations with subgraph size were consistent with this model for most subgraph indices.

After using this method to reduce the number of indices to 36 (plus 72 transforms), additional pairs of alternate indices were identified and reduced by intercorrelating all indices and selecting from those pairs with high intercorrelations the index having a higher correlation with profits. This ad hoc method revealed strong patterns of intercorrelation among indices and of correlations with profits.

Twelve indices constituted the final group selected for use in the path analyses in Chapter 8. These twelve indices represent all four types of index on four types of tie -- some based on real-valued ties, some on binary-valued; some based on director-director, some based on director-officer and officer-officer ties. The only category of interlock indices that was entirely eliminated in this chapter is bank-mediated P2 ties: these were found to be highly intercorrelated with, but inferior in predictive power to, direct ties with banks. Six of the twelve indices -- based on the sparse graphs excluding bank ties -- were found to have much greater power to predict profits when market areas with null graphs (none of this type of tie) were excluded from consideration. Therefore, indices based on reduced N were added to the selected group. None of the log-transformed indices was found to be substantially superior to the corresponding raw indices, so no log transformations were selected.

CHAPTER 8

Analysis and Results

In this chapter I describe the path analyses used to test the hypotheses developed in Chapters 3 and 7, and the results of these path analyses. The chapter has three sections: a recapitulation of the hypotheses and the variables used to test them; tests of the hypotheses concerning concentration, interlocking and profits, and comparisons of various kinds of interlocking with respect to their relationships with concentration and profits; and a summary. Theoretical, substantive and methodolcgical conclusions of this study, and its implications for policy formulation and for further research, are discussed in Chapter 9.

8.1 Recapitulation of hypotheses

The general hypothesis of this study is that director interlocks are one method by which enterprises co-opt one another, or co-ordinate their actions, in oligopolistic markets. Operationally, the degree of interlocking is hypothesized to explain part of the association between concentration and profits. The hypothesized relationships developed in Chapter 3 are modelled in the path diagram, equations and hypotheses of Figure 8.1.

In Chapter 7 I developed the hypothesis that interlocking in a central clique of enterprises -- presumed to dominate the market area -- was related to profits over and above the effect of interlocking in general, and that the two forms of interlocking are mutual suppressors: i.e., as overall interlocking increases, profits increase; but simultaneously, the size of the central clique increases, interlocking (and therefore co-ordination in the central clique) decrease, and therefore profits decrease. This hypothesized process is shown in the path diagram, equations and hypotheses in Figure 8.2.

8.2 Tests of hypotheses

Hypotheses were tested using multiple regressions on standardized (mean=0, s.d.=1) variables. For the tests on subsets of market areas (N=12, N=22), the variables were re-standardized over the reduced N. Path coefficients (standardized betas) for tests of hypotheses H1 to H5 are shown in Table 8.1. All variables referred to in Table 8.1 and other tables in this chapter are defined in Table 8.2. Unstandardized regression coefficients were also calculated

Figure 8.1

Path models and hypotheses for relationships among concentration, interlocking and profit margins.

(1) Path models

$$CO \xrightarrow{\beta_1} P$$

$$DI \xrightarrow{\beta_2} P$$

$$CO \xrightarrow{\beta_3} DI \xrightarrow{\beta_5} P \qquad (CO \xrightarrow{\beta_4} P)$$

(2) Equations

(8.1) $P = \beta_1 CO + R1$

(8.2) $P = \beta_2 DI + R2$

(8.3) $DI = \beta_3 CO + R3$

(8.4) $P = \beta_4 CO + \beta_5 DI + R4$

(3) Hypotheses

H_1: $\beta_1 > 0$

H_2: $\beta_2 > 0$

H_3: $\beta_3 > 0$

H_4: $\beta_4 > \beta_1$

H_5: $\beta_5 = \beta_2$

Notes:

CO: concentration

DI: degree of interlocking

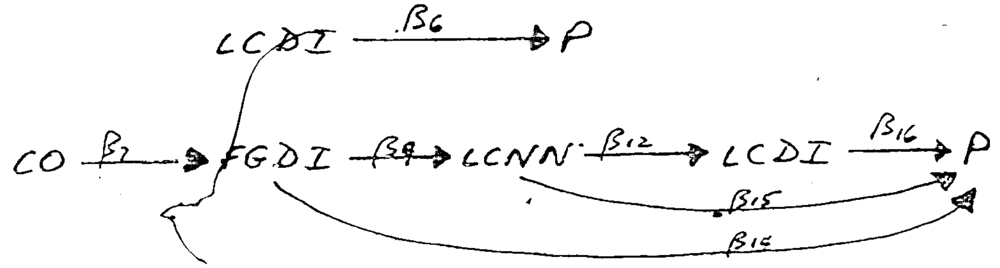
P: profit margins

R: residuals

Figure 8.2

Further specification of relationships among concentration, profits and interlocking, including central clique size and interlocking.

(1) Path models



(2) Equations

(8.5) $P = \beta_6 LCDI + R_5$

(8.6) $FGDI = \beta_7 CO + R_6$

(8.7) $LCNN = \beta_8 CO + \beta_9 FGDI + R_7$

(8.8) $LCDI = \beta_{10} CO + \beta_{11} FGDI + \beta_{12} LCNN + R_8$.

(8.9) $P = \beta_{13} CO + \beta_{14} FGDI + \beta_{15} LCNN + \beta_{16} LCDI + R_9$

(3) Hypotheses

$H_6 : \beta_6 \leq 0$ (derived <u>post hoc</u> from tests of H_2)

$H_7 : \beta_7 > 0$

$H_8 : \beta_8 = 0$ $H_9 : \beta_9 > 0$

$H_{10} : \beta_{10} = 0$ $H_{11} : \beta_{11} = 0$ $H_{12} : \beta_{12} < 0$

$H_{13} : \beta_{13} = 0$ $H_{14} : \beta_{14} > \beta_5$ $H_{15} : \beta_{15} < 0$

$H_{16} : \beta_{16} > 0$

and are shown in Appendix B, Table 1.

Very few of the coefficients discussed in this chapter are statistically significant at even the 0.10 level. However, this was taken as being due to the combination of fairly weak associations and low N's, rather than to the nonexistence of relationships. Grounds for this conclusion include the consistency of some relationships over tests using different indices, and the consistency of (weak) associations between profits and concentration with the associations reported elsewhere. However, the lack of statistical significance -- and the concomitant small associations and differences -- make the need for independent confirmation of the findings reported here more pressing.

All hypotheses involving concentration were tested twice -- once for each index of concentration. In all tests, the results for the two concentration indices were similar (as is to be expected from two indices with an intercorrelation of 0.95), but in a few cases differed considerably in magnitude. In the discussion of results in this chapter, I refer generally to "concentration", meaning both indices, and refer to a specific index of concentration when necessary.

The simple betas in Table 8.1 (beta1 to beta3, testing hypotheses H1-H3) are of course identical to the zero-order correlation coefficients discussed in Chapters 4 and 7. Only the concentration indices and the four full graph density

Table 8.1

Path coefficients from multiple and simple regressions of corrected price-cost margins on concentration and interlocking, and from simple regressions of interlocking on concentration
(1) N = 30

	Eq'n	HVS	RVS4	DI	R^2	Eq'n	Simple R HVS	Simple R RVS4
		beta1	beta1					
	8.1	0.25			0.06			
	8.1		0.23		0.05			
		beta4	beta4	beta2/ beta5			beta3	beta3
RFGDN1	8.2			0.20	0.04	8.3	0.28	0.34"
	8.4	0.20		0.14	0.08			
	8.4		0.18	0.14	0.07			
RFGDN2	8.2			0.22	0.05	8.3	0.36'	0.35"
	8.4	0.19		0.15	0.08			
	8.4	0.17	0.16	0.07	0.08			
BFGDN3	8.2			0.37'	0.13	8.3	0.63*	0.61*
	8.4	0.03		0.35	0.13			
	8.4		0.0	0.36	0.13			
BFGDN4	8.2			0.34"	0.12	8.3	0.38'	0.40'
	8.4	0,13		0.29	0.13			
	8.4		0.11	0.30	0.12			
RLCCP1	8.2			0.06	0.0	8.3	0.05	0.12
	8.4	0.25		0.04	0.06			
	8.4		0.23	0.03	0.05			
RLCCD1	8.2			0.01	0.0	8.3	0.27	0.23
	8.4	0.26		-0.06	0.06			
	8.4		0.24	-0.04	0.05			
RLCCP2	8.2			0.04	0.0	8.3	-0.14	-0.09
	8.4	0.26		0.07	0.07			
	8.4		0.23	0.06	0.05			
RLCCD2	8.2			-0.05	0.0	8.3	0.05	0.09
	8.4	0.25		-0.06	0.06			
	8.4		0.24	-0.07	0.06			
ELCCP3	8.2			-0.17	0.03	8.3	-0.29	-0.33"
	8.4	0.22		-0.11	0.07			
	8.4		0.19	-0.11	0.06			
ELCCC3	8.2			-0.09	0.01	8.3	-0.24	-0.15
	8.4	0.24		-0.04	0.06			
	8.4		0.22	-0.06	0.05			
ELCCP4	8.2			0.17	0.03	8.3	-0.10	-0.14
	8.4	0.27		0.20	0.10			
	8.4		0.26	0.21	0.11			
ELCCC4	8.2			0.06	0.0	8.3	-0.17	-0.23
	8.4	0.27		0.11	0.07			
	8.4		0.26	0.12	0.07			

Notes: see Figure 8.1 for path models and equations, and Table 8.2 for definitions of variables.
*significant at < 0.01.
'significant at < 0.05.
"significant at < 0.10.

(cont'd)

Table 8.1 (cont'd)

(2) N = 12

	Eq'n	HVS	RVS4	DI	R^2	Eq'n	Simple R HVS	Simple R RVS4
		beta1	beta1					
	8.1	0.54"			0.29"			
	8.1		0.66'		0.43'			
		beta4	beta4	beta2/ beta5			beta3	beta3
RFGDN1	8.2			0.63'	0.39'	8.3	0.37	0.47
	8.4	0.36		0.49"	0.50'			
	8.4		0.47"	0.40	0.56'			
RFGDN2	8.2			0.44	0.19	8.3	0.43	0.41
	8.4	0.43		0.25	0.35			
	8.4		0.57"	0.20	0.47"			
EFGDN3	8.2			0.31	0.10	8.3	0.71*	0.73*
	8.4	0.64		-0.14	0.30			
	8.4		0.92'	-0.36	0.49'			
EFGDN4	8.2			0.58'	0.34'	8.3	0.56"	0.63'
	8.4	0.31		0.40	0.41"			
	8.4		0.49	0.27	0.48"			
RLCCP1	8.2			0.35	0.12	8.3	-0.11	0.05
	8.4	0.59'		0.41	0.46"			
	8.4		0.64'	0.31	0.54'			
RLCCD1	8.2			0.09	0.01	8.3	0.34	0.28
	8.4	0.58"		-0.10	0.30			
	8.4		0.69'	-0.10	0.44"			
RLCCP2	8.2			0.13	0.02	8.3	0.04	0.11
	8.4	0.54"		0.11	0.31			
	8.4		0.65'	0.06	0.44"			
RLCCD2	8.2			0.09	0.01	8.3	0.0	0.06
	8.4	0.54"		0.09	0.30			
	8.4		0.66'	0.04	0.44"			
EICCP3	8.2			-0.27	0.07	8.3	-0.47	-0.63'
	8.4	0.53		-0.02	0.29			
	8.4		0.81'	0.24	0.47"			
EICCC3	8.2			0.32	0.10	8.3	0.22	0.39
	8.4	0.49		0.21	0.34			
	8.4		0.63'	0.07	0.44"			
EICCP4	8.2			-0.07	0.0	8.3	-0.15	-0.21
	8.4	0.54		0.01	0.29			
	8.4		0.67'	0.07	0.44"			
ELCCC4	8.2			-0.26	0.07	8.3	-0.39	-0.53"
	8.4	0.52		-0.06	0.30			
	8.4		0.72'	0.12	0.45"			

Notes: see Figure 8.1 for path models and equations, and Table 8.2 for definitions of variables.
*significant at < 0.01.
'significant at < 0.05.
"significant at < 0.10.

(cont'd)

Table 8.1 (cont'd)

(3) N = 22

	Eq'n	HVS	RVS4	DI	R^2	Eq'n	Simple R HVS	Simple R RVS4
		beta1	beta1					
	8.1	0.25			0.06			
	8.1		0.26		0.07			
		beta4	beta4	beta2/ beta5			beta3	beta3
RFGDN1	8.2			0.32	0.10	8.3	0.40"	0.48'
	8.4	0.14		0.26	0.12			
	8.4		0.14	0.25	0.12			
RFGDN2	8.2			0.35	0.12	8.3	0.43'	0.40"
	8.4	0.12		0.30	0.13			
	8.4		0.15	0.29	0.14			
RFGDN3	8.2			0.28	0.07	8.3	0.72*	0.73*
	8.4	0.10		0.20	0.08			
	8.4		0.13	0.18	0.08			
RFGDN4	8.2			0.29	0.08	8.3	0.44'	0.47'
	8.4	0.15		0.22	0.10			
	8.4		0.16	0.21	0.10			
RLCCP1	8.2			0.19	0.04	8.3	0.19	0.29
	8.4	0.22		0.15	0.08			
	8.4		0.22	0.13	0.08			
RLCCD1	8.2			0.04	0.0	8.3	0.30	0.25
	8.4	0.26		-0.03	0.06			
	8.4		0.27	-0.02	0.07			
RLCCP2	8.2			0.12	0.01	8.3	-0.24	-0.20
	8.4	0.29		0.19	0.09			
	8.4		0.30	0.18	0.10			
RLCCD2	8.2			-0.01	0.0	8.3	0.03	0.06
	8.4	0.25		-0.02	0.06			
	8.4		0.26	-0.03	0.07			
ELCCP3	8.2			-0.06	0.0	8.3	-0.40"	-0.46'
	8.4	0.26		0.04	0.06			
	8.4		0.29	0.07	0.07			
ELCCC3	8.2			-0.14	0.02	8.3	-0.31	-0.21
	8.4	0.22		-0.07	0.06			
	8.4		0.24	-0.09	0.08			
ELCCP4	8.2			0.31	0.09	8.3	-0.12	-0.14
	8.4	0.29		0.34	0.17			
	8.4		0.31	0.35	0.19			
ELCCC4	8.2			0.04	0.0	8.3	-0.25	-0.32
	8.4	0.27		0.11	0.07			
	8.4		0.31	0.14	0.09			

Notes: see Figure 8.1 for path models and equations, and Table 8.2 for definitions of variables.

*significant at < 0.01.

'significant at < 0.05.

"significant at < 0.10.

indices have correlations greater than 0.2 with profits. These 6 indices also have high concentration-interlocking correlations; of the subgraph indices, only centralization of degree on TOT1 (RLCCD1) conforms to H3 and the others have weak or negative correlations with concentration.

The partial betas (beta4, beta5) are consistent with the general hypothesis of this study in the case of full graph density of interlocking on TOT's 3 and 4 over all 30 market areas (Table 8.1, panel 1), on TOT's 3 and 4 over the 22 market areas with non-null graphs for TOT's 1 and 2 (Table 8.1, panel 3), and are consistent with H4 but not H5 for TOT's 1 and 4 on 12 market areas (panel 2) and TOT's 1 and 2 on 22 market areas. Implications of these betas are discussed in detail below.

8.2.1 Directly horizontal interlocking in 12 market areas

The 12 market areas where directly horizontal interlocks exist (listed in Table 8.3) are also characterized by strong associations between concentration and profits (0.54 and 0.66 for Herfindahl and top-4 ratio respectively) and strong associations between concentration and interlocking (ranging from 0.37 to 0.73). The size of these various coefficients is not merely due to the statistical fact that, *ceteris paribus*, all associations tend to become larger as N becomes smaller. Many of the coefficients computed on the 12 market areas are significant at the 0.10 and even the 0.05 level; whereas none of the

Table 8.2

Definitions of variables used in tests of hypotheses

HVS: Herfindahl index of inequality of value of shipments

RVS4: top-4 concentration ratio for value of shipments

CPCMT: corrected price-cost margin for all market area members

LCNN: number of nodes in the largest connected component

FGDN: 4 indices measuring full graph density on 4 TOT's

ICDI: 8 indices measuring aspects of the degree of interlocking in the largest connected component

Indices of degree of interlocking

Index	Connectedness		Level of measure-ment	Type of index	TOT	Affils
RFGDN1	full	graph	real	density	1	DD
RFGDN2	"	"	"	"	2	DO/OO
BFGDN3	"	"	binary	"	3	DD
BFGDN4	"	"	"	"	4	DO/OO
RLCCP1	largest	component	real	compactness	1	DD
RLCCD1	"	"	"	cent. degree	1	DD
RLCCP2	"	"	"	compactness	2	DO/OO
RLCCD2	"	"	"	cent. degree	2	DO/OO
BLCCP3	"	"	binary	compactness	3	DD
BLCCC3	"	"	"	cent.closeness	3	DD
BLCCP4	"	"	"	compactness	4	DO/OO
BLCCC4	"	"	"	cent.closeness	4	DO/OO

associations with profits, and few of the concentration-interlocking associations were significant even at the 0.10 level when computed on 30 market areas. The two crucial associations -- those between profits and concentration and interlocking are extremely high (0.66 for top-4 concentration, 0.63 for density of directly horizontal interlocking), and both are significant at the 0.05 level. Concentration and interlocking together account for 56% of the variance in profit margins in these 12 market areas.

These 12 market areas have little uniquely in common besides the existence of directly anticompetitive interlocks. They vary widely in concentration (top 4 ratios vary from 0.11 to 0.80 -- see Table 8.3) and profit levels (mean corrected price-cost margin is 0.297, vs. 0.301 for N = 30 and 0.297 for N = 22) and type of industrial activity. Their only common feature seems to be that it is in these market areas that the success of oligopolistic co-ordination is most important to profit margin levels. Where concentration and interlocks are high, so are profit margins; where concentration and interlocks are low, so are profits. In the other 18 market areas, other factors than concentration and interlocking must play a larger role in determining profit levels.

In these 12 market areas, the hypothesis that interlocking is one method of co-ordination used in oligopolistic industries is borne out. Inclusion of the

Table 8.3

Structural attributes of 12 market areas with directly horizontal interlocks, in order of profit margins

Market area	RVS4	RFGDN1	CPCMT
26 aircraft and parts	0.804	0.079	0.378
3 metal mines	0.733	0.029	0.362
4 gold quartz mines	0.628	0.041	0.340
34 industrial chemicals	0.565	0.002	0.337
28 appliances, radio, TV	0.687	0.005	0.304
22 metal fabrication	0.398	0.001	0.301
11 textiles	0.318	0.011	0.278
14 sawmills	0.189	0.002	0.264
7 flour, feed, bakeries	0.420	0.003	0.260
12 clothing	0.106	0.021	0.258
20 primary iron and steel	0.757	0.011	0.256
16 pulp and paper	0.345	0.013	0.223

index of directly horizontal interlocks in the regression of profits on concentration reduces the concentration beta from 0.66 to 0.47. In other words, almost one-third of the effect of concentration on profits is due to directly horizontal interlocking. On the other hand, the simple association of interlocking and profits is reduced by about one-third (0.63 to 0.40) when concentration is controlled (contrary to H5) -- i.e., about one-third of the apparent relationship between interlocking and profits is spurious, caused by their mutual dependence on concentration. However, these results certainly support the claim that <u>where it exists</u>, direct interlocking between competing firms is strongly related to profit margins, and partly explains the relationship of concentration and profit margins.

An interesting subsidiary finding for these 12 market areas is that other kinds of interlocks -- indirectly horizontal interlocks, and bank interlocks -- are less strongly associated with profits than directly horizontal interlocks (Table 8.1). Although indices of these other interlocks have betas that are consistent with those discussed above, the results are weaker. Thus in these 12 market areas, direct ties between competitors are the primary form of interlocking used for oligopolistic co-ordination.

8.2.2 Indirectly horizontal ties in 10 market areas

In addition to these 12 market areas, 10 market areas had indirectly horizontal ties but no directly horizontal ties. Results of tests on these 22 market areas are shown in Table 8.1, panel 3. Remarkably, although the density of directly horizontal ties in these 10 market areas is zero, the index based on these ties (RFGDN1) is almost as highly correlated with profits (R=0.32) as is the index of combined directly and indirectly horizontal ties (R=0.35) and is more highly correlated with profits than either index of concentration (R=0.25 and 0.26 for Herfindahl and top-4 concentration respectively). The obvious conclusion is that the additional 10 market areas have very low profits corresponding to their zero directly horizontal interlocks -- but this is absolutely untrue, since the mean profit margin over the 22 market areas is precisely equal to the mean over the 12 (0.297), and very close indeed to the mean over 30 market areas (which is 0.301 -- the standard deviation of corrected price-cost margins over 30 market areas is 0.068, so the difference between 0.301 and 0.297 is only 1/17 of a standard deviation). Since there is considerable variation in profits in these 10 additional market areas (the standard deviation of corrected price-cost margins over 22 market areas is 0.066, vs. 0.049 over 12 market areas), which cannot be explained by directly horizontal ties (all null), one must conclude that this variation is also not associated with concentration.

Since the correlation of directly horizontal interlocking with profits is halved (0.63 to 0.32) when these 10 market areas are added, but the correlation with profits of directly plus indirectly horizontal ties is reduced by one one-sixth (0.44 to 0.35), the indirectly horizontal ties in these 10 market areas must be strongly associated with profit levels. Although no index of indirectly horizontal interlocking alone had been computed, I concluded that in these 10 market areas, indirectly horizontal interlocking is the primary form of interlocking used for oligopolistic co-ordination.

Unfortunately, a separate index of indirectly horizontal interlocking was not computed, since its importance was not appreciated at the early stage of the research when these indices were defined. It would have been useful as the predictor of profits in these 10 market areas. Lacking this, both indices of horizontal interlocking had approximately the same predictive power over 22 market areas (R=0.32 for directly horizontal, 0.35 for directly plus indirectly horizontal). Over 22 market areas, either index explained approximately half of the relationship between concentration and profits (the Herfindahl R=0.25 was reduced to 0.12 and 0.10 by inclusion of density of directly horizontal ties--RFGDN1--and density of directly and indirectly horizontal ties--RFGDN2--respectively, in the equation; the top-4 R (0.26) was reduced to 0.14 and 0.15 respectively). Here, in contrast to tests on 12 market areas, little of the relationship between interlocking and profits was explained by concentration: simple R's of 0.32 and 0.35 were reduced to 0.26, 0.25 and 0.30, 0.29 by the addition of Herfindahl and top-4 concentration respectively to the regressions. These results are much more consistent with hypothesis H5 than those on 12 market areas.

Again, the other indices of interlocking including bank interlocks (BFGDN3, BFGDN4) showed similar but weaker results. Thus I concluded that in these additional 10 market areas, indirectly horizontal ties were a major mechanism of oligopolistic co-ordination explaining how concentration affects profits; and that over the 22 market areas as a whole, directly and indirectly horizontal ties between enterprises are indeed important in oligopolistic co-ordination, since considered alone they account for 12% of the variation in profit margins, and considered with concentration they explain almost 50% of the relationship between concentration and profits.

8.2.3 Bank interlocks in 8 market areas

The remaining 8 market areas were characterized by no ties among competing enterprises but ties between enterprises and banks (all 30 market areas had this kind of tie but it was unique only in these 8 market areas).

Although no separate index of bank interlocks had been computed, the index of interlocking based on combined bank ties with firms in the market area and directly horizontal ties (BFGDN3) had a simple correlation of 0.37 with profit margins over all 30 market areas, and the index based on all types of ties -- directly and indirectly horizontal, plus bank ties with firms within and outside the market area -- (BFGDN4) had a simple R of 0.34. Thus the inclusion of the remaining 8 market areas caused these two simple correlations to increase by 0.09 and 0.05 respectively, while it caused the correlations of the other two interlock indices to drop by 0.12 and 0.13 to 0.20 and 0.22 respectively. Thus the very poor performance on 8 market areas of the indices of horizontal ties -- which have zero values for these 8 market areas -- and the very good performance of the indices based on combined bank and horizontal ties, make the latter indices the best predictors of profit margins over all 30 market areas.

Here, the hypothesis that interlocking explains the effect of concentration on profits is very strongly confirmed. Regressing profit margins on concentration and interlocking (BFGDN3) over 30 market areas results in the reduction of the simple correlations of 0.25 and 0.23 for two concentration indices to 0.03 and 0.0 respectively, but reduces the simple R for interlocking (0.37) by a negligible 0.02 and 0.01 respectively. These results are precisely those predicted in Chapter 3. I conclude that a combination of directly horizontal innterlocking and interlocking between firms in the market area and banks entirely explains the relationship between concentration and profits over the 30 market areas.

8.2.4 Subgraph-based indices of interlocking

The 8 subgraph-based indices of interlocking have not been discussed thus far because all had approximately zero or negative simple and partialled relationships with profits over 12, 22 and 30 market areas, with a few exceptions (BLCCC3 for N=12, RLCCP1 and BLCCP4 for N=22, BLCCP4 for N=30; these indices are defined in Table 8.2) that were still considerably inferior to the full graph density indices discussed above.

Table 8.4 shows the results of tests of the general hypothesis that the direct effects of interlocking in the central clique are suppressed by the effects of full graph density and the size of the central clique (hypothes H6 to H12 in Figure 8.2). For the sake of simplicity in presentation, only standardized coefficients from regressions using the Herfindahl index are presented in Table 8.4. Results of regressions using the top-4 concentration ratio, which are consistent with those for the Herfindahl, are shown in Appendix B, Table 2; and all unstandardized coefficients are given in Appendix B, Table 3.

Table 8.4

Path coefficients from multiple regressions of corrected price-cost margins on concentration, full graph density of interlocks, size of central clique, and indices of central clique interlocks

(1) N = 30

	Eqn	Dependent variable	HVS	FGDN	LCNN	LCDI	R^2
Para-digm	8.9	CPCMT	beta13	beta14	beta15	beta16	
	8.8	LCDI	beta10	beta11	beta12		
	8.7	LCNN	beta8	beta9			
	8.6	FGDN	beta7				
RLCCP1	8.9	CPCMT	0.22	0.26	-0.15	-0.11	0.10
	8.8	RLCCP1	-0.10	0.71*	-0.17		0.43*
	8.7	LCNN1	0.18	0.30			0.15
	8.6	RFGDN1	0.28				0.08
RLCCD1	8.9	CPCMT	0.24	0.21	-0.10	-0.10	0.10
	8.8	RLCCD1	0.10	0.25	0.37'		0.31'
	8.7	LCNN1	0.18	0.30			0.15
	8.6	RFGDN1	0.28				0.08
RLCCP2	8.9	CPCMT	0.23	0.19	-0.10	0.04	0.10
	8.8	RLCCP2	-0.10	0.18	-0.31		0.10
	8.7	LCNN2	0.23	0.37'			0.25'
	8.6	RFGDN2	0.36'				0.13'
RLCCD2	8.9	CPCMT	0.22	0.21	-0.11	-0.08	0.10
	8.8	RLCCD2	-0.03	0.11	0.12		0.03
	8.7	LCNN2	0.23	0.37'			0.25'
	8.6	RFGDN2	0.36'				0.13'
BLCCP3	8.9	CPCMT	0.03	0.56"	-0.38	-0.09	0.20
	8.8	BLCCP3	0.14	-0.35	-0.51'		0.52*
	8.7	LCNN3	-0.04	0.71*			0.47*
	8.6	BFGDN3	0.63*				0.40*
BLCCC3	8.9	CPCMT	0.0	0.60"	-0.34	-0.06	0.20
	8.8	BLCCC3	-0.26	0.07	-0.07		0.06
	8.7	LCNN3	-0.04	0.71*			0.47*
	8.6	BFGDN3	0.63*				0.40*
BLCCP4	8.9	CPCMT	0.16	0.27	0.0	0.17	0.16
	8.8	BLCCP4	-0.01	0.18	-0.76*		0.58*
	8.7	LCNN4	0.19	0.05			0.05
	8.6	BFGDN4	0.38'				0.15'
BLCCC4	8.9	CPCMT	0.16	0.31	-0.06	0.10	0.16
	8.8	BLCCC4	0.0	-0.08	-0.67*		0.46*
	8.7	LCNN4	0.19	0.05			0.05
	8.6	BFGDN4	0.38'				0.15'

Notes: see Figure 8.2 for path model and equations, and Table 8.2 for definitions of variables.

*significance < 0.01

'significance < 0.05

"significance < 0.10

(cont'd)

Table 8.4 (cont'd)

(2) N = 12

	Eqn	Dependent variable	HVS	FGDN	LCNN	LCDI	R^2
RLCCP1	8.9	CPCMT	0.42	0.34	0.10	0.33	0.56
	8.8	RLCCP1	-0.06	0.47"	-0.67'		0.63'
	8.7	LCNN1	0.35	-0.04			0.11
	8.6	RFGDN1	0.37				0.14
RLCCD1	8.9	CPCMT	0.43	0.50	-0.09	-0.13	0.53
	8.8	RLCCD1	0.24	0.10	0.22		0.17
	8.7	LCNN1	0.35	-0.04			0.11
	8.6	RFGDN1	0.37				0.14
RLCCP2	8.9	CPCMT	0.38	0.29	0.07	0.20	0.38
	8.8	RLCCP2	0.36	-0.11	-0.65"		0.38
	8.7	LCNN2	0.35	0.16			0.19
	8.6	RFGDN2	0.43				0.19
RLCCD2	8.9	CPCMT	0.45	0.27	-0.05	0.09	0.36
	8.8	RLCCD2	0.06	-0.03	-0.10		0.01
	8.7	LCNN2	0.35	0.16			0.19
	8.6	RFGDN2	0.43				0.19
BLCCP3	8.9	CPCMT	0.58	0.05	-0.47	-0.29	0.41
	8.8	BLCCP3	-0.26	0.04	-0.58		0.48
	8.7	LCNN3	0.03	0.58			0.36
	8.6	BFGDN3	0.71*				0.51*
BLCCC3	8.9	CPCMT	0.51	0.21	-0.43	0.32	0.45
	8.8	BLCCC3	0.44	-0.55	0.38		0.20
	8.7	LCNN3	0.03	0.58			0.36
	8.6	BFGDN3	0.71*				0.51*
BLCCP4	8.9	CPCMT	0.24	0.51	-0.08	-0.24	0.44
	8.8	BLCCP4	-0.16	0.32	-0.69'		0.63'
	8.7	LCNN4	0.43	-0.33			0.14
	8.6	BFGDN4	0.56"				0.31"
BLCCC4	8.9	CPCMT	0.27	0.43	0.05	-0.06	0.42
	8.8	BLCCC4	-0.20	-0.09	-0.58"		0.45
	8.7	LCNN4	0.43	-0.33			0.14
	8.6	BFGDN4	0.56"				0.31"

Notes: see Figure 8.2 for path model and equations, and Table 8.2 for definitions of variables.

*significance < 0.01

'significance < 0.05

"significance < 0.10

(cont'd)

Table 8.4 (cont'd)

(3) N = 22

	Eqn	Dependent variable	HVS	FGDN	LCNN	LCDI	R^2
RLCCP1	8.9	CPCMT	0.17	0.30	-0.11	-0.02	0.13
	8.8	RLCCP1	0.01	0.66*	-0.23		0.39'
	8.7	LCNN1	0.23	0.22			0.14
	8.6	RFGDN1	0.40"				0.16"
RLCCD1	8.9	CPCMT	0.18	0.31	-0.07	-0.10	0.14
	8.8	RLCCD1	0.10	0.25	0.34		0.28
	8.7	LCNN1	0.23	0.22			0.14
	8.6	RFGDN1	0.40"				0.16"
RLCCP2	8.9	CPCMT	0.12	0.32	0.14	0.31	0.20
	8.8	RLCCP2	0.03	-0.05	-0.57'		0.34"
	8.7	LCNN2	0.35	0.19			0.22"
	8.6	RFGDN2	0.43'				0.19'
RLCCD2	8.9	CPCMT	0.13	0.31	-0.03	-0.01	0.14
	8.8	RLCCD2	0.05	-0.02	-0.03		0.0
	8.7	LCNN2	0.35	0.19			0.22"
	8.6	RFGDN2	0.43'				0.19'
BLCCP3	8.9	CPCMT	0.08	0.40	-0.22	0.05	0.11
	8.8	BLCCP3	0.01	-0.20	-0.56'		0.51*
	8.7	LCNN3	-0.07	0.75*			0.48*
	8.6	BFGDN3	0.72*				0.53*
BLCCC3	8.9	CPCMT	0.07	0.38	-0.26	-0.08	0.12
	8.8	BLCCC3	-0.16	-0.11	-0.15		0.13
	8.7	LCNN3	-0.07	0.75*			0.48*
	8.6	BFGDN3	0.72*				0.53*
BLCCP4	8.9	CPCMT	0.25	0.03	0.17	0.44	0.20
	8.8	BLCCP4	-0.16	0.42'	-0.60*		0.54*
	8.7	LCNN4	0.29	-0.11			0.07
	8.6	BFGDN4	0.44'				0.20'
BLCCC4	8.9	CPCMT	0.19	0.21	-0.06	0.07	0.11
	8.8	BLCCC4	-0.17	0.05	-0.45'		0.26
	8.7	LCNN4	0.29	-0.11			0.07
	8.6	BFGDN4	0.44'				0.20'

Notes: see Figure 8.2 for path model and equations, and Table 8.2 for definitions of variables.

*significance < 0.01

'significance < 0.05

"significance < 0.10

Over the 12 market areas having directly horizontal interlocks, the introduction of full graph density of interlocks and central clique size makes no substantial difference in the betas for any of the subgraph-based indices.

Over the 22 market areas having direct or indirect horizontal interlocks, betas for RLCCP2 -- the compactness of directly and indirectly horizontal ties in the central clique -- and for BLCCP4 -- compactness of all types of ties in the central clique -- are substantially increased. Furthermore, the multiple R-square for each of the regressions involving 4 predictors is 0.20, a substantial improvement over the R-square of 0.13 for the best 2-predictor regression of profits on concentration and full graph density of directly and indirectly horizontal ties.

The effect on profits of compactness of horizontal ties in the central clique (RLCCP2) over 22 market areas appears to be suppressed by both concentration and central clique size. When concentration is controlled, the association between RLCCP2 and profits is increased by approximately 50%, from 0.12 to 0.19 (Table 8.1, panel 3). When central clique size is also controlled, the beta again increases by approximately 50% to 0.31 (Table 8.4, panel 3). Thus inclusion of compactness of horizontal ties in the subgraph in the prediction equation for profits, substantially increases the predictive power of the model, since the substantial independent effect of compactness is now included. A stepwise regression of profits, entering the 4 predictors into the regression one at a time in order of predictive power, showed that full graph density on TOT 2 had the greatest power alone (R-square=0.12), subgraph compactness then added 0.05 to the R-square, subgraph size added an additional 0.02 and the Herfindahl added 0.01.

Compactness of all ties in the subgraph (BLCCP4) over 22 market areas has a different effect. Including this index in the regression for profits reduces the beta for full graph density of all types of ties on 22 market areas to approximately zero (Table 8.4, panel 3), and doubles the R-square from 0.10 to 0.20. Compactness of all ties in the subgraph completely explains the effect of full graph density on profits and in addition is suppressed by both full graph density and central clique size.

In view of the fact that regression of profits on 4 predictors including 2 interlock indices based only on horizontal ties has an R-square (0.20) equal to that including interlock indices based on all four types of ties, the former model was selected on grounds of parsimony. In this model, inclusion of compactness of horizontal ties in the subgraph causes no change in the effects of concentration and full graph tie density on profits, but adds a substantial independent relationship with profits that increases the predictive power of the model.

Over all 30 market areas, the index of interlocking that conformed most with the hypotheses of this study was found to be the density of directly horizontal ties plus bank ties with firms in the market area (BFGDN3). None of the subgraph-based indices for this or any other type of tie showed any particular improvement when full graph density and central clique size were controlled (Table 8.4, panel 1). However, controlling for central clique size had a dramatic effect on the beta for full graph density, which increased from 0.35 (Table 8.1, panel 1) to 0.56, and on the multiple R-square, which increased from 0.13 for 2 predictors to 0.20 for 4. Here, central clique size and full graph density are mutual suppressors. Full graph density has a very strong positive effect on central clique size (beta=0.71) -- central clique size is increased by increased density of ties) and central clique size has a negative effect (beta=-.36) on profits -- co-ordination becomes more difficult as the central clique grows. Thus holding central clique size constant causes a dramatic increase in the relationship between full graph density and profits. This conclusion has limited importance for this study, since the correlation between full graph density and central clique size for TOT 3 is so strong: "holding central clique size constant" is a rather artificial procedure, since in reality it varies so regularly with full graph density.

On the other hand, the increase in the multiple R-square from 0.13 to 0.20 when subgraph size and compactness of interlocking are included in the regression indicates that they have substantial independent predictive power on profits. This conclusion was confirmed by performing a stepwise regression of profits on the 4 predictors, adding one predictor at a time, in order of their predictive power. Full graph density on TOT 3 alone produced an R-square of 0.13. Addition of central clique size for TOT 3 raised this to 0.196. Addition of subgraph compactness for TOT 3 and of the Herfindahl raised the R-square to 0.1995 and 0.2000 respectively. Thus the only important direct predictors are full graph density and central clique size.

The conclusion of this examination of subgraph-based indices of interlocking and of largest component size is that they appear to have considerable importance in explaining the relationship between interlocking and profit margins, but no effect on the proportion of the relationship between concentration and profit margins that is explained by interlocking. On 22 market areas, inclusion in the multiple regression (of profit margins) of compactness of TOT 2 ties in the largest component increased the multiple R-square by 0.05, and inclusion of central clique size increased the multiple R-square by an additional 0.02. Neither inclusion changed the original result that full graph tie density alone explained approximately 50% of the relationship between concentration and profits. Similarly, on 30 market areas, inclusion of central clique size for TOT 3 increased the R-square for the regression of profits from 0.13 to 0.20, and the direct effect of full graph density on TOT 3 from 0.35 to 0.56. However, the fact that full graph density alone explained practically the entire relationship between concentration and profits was not affected.

There is some possibility that these two cases of the importance of central clique size and interlocking may be peculiarities of this particular data set rather than indicators of general patterns. I am skeptical of these two findings because they are isolated occurrences among a very large number of non-results for subgraph size and interlocking and because I have been unable to devise a rationale for them. This is not the case for the findings on full graph density of interlocking, which are quite consistent over many tests, and have clear explanations.

8.3 Summary

The path analyses discussed above have demonstrated that interlocking does indeed explain a considerable amount of the effect of concentration on profit margins. However, a distinction must be made between two kinds of interlocking and their effects.

In the 22 market areas where directly and indirectly horizontal ties exist between enterprises, these kinds of ties explain one-third to one-half of the relationship between concentration and profit margins. For these 22 market areas, the general hypothesis of this study is definitely consistent with the data.

Over all 30 market areas, directly and indirectly horizontal interlocks alone account for only about one-quarter of the relationship between concentration and profits. However, when directly horizontal interlocks are combined with bank ties with firms in the market area, the relationship between concentration and profit margins is <u>entirely explained</u>. But bank ties are not horizontally co-optive ties, they are co-optive ties with sources of money and (presumably) information. They are more like vertical ties -- i.e., ties with one's suppliers or consumers, where the commodity being supplied here is money, and probably information.

Thus bank ties represent an entirely different form of co-optation -- namely co-optation of sources of credit and information -- from horizontal ties. The co-ordination that presumably results from these bank ties, and which explains the relationship between concentration and profits in these cases, is co-ordination of separate pairs of actors, one a supplier, one a consumer of credit. Presumably this co-ordination through interlocking can only be effective in concentrated markets; where there are many consumers of credit, banks cannot maintain interlocks with them all. The implications of this kind of co-ordination, which are discussed in the next chapter, are somewhat different from the implications of horizontal co-ordination.

On the other hand, bank interlocks are closely associated with bank-mediated P2 ties between competing enterprises -- the correlation between density of bank ties and of bank-mediated P2 horizontal ties over 30 market areas is 0.97. Thus the apparent effect of bank ties could well be due to their functioning as intermediaries between competing enterprises -- as facilitators of indirect co-optation. Given the extremely high intercorrelation of direct bank ties and bank-mediated P2 ties, I know of no statistical method to separate the two effects.

Furthermore, it should be noted that indices of interlocking on the four types of ties considered in this chapter are rather highly intercorrelated (see Table 8.5), and the conclusions that have been drawn in this chapter for one or another type of interlocking have been true for the other types of interlocks to a somewhat lesser extent. In other words, each market area tends to have a characteristic level of co-ordination, related to its level of concentration, and affecting its profit level, and this level of co-ordination is represented to a greater or lesser degree by directly and/or indirectly horizontal ties and by bank ties, and by bank-mediated P2 ties.

Table 8.5

Intercorrelations over four types of tie of indices of density of interlocking on the full graph

(1) N = 30	RFGDN2	BFGDN3	BFGDN4
RFGDN1	0.54*	0.64*	0.69*
RFGDN2		0.42'	0.64*
BFGDN3			0.67*

(2) N = 12			
RFGDN1	0.51"	0.70'	0.91*
RFGDN2		0.41	0.73*
BFGDN3			0.79*

(3) N = 22			
RFGDN1	0.54*	0.72*	0.74*
RFGDN2		0.45'	0.67*
BFGDN3			0.67*

Notes: see Table 8.2 for definitions of variables.
*significance < 0.01
'significance < 0.05
"significance < 0.10

CHAPTER 9

Conclusions

The conclusions and implications of this study fall into four broad categories: substantive conclusions, theoretical implications, public policy implications and methodological conclusions and implications.

9.1 Substantive conclusions.

The main substantive question addressed by this study is: Do directorship interlocks among competing enterprises in Canada affect profit levels in markets? The answer to this is a qualified yes. Data from 1972 on 35 groupings of markets, termed market areas, covering nearly all logging, mining and manufacturing industries, were examined: I did not analyze interlocking in five of these market areas because the data on concentration and/or profits exhibited irregular characteristics -- either because these market areas really are atypical, or because of inadequacies in the data collected (see Chapter 4). Of the remaining 30 market areas, 22 had directorship interlocks between enterprises operating in the market area. In these 22 market areas, variation in the density of these interlocks explained 12% of the variance in profit margins across market areas. The positive sign of the simple correlation coefficient (0.35) indicates that profit margins vary positively with density of interlocks. In 12 of these market areas, enterprises had <u>directly</u> horizontal interlocks; i.e., the interlocks were between firms operating in the market area. In these 12 market areas, variation in directly horizontal interlocking accounted for 39% of the variance in profit margins (R=0.63).

This study also addressed the question: Is directorship interlocking one of the mechanisms by which actors in oligopolistic industries co-ordinate their action, with the result of approaching a joint monopoly? The answer to this is also yes for the 22 market areas in which horizontal interlocks exist. In these 22 market areas, the density of interlocks increases with concentration (R=0.63), as do profits: the correlation between the top-4 concentration ratio and profit margins was found to be 0.26 (0.25 for the Herfindahl index). When profit margins were regressed over concentration and interlock density together, the standardized beta for concentration was reduced to 0.15 (0.12 for the Herfindahl). The standardized beta for interlock density was 0.29, compared to the simple R of 0.35. Thus, interlock density explains approximately 40% of the variance in profits previously attributed to concentration. Over the 12 market areas containing directly horizontal ties, these ties explained appproximately 30% of the variance in profits previously attributed to concentration. These results suggest the conclusion that to the extent an industry is concentrated, its members tend to form interlocks with each other for the purpose of mutual co-optation or co-ordination; and that profit margins in the industry are strongly affected by their success in doing so.

Over all 30 market areas, including 8 that have no horizontal interlocks, the average importance of horizontal interlocks is of course smaller. They explain only 5% of the variation in profit margins, or approximately 25% of the variation attributed to concentration (the simple correlation of the Herfindahl index with profit margins of 0.25 is reduced to a standardized beta of 0.19 when horizontal interlocks are controlled). However, a combination of directly horizontal interlocks and interlocks between banks and firms in the market area explains 13% of the variation in profit margins and all of the variation attributed to concentration. Thus bank interlocks have a very strong effect on profit margins in market areas where no horizontal interlocks are present. Two conclusions, which are not mutually exclusive, can be drawn from the importance of bank interlocks. One conclusion is that indirect bank-mediated ties between enterprises (i.e. the same bank is interlocked with two competing enterprises by different members of its board) serve an important co-ordinating role in market areas where there are no direct ties between enterprises. This conclusion is supported by the fact that banks rarely have ties to only one enterprise in a market area--i.e. nearly all direct ties between banks and enterprises also create bank-mediated ties between enterprises (the correlation between density of direct bank-enterprise ties and bank-mediated enterprise-enterprise horizontal ties is 0.97 over all 30 market areas). The other possible conclusion is that direct ties with banks help increase profit margins by securing preferential access to credit and information. The latter phenomenon is not, strictly speaking, horizontal co-optation; rather, it is co-optation of a supplier and consumer of commodities, namely credit and information, which is closer to being vertical co-optation. However, it could be, and has been, argued that by supplying "information" to multiple actors in an industry, the banks serve an implicit co-ordinating function, even where they do not create P2 horizontal ties.

9.2 Theoretical implications.

The theory of interorganizational co-optation claims that organizations form co-optive ties with other organizations that are problematic for them, and that their success in doing so affects their "organizational effectiveness" -- or, as I argued in Chapter 2, their power to reach their goals. Private business corporations have as their major goal the maximization of profits. Thus relative profit levels provide an index of corporations' ability to attain their major goal -- an index that is far more precise than those available in most other institutional spheres. For a corporation selling products in a given market, one set of particularly "problematic others" is the set of its competitors in that market. Thus evidence provided by this study, that enterprises' direct and indirect directorship interlocks with their competitors positively affect profit margins, is evidence that supports the theory of interorganizational co-optation.

Economists have had difficulty developing and confirming a theory of the operation of oligopolistic markets. In particular, they have been unable to find systematic empirical evidence in favour of one or another of the various speculative theories advanced to explain the observed positive correlation between market concentration and profits. Although it is generally accepted that some sort of tacit joint maximization strategies are used by oligopolists, the mechanisms of these strategies are poorly understood. This study has shown that horizontal directorship interlocks occur in 22 of the 30 market areas studied, that in these market areas their density varies with concentration, and that variations in their density explain a considerable part of the variation in profit margins associated with concentration. In all 30 market areas, a combination of horizontal and bank directorship interlocks (the latter being closely associated with bank-mediated P2 horizontal interlocks) explained all of the variation in profit margins associated with concentration. This is very strong evidence in support of the view that oligopolistic co-ordination is achieved through these interlocks.

The findings of this study also have implications for the debate concerning the role of banks in industrial capitalism. Several researchers have found that interlocks among corporations in the U.S.A. form clusters centred on the large banks. This finding has occasioned considerable debate as to whether it confirms the Lenin-Hilferding theory that large banks control an entourage of satellite industrial corporations. A similar clustering effect has been found in Canada. However, Niosi (1978) has argued convincingly (mainly from the absence of ownership ties) that Canadian banks do not control associated industrial corporations. What, then, is the meaning of this clustering of corporations around the Canadian banks? Evidence from the present study suggest that Canadian banks play a co-ordinating role among competing industrial corporations, enabling them to avoid competing vigorously. It would be interesting to know if this were true in other industrial capitalist economies.

9.3 Policy implications

This study has shown that in producer markets, direct and indirect interlocking between competitors and with banks increases average profit margins in the market. If the goal of anti-combines policy is to promote competition then interlocks between competitors, including bank-mediated P2 interlocks, should be prevented.

It is often argued that in order to benefit from economies of scale and to "compete effectively in world markets" Canadian corporations need to be so large that domestic markets will inevitably be highly concentrated. If this is true, then prevention of horizontal interlocks is doubly important. Density of these interlocks currently varies with market concentration. Thus an economy increasingly characterized by oligopoly will also be increasingly characterized by horizontal interlocks unless they are regulated. However, <u>even when concentration is controlled in the prediction equation</u>, interlocks explain a large part of variations in profit margins. Thus, even if it is necessary to condone widespread industrial concentration in Canada, the concomitant excess profit margins can be reduced considerably by preventing direct and indirect horizontal interlocking (unless other equally effective mechanisms of co-ordination are then used).

This research has studied market area profit margins, not the margins of individual corporatins. Thus it has <u>not</u>

shown that the degree of interlocking of a particular firm affects its profit margin. Indeed, the fact that top-4 and top-8 profit margins are so highly correlated with overall market margins strongly suggests that profit margins are consistent over at least the significant firms in a particular market -- regardless of which firms interlock and which do not. This finding could explain why other studies have failed to find a relationship between interlocks and profits at the individual firm level.

This has an important implication for anti-combines policy. If an anti-interlock policy were applied on a case-by-case basis, in which a particular interlock between a pair of competitors was considered for its effect on the "public interest', one might well be able to demonstrate that this interlock had no relationship with the profits of the firms concerned. Rather, the sum of all interlocks in the market appears to contribute to the profit margins of all members of the market (or at least all members with significant market share).

This study has not differentiated between "domestic" interlocks between Canadian firms and "foreign" interlocks involving at least one non-Canadian firm. The data do include substantial numbers of interlocks between Canadian and foreign (mainly American) firms and between pairs of foreign firms. Thus this study does not shed any light on the question of the relative contribution of "nationality of interlock" to profit margins in Canadian markets. It is at least conceivable that the effect of prohibiting interlocks between Canadian firms belonging to competing enterprises could be attenuated by indirect interlocking through foreign firms. In view of the large number of enterprises operating in Canadian markets that have foreign firms as members, research on the relative effect of "foreign interlocks" is needed.

A final policy implication is that the Canadian government must start publishing (in computer-readable form) directorship or director interlock data for Canadian firms and, where possible, their foreign affiliates. If one takes the findings of this study seriously, there is as much need for study of interlocks as for study of market concentration. However, interlock data are scattered, incomplete, and expensive to make computer-readable. Publication of ownership data has enabled social scientists to do important research on corporate control that previously was impossible (e.g. Niosi 1978); publication of interlock data would probably have the same salutary effect on research on oligopolistic co-ordination.

9.4 Methodological conclusions and implications

This study has made several methodological innovations in interlock research. These innovations had two motivations: (1) to do everything possible to demonstrate the relationship between concentration, profits and interlocking, if such a relationship existed, and (2) to specify variations in the relationship by comparing the results obtained from different indices and models. The results of these innovations, and their implications for future research, are discussed below.

9.4.1 Units of analysis.

Research linking interlocks to profits may be more successful at the market level than at the individual firm or enterprise level. Several researchers have failed to find a relationship between firms' interlocks and their profits. This could have several reasons: (1) It may be true that all the firms in a market benefit from the level of interlocking, as suggested above. (2) High profit margins in one area of a firm's activity may be offset by low margins in another. (3) Firm-level profits data may be distorted by variations in accounting practices, etc. (4) In multifirm enterprises, each firm may not be an independent profit maximizer; profits may be transferred among enterprise members for various reasons. However, collecting enterprise-level profits data would only exacerbate the problem of lumping together different profit levels from different activities -- and create the additional problem of including profits from foreign members of multinational enterprises.

This study used broad aggregations of markets called "market areas", corresponding in coarseness of aggregation to Statistics Canada's 2-digit "industry groups". This caused two problems: (1) Using an unconventional unit of aggregation caused problems of comparability between data on concentration, profits and interlocking. (2) Use of the relatively coarse level of aggregation results in lumping together industries that are not homogeneous. One or both of these problems probably contributed to the anomalous relationships between concentration and profits in 5 market areas that necessitated their omission from the study. In addition, both of these problems probably contributed to attenuation of the computed statistics of association.

The obvious solution to both of these problems would be to use the 4 digit S.I.C. industry as the unit of analysis, as most industrial organization studies do. This would have the additional important advantage of greatly increasing the N on which all the associations were computed, thereby probably increasing the statistical significance of the results. This would require a much larger sample of firms, so that interlocks in each industry could be measured on an adequate set of nodes.

9.4.2 Types of tie

This study is unique in its inclusion of one type of interlock -- the indirectly horizontal tie (involving at least one enterprise member outside the market area) -- and its exclusion of another type -- the interlock that is internal to the enterprise. Indirectly horizontal ties were the best predictor of profits in the set of 22 market areas where they existed. Clearly this justifies their use. There is no precise way to evaluate the effect of excluding internal enterprise interlocks. I would guess that they do not contribute significantly to profits, since co-ordination <u>within</u> the enterprise is presumably not the difficult problem that it is between independent competitors, and there are many methods besides interlocks available for managing an enterprise. Thus inclusion of internal ties, which far outnumber the inter-enterprise ties used in this study, would probably wash out associations between interlocking and other aspects of market organization. This may be another reason for the failure of some other studies to find associations between interlocking and other attributes of firms or markets.

The obvious implication of this discussion is that it is important to aggregate firms into enterprises before studying industrial organization. It has already been pointed out that this follows from the theory of competition, but the results of this and other studies seem to confirm it.

Direct bank ties were selected in preference to bank-mediated P2 horizontal ties because of their slightly higher correlations with profit margins. However, the theoretical and substantive interpretation of P2 horizontal ties in terms of horizontal co-optation is much clearer than that of direct bank ties. Of course, the latter are themselves extremely important and interesting, but somewhat tangential for a study of <u>horizontal</u> co-optation. However, because of the extremely high intercorrelation between the two, results obtained for one could confidently be extended to the other.

Financial constraints prevented correction of the decision, made very early in the analysis, that the different types of tie should be combined in the creation of indices. This had the result that no interlock indices were computed on indirectly horizontal ties alone, or on bank ties alone, or on bank-mediated P2 ties alone. This made it much more difficult to make precise comparisons of the effects of different kinds of interlocking, although comparisons were possible, based on differences between coefficients for separate and combined ties. On the other hand, the various types of tie as measured appeared to have very similar structures -- thus separating them might have had little effect. This possibility could not be tested once the types of ties had been combined. Future research should employ separate indices of each type of tie.

9.4.3 Types of index

Three indices of interlocking were computed in addition to the obvious index, density. Centralization of degree on the full graph was highly correlated with density but less strongly associated with profits. The four indices computed on interlocks in the largest connected component were virtually uncorrelated with profits, even (with a couple of exceptions) when a more elaborate model was used.

There are at least two possible reasons for this: (1) Interlocking in the top few firms may indeed be unrelated with profits. (2) The largest connected component may be substantially different from the top few firms. Further research is needed to evaluate more thoroughly the impact of interlocking in the top few firms and/or the "central clique". Apparently, however, density is the best measure of interlocking as it relates to profits in markets.

9.4.4 Level of measurement

In this study, interlocks were represented by both binary-valued and real-valued graphs. The latter were computed using a rather elaborate scaling procedure. For some types of tie, indices based on binary-valued graphs were more strongly associated with profit margins, and for others the real-valued ties performed better. Two conclusions are possible: (1) It is indeed true that some types of tie between enterprises are metered more precisely with respect to the number of interlocks and the number of pairs of firms, and/or for some types of tie, there are substantial numbers of weak ties (discriminated by the real-valued measurement) that do not contribute to anticompetitive co-ordination. (2) The intensity of ties is in all cases a significant factor, but the chosen scaling function measured intensity inadequately.

Further research comparing the results of various real-valued scaling functions, and of binary graphs with various threshold levels, is needed to resolve this question. The high intercorrelation between corresponding pairs of indices with alternate levels of measurement suggests that this aspect of the index is not very important.

9.4.5 Affiliations of interlockers

The implications of the relative performance of indices based on "DD" and "DO/OO" ties are similar to those for the level of measurement. For some types of tie, one form of affiliation performed better; in other cases the other did. However, this dimension of the interlocks produced considerably more variation in correlations with profits than did the level of measurement; and in this case no elaborate transformations were made. Thus it appears that both kinds of ties need to be considered separately.

9.4.6 Other controls

This study was intentionally kept very simple by introducing only one control variable -- concentration. Now that the importance of interlocking for profit levels has been established, the research should be repeated with other controls. These should include the other industrial organization variables and especially vertical interlocking. Burt has shown the prevalence of co-optive vertical interlocking but not its relation to profits; it would be instructive to see if it is related to profits and to horizontal interlocking, and the relative strengths of their effects on profits.

9.4.7 Summary

This study has made several methodological innovations that have contributed to its successful results. On the other hand, it has some methodological weaknesses, remedies for which have been suggested above. The research now needs to be replicated with more carefully controlled comparative variations in methodology. Its results should also be validated and extended by replicating the research on data for different years for Canada, and on other national economies.

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APPENDIX A

Characteristics of market areas

Table A.1

Definitions of market areas

<u>35 market areas analyzed in Chapter 5</u>

Mkt area — Specifications

line 1: Name of market area
line 2: 3 digit (old) SIC codes subsumed
line 3: 4 digit (new) SIC codes subsumed
line 4: Corresponding *Corporation Financial Statistics* group

2 Logging
031
0311,0319
031,039

3 Metal mines (excl. gold quartz mines)
053,054,055,056,057,058,059
0580,0591,0592,0593,0594,0599
051-059

4 Gold quartz mines
052
0520
053-059

5 Meat and dairy products
101,103,105,107
1011,1012,1040
101-139

6 Fish products, fruit and veg. canners
111,112
1020,1031,1032
101-139

7 Feed, flour and [illegible]ery products
123,124,128,129
1050,1060,1071,1072
101-139

8 Misc. food processors
131,133,139
1081,1083,1089
101-139

(cont'd)

Table A.1 (cont'd)

9	Beverage mfg. 141,143,145,147 1091,1092,1093,1094 141-147
10	Rubber industries 163,169 1620 161-169
11	Textiles and knitting mills 212,213,218,219,229,231,239 1840,1880,1891,1893,1894,1899,2310,2391,2392 183-229,231-239
12	Clothing industries 243,244,245 2431,2432,2441,2442,2450 243-249
13	Wood industries 252,254,256,259 2520,2541,2542,2543,2544,2560,2591,2592,2593,2599 251-259
14	Sawmills 251 2511,2513 251-259
15	Furniture industries 261,264,266 2611,2619,2640,2660 261-268
16	Pulp and paper mills 271 2710 271-274
17	Paper box and bag mfg. 273 2731,2732,2733 271-274

(cont'd)

Table A.1 (cont'd)

18	Misc. paper converters 274 2740 271-274
19	Printing and publishing 286,288,289 2860,2880,2890 286-289
20	Primary iron and steel industries 291,292,294,295 2910,2920,2940,2950 291-298
21	Misc. primary metal industries 296,297,298 2960,2970,2980 291-298
22	Metal fabricating 301,302,303,304,305 3010,3020,3031,3039,3041,3042,3050 301-309
23	Misc. metal fabricating 309 3090 301-309
24	Misc. machinery and equipment mfg. 315 3150 311-318
25	Automobile, truck and parts mfg. 323,324,325 3230,3241,3242,3243,3250 321-329
26	Aircraft and parts mfg. 321 3210 321-329
27	Shipbuilding and repair 327 3270 321-329

(cont'd)

Table A.1 (cont'd)

28	Appliance, radio and TV mfg. 331,332,334 3310,3320,3340 331-339
29	Communications equipment mfg. 335 3350 331-339
30	Non-metallic mineral products 351,352,354,355 3511,3512,3520,3591,3599 341-359
31	Petroleum and coal products 365,369 3651,3652,3690 365-369
32	Mixed fertilizers mfg. 372 3720 371-379
33	Paint and varnish mfg. 375 3750 371-379
34	Industrial chemicals mfg. 378 3781,3782,3783 371-379
35	Misc. chemicals industries 379 3791,3799 371-379
36	Sporting goods and toy mfg. 393 3931,3932 381-399

(cont'd)

Table A.1 (cont'd)

Other market areas

Mkt area	3 digit SIC codes	Name of market area
1	011,013 015,017 019	Commercial farms
37	404,406	Building, highway, bridge and street constr'n
38	409	Misc. general contractors
39	421	Special-trade contractors
40	501,502	Air transport and services
41	508,509	Urban transit and interurban bus transit
42	504	Water transport
43	505	Services incidental to water transport
44	506	Railway transit
45	507	Truck transport
46	515	Pipeline transport
47	517	Misc. services incidental to transport
48	524	Grain elevators
49	527	Misc. storage and warehousing
50	544,545	Telephone, telegraph and cable systems
51	543	Radio and TV broadcasting
52	572	Electric power utilities
53	574	Gas utilities
54	608	Petroleum products wholesalers
55	611	Paper and products wholesalers
56	614	Food wholesalers

(cont'd)

Table A.1 (cont'd)

57	617	Clothing and drygoods wholesalers
58	618	Furniture wholesalers
59	619	Autos and accessories wholesalers
60	621	Electrical machinery & supplies wholesalers
61	623	Misc. machinery and eqpt. wholesalers
62	624	Hardware, plumbing and heating eqpt. wholesalers
63	625	Misc. metal and products wholesalers
64	626	Lumber and building materials wholesalers
65	631	Retail stores
66	642	Department stores
67	652,654	Gasoline service stations
68	656	Motor vehicle dealers
69	665,667 669	Clothing and shoe stores
70	676	Furniture and appliance stores
71	681	Drugstores
72	699	Misc. retail stores
73	712	Chartered banks
74	714	Trust companies
75	715	Mortgage and loan companies
76	723,725	Sales finance and consumer loan companies
77	741	Securities brokers
78	751,752	Mutual funds
79	769	Misc. financial agencies
80	771	Life insurance carriers

(cont'd)

Table A.1 (cont'd)

81	071,077 079,083 087	Nonmetal mines and quarries
82	781	Insurance and real estate agencies

TABLE A.2

VALUES OF INDUSTRIAL ORGANIZATION VARIABLES FOR 35 MARKET AREAS

MKTAREA	HVS	RVS4	RVS8	PCM4	PCM8	PCMT	CRSP	CRS	CRVS	CUPCM4	CUPCM8	CUPCMT
2	.050990	.364	.506	0.208675	0.209211	0.230803	0.89742	0.62202	0.0001729	0.198371	0.199616	0.220929
3	.167154	.733	.886	0.450334	0.443318	0.429736	2.05698	2.02563	0.0023258	0.380165	0.377972	0.362487
4	.133500	.628	.898	0.408247	0.411421	0.406992	2.05698	2.02563	0.0556928	0.338078	0.346076	0.339743
5	.078976	.454	.558	0.119640	0.126518	0.129811	0.29864	0.29772	0.0005991	0.140251	0.145712	0.149564
6	.065075	.430	.576	0.277746	0.277536	0.253973	0.29864	0.29772	0.0024970	0.298357	0.296729	0.273726
7	.065368	.420	.551	0.265133	0.269460	0.240405	0.29864	0.29772	0.0015853	0.285743	0.288654	0.260158
8	.075914	.429	.555	0.321945	0.350180	0.323156	0.29864	0.29772	0.0020276	0.342556	0.369373	0.342909
9	.211645	.751	.845	0.586699	0.573894	0.550627	0.58699	0.58538	0.0006723	0.592423	0.579224	0.556112
10	.116700	.607	.763	0.380338	0.395302	0.383556	0.61451	0.61420	0.0008630	0.384641	0.399309	0.387680
11	.066506	.318	.572	0.303441	0.292408	0.274638	0.63358	0.63246	0.0014787	0.306759	0.295498	0.277818
12	.006455	.106	.173	0.228117	0.232307	0.229490	0.11553	0.11521	0.0001270	0.258181	0.260305	0.258303
13	.069127	.388	.512	0.236822	0.224515	0.233150	0.63414	0.62890	0.0015191	0.240112	0.227578	0.236302
14	.016865	.189	.287	0.188270	0.206757	0.261034	0.63414	0.62890	0.0008707	0.191559	0.209820	0.264186
15	.016117	.175	.273	0.316524	0.319605	0.285340	0.25565	0.25435	0.0002367	0.339354	0.340865	0.307220
16	.046900	.345	.525	0.275996	0.263195	0.249323	1.23779	1.23446	0.0021167	0.248120	0.237236	0.222607
17	.061151	.483	.689	0.223436	0.232535	0.234599	1.23779	1.23446	0.0085917	0.195560	0.206576	0.207883
18	.041500	.335	.456	0.315285	0.316015	0.312869	1.23779	1.23446	0.0146148	0.287409	0.290055	0.286153
19	.035272	.296	.447	0.532567	0.539719	0.461101	0.83129	0.46148	0.0005014	0.525677	0.533304	0.454499
20	.205149	.757	.904	0.308721	0.290629	0.287811	1.33238	1.33027	0.0013858	0.275961	0.260121	0.256415
21	.254426	.760	.875	0.171889	0.177955	0.192231	1.32235	1.32026	0.0064105	0.139647	0.147929	0.161331
22	.064833	.398	.511	0.276433	0.288701	0.286248	0.39928	0.39717	0.0006158	0.291848	0.303056	0.301021
23	.013100	.151	.239	0.367619	0.350489	0.311566	0.39928	0.39717	0.0028667	0.383034	0.364644	0.326340
24	.010100	.125	.217	0.263370	0.241198	0.294188	0.44953	0.43555	0.0008767	0.276190	0.253137	0.306474
25	.215041	.802	.871	0.162430	0.173390	0.188230	0.24834	0.24712	0.0003961	0.185637	0.195002	0.210421
26	.139600	.804	.880	0.370291	0.368901	0.356096	0.24834	0.24712	0.0051903	0.393499	0.390513	0.378357
27	.139000	.637	.851	0.203752	0.214072	0.217763	0.24834	0.24712	0.0076172	0.226960	0.235684	0.240004
28	.113850	.687	.857	0.290361	0.286779	0.286102	0.33728	0.33610	0.0014590	0.308977	0.304114	0.303943
29	.147900	.565	.673	0.454100	0.430335	0.429251	0.33728	0.33610	0.0016922	0.472723	0.447670	0.447092
30	.122336	.682	.874	0.518548	0.504420	0.486342	0.94195	0.93780	0.0026615	0.505946	0.492683	0.474264
31	.199656	.854	.814	0.409879	0.395547	0.391348	0.75349	0.74628	0.0130674	0.407007	0.392872	0.388595
32	.169700	.751	.894	0.237305	0.226165	0.228365	0.69875	0.69788	0.0355229	0.237259	0.226122	0.228321
33	.053300	.376	.542	0.422676	0.437024	0.406632	0.69875	0.69788	0.0089869	0.422629	0.436981	0.406587
34	.103542	.565	.781	0.322472	0.330120	0.337277	0.69875	0.69788	0.0026139	0.322426	0.330077	0.337233
35	.062011	.350	.466	0.414692	0.417269	0.378615	0.69875	0.69788	0.0053230	0.414646	0.417226	0.378771
36	.088677	.485	.635	0.320891	0.318364	0.311498	0.38675	0.38489	0.0030817	0.336953	0.333321	0.326892

HVS: Herfindahl index of inequality of value of shipments.
RVS4: Top-4 concentration ratio for value of shipments.
RVS8: Top-8 concentration ratio for value of shipments.
PCM4: Price-cost margin for top-4.
PCM8: Price-cost margin for top-8.
PCMT: Price-cost margin for entire market area.
CRSP: Capital-output ratio based on sales of products.
CRS: Capital-output ratio based on all sales.
CRVS: Capital-output ratio based on value of shipments.
CUPCM4: Corrected price-cost margin for top-4.
CUPCM8: Corrected price-cost margin for top-8.
CUPCMT: Corrected price-cost margin for entire market area.

APPENDIX B

Additional regression coefficients

Table B.1

Unstandardized coefficients from multiple and simple regressions of corrected price-cost margins on concentration and interlocking, and interlocking on concentration

(1) N = 30

	Eqn	HVS	RVS4	DI	R^2	Eqn	DI on: HVS	DI on: RVS4
		beta1	beta1					
	8.1	0.30			0.06			
	8.1		0.08		0.05			
		beta4	beta4	beta2/ beta5			beta3	beta3
RFGDN1	8.2			0.84	0.04	8.3	0.08	0.03"
	8.4	0.25		0.60	0.08			
	8.4		0.06	0.58	0.07			
RFGDN2	8.2			1.10	0.05	8.3	0.09'	0.02"
	8.4	0.24		0.75	0.08			
	8.4		0.06	0.80	0.08			
RFGDN3	8.2			0.96'	0.13	8.3	0.29*	0.08*
	8.4	0.03		0.91	0.13			
	8.4		0.0	0.95	0.13			
RFGDN4	8.2			0.65"	0.12	8.3	0.24'	0.07'
	8.4	0.17		0.55	0.13			
	8.4		0.04	0.57	0.12			
RLCCP1	8.2			0.02	0.0	8.3	0.25	0.14
	8.4	0.30		0.01	0.06			
	8.4		0.07	0.01	0.05			
RLCCD1	8.2			0.01	0.0	8.3	0.71	0.17
	8.4	0.32		-0.03	0.06			
	8.4		0.08	-0.02	0.05			
RLCCP2	8.2			0.01	0.0	8.3	-0.46	-0.08
	8.4	0.32		0.03	0.07			
	8.4		0.08	0.02	0.05			
RLCCD2	8.2			-0.02	0.0	8.3	0.14	0.06
	8.4	0.31		-0.03	0.06			
	8.4		0.08	-0.03	0.06			
RLCCP3	8.2			-0.06	0.03	8.3	-1.02	-0.33"
	8.4	0.26		-0.04	0.07			
	8.4		0.06	-0.04	0.06			
RLCCD3	8.2			-0.02	0.01	8.3	-1.30	-0.23
	8.4	0.29		0.0	0.06			
	8.4		0.07	-0.01	0.05			
RLCCP4	8.2			0.22	0.03	8.3	-0.10	-0.04
	8.4	0.33		0.25	0.10			
	8.4		0.09	0.26	0.11			
RLCCC4	8.2			0.03	0.0	8.3	-0.38	-0.15
	8.4	0.32		0.06	0.07			
	8.4		0.09	0.07	0.07			

Notes: See Figure 8.1 for path models and equations, and Table 7.1 for definitions of variables.
*significant at < 0.01.
'significant at < 0.05.
"significant at < 0.10.

(cont'd)

Table B.1 (cont'd)

(2) N = 12

	Eqn	HVS	RVS4	DI	R^2	Eqn	DI on: HVS	RVS4
		beta1	beta1					
	8.1	0.43"			0.29"			
	8.1		0.14'		0.44'			
		beta4	beta4	beta2/ beta5			beta3	beta3
RFGDN1	8.2			1.33'	0.39'	8.3	0.14	0.05
	8.4	0.28		1.05"	0.50'			
	8.4		0.10"	0.86	0.56'			
RFGDN2	8.2			1.09	0.19	8.3	0.14	0.03
	8.4	0.34		0.63	0.35			
	8.4		0.12"	0.50	0.47"			
RFGDN3	8.2			0.46	0.10	8.3	0.38*	0.10*
	8.4	0.50		-0.21	0.30			
	8.4		0.19'	-0.52	0.49'			
RFGDN4	8.2			0.60'	0.34'	8.3	0.43"	0.13'
	8.4	0.25		0.41	0.41"			
	8.4		0.10	0.28	0.48"			
RLCCP1	8.2			0.06	0.12	8.3	-0.45	0.05
	8.4	0.46'		0.08	0.46"			
	8.4		0.13'	0.06	0.54'			
RLCCD1	8.2			0.02	0.01	8.3	1.18	0.26
	8.4	0.45		-0.02	0.30			
	8.4		0.14'	-0.02	0.44"			
RLCCP2	8.2			0.03	0.02	8.3	0.14	0.10
	8.4	0.42"		0.03	0.31			
	8.4		0.14'	0.01	0.44"			
RLCCD2	8.2			0.02	0.01	8.3	0.02	0.06
	8.4	0.42"		0.02	0.30			
	8.4		0.14'	0.01	0.44"			
RLCCP3	8.2			-0.06	0.07	8.3	-1.69	-0.60'
	8.4	0.42		0.0	0.29			
	8.4		0.17'	0.05	0.47"			
RLCCC3	8.2			0.10	0.10	8.3	0.58	0.27
	8.4	0.39		0.06	0.34			
	8.4		0.13'	0.02	0.44"			
RLCCP4	8.2			-0.06	0.0	8.3	-0.14	-0.05
	8.4	0.43"		0.01	0.29			
	8.4		0.14'	0.06	0.44"			
RLCCC4	8.2			-0.10	0.07	8.3	-0.84	-0.30"
	8.4	0.41		-0.02	0.30			
	8.4		0.15'	0.04	0.45"			

Notes: See Figure 8.1 for path models and equations, and Table 7.1 for definitions of variables.

*significant at < 0.01.

'significant at < 0.05.

"significant at < 0.10.

(cont'd)

Table B.1 (cont'd)

(3) N = 22

	Eqn	HVS	RVS4	DI	R^2	Eqn	DI on: HVS	DI on: RVS4
		beta1	beta1					
	8.1	0.29			0.06			
	8.1		0.09		0.07			
		beta4	beta4	beta2/ beta5			beta3	beta3
RFGDN1	8.2			1.13	0.10	8.3	0.13"	0.04'
	8.4	0.17		0.93	0.12			
	8.4		0.05	0.89	0.12			
RFGDN2	8.2			1.57	0.12	8.3	0.11'	0.03"
	8.4	0.14		1.34	0.13			
	8.4		0.05	1.31	0.14			
BFGDN3	8.2			0.65	0.07	8.3	0.37*	0.10*
	8.4	0.12		0.48	0.08			
	8.4		0.04	0.42	0.08			
BFGDN4	8.2			0.48	0.08	8.3	0.32'	0.09'
	8.4	0.17		0.37	0.10			
	8.4		0.05	0.36	0.10			
RLCCP1	8.2			0.05	0.04	8.3	0.90	0.37
	8.4	0.26		0.04	0.08			
	8.4		0.07	0.03	0.08			
RLCCD1	8.2			0.02	0.0	8.3	0.92	0.21
	8.4	0.30		-0.01	0.06			
	8.4		0.09	-0.01	0.07			
RLCCP2	8.2			0.04	0.01	8.3	-0.79	-0.19
	8.4	0.35		0.07	0.09			
	8.4		0.10	0.07	0.10			
RLCCD2	8.2			-0.01	0.0	8.3	0.09	0.04
	8.4	0.29		-0.01	0.06			
	8.4		0.09	-0.01	0.07			
ELCCP3	8.2			-0.02	0.0	8.3	-1.31"	-0.42'
	8.4	0.31		0.01	0.06			
	8.4		0.10	0.03	0.07			
ELCCC3	8.2			-0.03	0.02	8.3	-1.57	-0.29
	8.4	0.26		-0.02	0.06			
	8.4		0.08	-0.02	0.08			
ELCCP4	8.2			0.45	0.09	8.3	-0.10	-0.03
	8.4	0.34		0.50	0.17			
	8.4		0.10	0.52	0.19			
ELCCC4	8.2			0.03	0.0	8.3	-0.41	-0.14
	8.4	0.33		0.08	0.07			
	8.4		0.10	0.11	0.09			

Notes: See Figure 8.1 for path models and equations, and Table 7.1 for definitions of variables.
*significant at < 0.01.
'significant at < 0.05.
"significant at < 0.10.

Table B.2

Standardized path coefficients from multiple regressions of corrected price-cost margins on top-4 concentration, full graph density of interlocks, size of largest clique, and interlocking in the largest clique.

(1) N = 30

	Eqn	Dependent variable	RVS4	FGDN	LCNN	LCDI	R^2
Para-digm	8.9	CPCMT	beta13	beta14	beta15	beta16	
	8.8	LCDI	beta10	beta11	beta12		
	8.7	LCNN	beta8	beta9			
	8.6	FGDN	beta7				
RLCCP1	8.9	CPCMT	0.18	0.26	-0.12	-0.12	0.09
	8.8	RLCCP1	-0.09	0.72*	-0.18		0.43*
	8.7	LCNN1	0.09	0.32			0.13
	8.6	RFGDN1	0.34"				0.12"
RLCCD1	8.9	CPCMT	0.20	0.20	-0.07	-0.08	0.09
	8.8	RLCCD1	0.07	0.25	0.38'		0.30'
	8.7	LCNN1	0.09	0.32			0.13
	8.6	RFGDN1	0.34"				0.12
RLCCP2	8.9	CPCMT	0.19	0.19	-0.08	0.04	0.08
	8.8	RLCCP2	-0.06	0.18	-0.32		0.09
	8.7	LCNN2	0.15	0.40'			0.23'
	8.6	RFGDN2	0.35"				0.13"
RLCCD2	8.9	CPCMT	0.19	0.21	-0.08	-0.09	0.09
	8.8	RLCCD2	0.03	0.10	0.10		0.03
	8.7	LCNN2	0.15	0.40'			0.23'
	8.6	RFGDN2	0.35"				0.13"
BLCCP3	8.9	CPCMT	-0.02	0.59"	-0.38	-0.08	0.20
	8.8	BLCCP3	0.02	-0.26	-0.52'		0.51*
	8.7	LCNN3	-0.08	0.74*			0.48*
	8.6	BFGDN3	0.61*				0.38*
BLCCC3	8.9	CPCMT	-0.03	0.61'	-0.34	-0.06	0.20
	8.8	BLCCC3	-0.12	-0.02	-0.07		0.03
	8.7	LCNN3	-0.08	0.74*			0.48*
	8.6	BFGDN3	0.61*				0.38*
BLCCP4	8.9	CPCMT	[illegible].15	0.27	0.03	0.19	0.16
	8.8	BLCCP4	-0.09	0.21	-0.75*		0.59*
	8.7	LCNN4	0.16	0.06			0.04
	8.6	BFGDN4	0.40'				0.16'
BLCCC4	8.9	CPCMT	0.14	0.31	-0.04	0.12	0.15
	8.8	BLCCC4	-0.10	-0.04	-0.65*		0.47*
	8.7	LCNN4	0.16	0.06			0.04
	8.6	BFGDN4	0.40'				0.16'

Notes: See Figure 8.2 for path models and equations, and Table 7.1 for definitions of variables.

*significant at < 0.01.

'significant at < 0.05.

"significant at < 0.10.

(cont'd)

Table B.2 (cont'd)

(2) N = 12

	Eqn	Dependent variable	RVS4	FGDN	LCNN	LCDI	R^2
RLCCP1	8.9	CPCMT	0.49	0.27	0.12	0.30	0.60
	8.8	RLCCP1	-0.02	0.46"	-0.69'		0.63'
	8.7	LCNN1	0.23	-0.02			0.05
	8.6	RFGDN1	0.48				0.23
RLCCD1	8.9	CPCMT	0.51	0.42	-0.06	-0.12	0.58
	8.8	RLCCD1	0.18	0.10	0.26		0.15
	8.7	LCNN1	0.23	-0.02			0.05
	8.6	RFGDN1	0.48				0.23
RLCCP2	8.9	CPCMT	0.53	0.23	0.06	0.15	0.49
	8.8	RLCCP2	0.33	-0.11	0.60"		0.38
	8.7	LCNN2	0.20	0.23			0.13
	8.6	RFGDN2	0.41				0.17
RLCCD2	8.9	CPCMT	0.57	0.21	-0.02	0.06	0.48
	8.8	RLCCD2	0.12	-0.05	-0.10		0.02
	8.7	LCNN2	0.20	0.23			0.13
	8.6	RFGDN2	0.41				0.17
BLCCP3	8.9	CPCMT	0.99"	-0.25	-0.16	0.13	0.54
	8.8	BLCCP3	-0.66"	0.37	-0.62'		0.65'
	8.7	LCNN3	-0.09	0.66			0.36
	8.6	BFGDN3	0.73*				0.53*
BLCCC3	8.9	CPCMT	0.86	-0.16	-0.26	0.05	0.53*
	8.8	BLCCC3	0.89'	-0.93"	0.45		0.46
	8.7	LCNN3	-0.09	0.66			0.36
	8.6	BFGDN3	0.73*				0.53*
BLCCP4	8.9	CPCMT	0.44	0.32	0.01	-0.06	0.49
	8.8	BLCCP4	-0.38	0.47	-0.63'		0.70
	8.7	LCNN4	0.43	-0.36			0.12
	8.6	BFGDN4	0.63'				0.40'
BLCCC4	8.9	CPCMT	0.53	0.28	0.11	0.13	0.49
	8.8	BLCCC4	-0.51	0.12	-0.51"		0.56"
	8.7	LCNN4	0.43	-0.36			0.12
	8.6	BFGDN4	0.63'				0.40'

Notes: See Figure 8.2 for path models and equations, and Table 7.1 for definitions of variables.
*significant at < 0.01.
'significant at < 0.05.
"significant at < 0.10.

(cont'd)

Table B.2 (cont'd)

(2) N = 22

	Eqn	Dependent variable	RVS4	FGDN	LCNN	LCDI	R^2
RLCCP1	8.9	CPCMT	0.15	0.29	-0.09	-0.02	0.13
	8.8	RLCCP1	0.03	0.64*	-0.24		0.39'
	8.7	LCNN1	0.10	0.27			0.11
	8.6	RFGDN1	0.48'				0.23'
RLCCD1	8.9	CPCMT	0.15	0.30	-0.06	-0.09	0.13
	8.8	RLCCD1	0.04	0.26	0.36		0.28
	8.7	LCNN1	0.10	0.27			0.11
	8.6	RFGDN1	0.48'				0.23'
RLCCP2	8.9	CPCMT	0.16	0.31	0.15	0.31	0.21
	8.8	RLCCP2	-0.01	-0.04	-0.56'		0.34"
	8.7	LCNN2	0.21	0.26			0.16
	8.6	RFGDN2	0.40"				0.16"
RLCCD2	8.9	CPCMT	0.15	0.30	-0.02	-0.02	0.14
	8.8	RLCCD2	0.08	-0.03	-0.03		0.01
	8.7	LCNN2	0.21	0.26			0.16
	8.6	RFGDN2	0.40"				0.16"
BLCCP3	8.9	CPCMT	0.10	0.38	-0.20	0.07	0.12
	8.8	BLCCP3	-0.19	-0.03	-0.60'		0.52*
	8.7	LCNN3	-0.19	0.84*			0.50*
	8.6	BFGDN3	0.73*				0.53*
BLCCC3	8.9	CPCMT	0.09	0.36	-0.25	-0.09	0.12
	8.8	BLCCC3	0.04	-0.27	-0.13		0.12
	8.7	LCNN3	-0.19	0.84*			0.50*
	8.6	BFGDN3	0.73*				0.53*
BLCCP4	8.9	CPCMT	0.31	-0.03	0.22	0.51	0.22
	8.8	BLCCP4	-0.27	0.48'	-0.59*		0.58*
	8.7	LCNN4	0.22	-0.08			0.04
	8.6	BFGDN4	0.47'				0.22
BLCCC4	8.9	CPCMT	0.21	0.20	-0.04	0.10	0.12
	8.8	BLCCC4	-0.30	0.12	-0.44'		0.31"
	8.7	LCNN4	0.22	-0.08			0.04
	8.6	BFGDN4	0.47'				0.22'

Notes: See Figure 8.2 for path models and equations, and Table 7.1 for definitions of variables.

*significant at < 0.01.

'significant at < 0.05.

"significant at < 0.10.

Table B.3a
Unstandardized coefficients from multiple regressions of corrected price-cost margins on concentration (HVS), full graph density of interlocks, size of largest clique, and interlocking in the largest clique.

(1) N = 30

	Eqn	Dependent variable	HVS4	FGDN	LCNN	LCDI	R^2
Paradigm	8.9	CPCMT	beta13	beta14	beta15	beta16	
	8.8	LCDI	beta10	beta11	beta12		
	8.7	LCNN	beta8	beta9			
	8.6	FGDN	beta7				
RLCCP1	8.9	CPCMT	0.27	1.07	0.0	-0.03	0.10
	8.8	RLCCP1	-0.44	10.62	-0.02		0.43
	8.7	LCNN1	8.96	50.05			0.15
	8.6	RFGDN1	0.08				0.08
RLCCD1	8.9	CPCMT	0.29	0.85	0.0	-0.04	0.10
	8.8	RLCCD1	0.27	2.24	0.019'		0.31'
	8.7	LCNN1	8.96	50.05			0.15
	8.6	RFGDN1	0.08				0.08
RLCCP2	8.9	CPCMT	0.27	0.93	0.0	0.02	0.10
	8.8	RLCCP2	-0.32	2.41	-0.01		0.10
	8.7	LCNN2	16.39	110.74'			0.25'
	8.6	RFGDN2	0.09'				0.13'
RLCCD2	8.9	CPCMT	0.26	1.01	0.0	-0.04	0.10
	8.8	RLCCD2	-0.08	1.18	0.0		0.03
	8.7	LCNN2	16.39	110.74'			0.25'
	8.6	RFGDN2	0.09'				0.13'
BLCCP3	8.9	CPCMT	0.03	1.46"	0.0	-0.03	0.20
	8.8	BLCCP3	0.51	-2.65	-0.016'		0.52*
	8.7	LCNN3	-4.20	175.79*			0.47*
	8.6	BFGDN3	0.29*				0.40*
BLCCC3	8.9	CPCMT	0.0	1.55"	0.0	-0.01	0.20
	8.8	BLCCC3	-1.39	0.81	0.0		0.06
	8.7	LCNN3	-4.20	175.79*			0.47*
	8.6	BFGDN3	0.29*				0.40*
BLCCP4	8.9	CPCMT	-0.20	0.51	0.0	0.21	0.16
	8.8	BLCCP4	-0.01	0.27	-0.007*		0.58*
	8.7	LCNN4	21.20	8.29			0.05
	8.6	BFGDN4	0.24'				0.15'
BLCCC4	8.9	CPCMT	0.20	0.58	0.0	0.05	0.16
	8.8	BLCCC4	0.01	-0.28	-0.014*		0.46*
	8.7	LCNN4	21.20	8.29			0.05
	8.6	BFGDN4	0.24'				0.15'

Notes: See Figure 8.2 for path models and equations, and Table 7.1 for definitions of variables.
*significant at < 0.01.
'significant at < 0.05.
"significant at < 0.10.

(cont'd)

Table B.3a (cont'd)

(2) N = 12

	Eqn	Dependent variable	RVS4	FGDN	LCNN	LCDI	R^2
RLCCP1	8.9	CPCMT	0.33	0.71	0.0	0.06	0.56
	8.8	RLCCP1	-0.24	5.37"	-0.045'		0.63'
	8.7	LCNN1	21.94	-6.99			0.11
	8.6	RFGDN1	0.14				0.14
RLCCD1	8.9	CPCMT	0.34	1.07	0.0	-0.03	0.53
	8.8	RLCCD1	0.80	0.95	0.01		0.17
	8.7	LCNN1	21.94	-6.99			0.11
	8.6	RFGDN1	0.14				0.14
RLCCP2	8.9	CPCMT	0.30	0.71	0.0	0.05	0.38
	8.8	RLCCP2	1.25	-1.21	-0.025"		0.38
	8.7	LCNN2	31.30	44.86			0.19
	8.6	RFGDN2	0.14				0.19
RLCCD2	8.9	CPCMT	0.35	0.66	0.0	0.02	0.36
	8.8	RLCCD2	0.20	-0.33	0.0		0.01
	8.7	LCNN2	31.30	44.86			0.19
	8.6	RFGDN2	0.14				0.19
BLCCP3	8.9	CPCMT	0.45	0.07	0.0	-0.06	0.41
	8.8	BLCCP3	-0.90	0.28	-0.01		0.48
	8.7	LCNN3	4.19	146.68			0.36
	8.6	BFGDN3	0.38*				0.51*
BLCCC3	8.9	CPCMT	0.40	0.31	0.0	0.09	0.45
	8.8	BLCCC3	1.17	-2.71	0.01		0.20
	8.7	LCNN3	4.19	146.68			0.36
	8.6	BFGDN3	0.38*				0.51*
BLCCP4	8.9	CPCMT	0.19	0.52	0.0	-0.20	0.44
	8.8	BLCCP4	-0.15	0.38	-0.005'		0.63'
	8.7	LCNN4	51.98	-52.32			0.14
	8.6	BFGDN4	0.43"				0.31"
BLCCC4	8.9	CPCMT	0.21	0.44	0.0	-0.02	0.42
	8.8	BLCCC4	-0.43	-0.25	-0.010"		0.45
	8.7	LCNN4	51.98	-52.32			0.14
	8.6	BFGDN4	0.43"				0.31"

Notes: See Figure 8.2 for path models and equations, and Table 7.1 for definitions of variables.

*significant at < 0.01.
'significant at < 0.05.
"significant at < 0.10.

(cont'd)

Table B.3a (cont'd)

(3) N = 22

	Eqn	Dependent variable	BVS4	FGDN	LCNN	LCDI	R^2
BLCCP1	8.9	CPCMT	0.20	1.06	0.0	0.0	0.13
	8.8	BLCCP1	0.03	9.12*	-0.02		0.39'
	8.7	LCNN1	13.05	38.17			0.14
	8.6	BFGDN1	0.13"				0.16"
BLCCD1	8.9	CPCMT	0.21	1.11	0.0	-0.04	0.14
	8.8	BLCCD1	0.30	2.22	0.02		0.28
	8.7	LCNN1	13.05	38.17			0.14
	8.6	BFGDN1	0.13"				0.16"
BLCCP2	8.9	CPCMT	0.14	1.44	0.0	0.11	0.20
	8.8	BLCCP2	0.10	-0.62	-0.025'		0.34"
	8.7	LCNN2	26.86	57.32			0.22"
	8.6	BFGDN2	0.11'				0.19'
BLCCD2	8.9	CPCMT	0.15	1.37	0.0	-0.01	0.14
	8.8	BLCCD2	0.15	-0.23	0.0		0.0
	8.7	LCNN2	26.86	57.32			0.22"
	8.6	BFGDN2	0.11'				0.19'
BLCCP3	8.9	CPCMT	0.09	0.94	0.0	0.02	0.11
	8.8	BLCCP3	0.03	-1.31	-0.014'		0.51*
	8.7	LCNN3	-9.16	186.94*			0.48*
	8.6	BFGDN3	0.37*				0.53*
BLCCC3	8.9	CPCMT	0.08	0.89	0.0	-0.02	0.12
	8.8	BLCCC3	-0.80	-1.09	-0.01		0.13
	8.7	LCNN3	-9.16	186.94*			0.48*
	8.6	BFGDN3	0.37*				0.53*
BLCCP4	8.9	CPCMT	0.29	0.05	0.0	0.64	0.20
	8.8	BLCCP4	-0.13	0.48'	-0.004*		0.54*
	8.7	LCNN4	32.29	-17.28			0.07
	8.6	BFGDN4	0.32'				0.20'
BLCCC4	8.9	CPCMT	0.22	0.35	0.0	0.05	0.11
	8.8	BLCCC4	-0.27	0.12	-0.007'		0.26
	8.7	LCNN4	32.29	-17.28			0.07
	8.6	BFGDN4	0.32'				0.20'

Notes: See Figure 8.2 for path models and equations, and Table 7.1 for definitions of variables.

*significant at < 0.01.

'significant at < 0.05.

"significant at < 0.10.

(cont'd)

Table B.3b
Unstandardized coefficients from multiple regressions of corrected price-cost margins on concentration (RVS4), full graph density of interlocks, size of largest clique, and interlocking in the largest clique.

(1) N = 30

	Eqn	Dependent variable	RVS4	FGDN	LCNN	LCDI	R^2
Para-digm	8.9	CPCMT	beta13	beta14	beta15	beta16	
	8.8	LCDI	beta10	beta11	beta12		
	8.7	LCNN	beta8	beta9			
	8.6	FGDN	beta7				
RLCCP1	8.9	CPCMT	0.06	1.06	0.0	-0.03	0.09
	8.8	RLCCP1	-0.11	10.73*	-0.02		0.43*
	8.7	LCNN1	1.20	53.47			0.13
	8.6	RFGDN1	0.03"				0.12"
RLCCD1	8.9	CPCMT	0.06	0.80	0.0	-0.04	0.09
	8.8	RLCCD1	0.05	2.24	0.02'		0.30'
	8.7	LCNN1	1.20	53.47			0.13
	8.6	RFGDN1	0.03"				0.12"
RLCCP2	8.9	CPCMT	0.06	0.95	0.0	0.01	0.08
	8.8	RLCCP2	-0.06	2.32	-0.01		0.09
	8.7	LCNN2	2.92	119.52'			0.23'
	8.6	RFGDN2	0.02"				0.13"
RLCCD2	8.9	CPCMT	0.06	1.03	0.0	-0.04	0.09
	8.8	RLCCD2	0.02	1.03	0.0		0.03
	8.7	LCNN2	2.92	119.52'			0.23'
	8.6	RFGDN2	0.02"				0.13"
BLCCP3	8.9	CPCMT	0.0	1.54"	0.0	-0.03	0.20
	8.8	BLCCP3	0.02	-2.02	-0.02'		0.51*
	8.7	LCNN3	-2.49	182.16*			0.48*
	8.6	BFGDN3	0.08*				0.38*
BLCCC3	8.9	CPCMT	0.0	1.59'	0.0	-0.01	0.20
	8.8	BLCCC3	-0.17	-0.25	0.0		0.03
	8.7	LCNN3	-2.49	182.16*			0.48*
	8.6	BFGDN3	0.08*				0.38*
BLCCP4	8.9	CPCMT	0.05	0.51	0.0	0.24	0.16
	8.8	BLCCP4	-0.02	0.32	-0.01*		0.59*
	8.7	LCNN4	4.74	10.17			0.04
	8.6	BFGDN4	0.07'				0.16'
BLCCC4	8.9	CPCMT	0.05	0.59	0.0	0.06	0.15
	8.8	BLCCC4	-0.06	-0.14	-0.01*		0.47*
	8.7	LCNN4	4.74	10.17			0.04
	8.6	BFGDN4	0.07'				0.16'

Notes: See Figure 8.2 for path models and equations, and Table 7.1 for definitions of variables.
*significant at < 0.01.
'significant at < 0.05.
"significant at < 0.10.

(cont'd)

Table B.3b (cont'd)

(2) N = 12

	Eqn	Dependent variable	RVS4	FGDN	LCNN	LCDI	R^2
RLCCP1	8.9	CPCMT	0.10	0.57	0.0	0.06	0.60
	8.8	RLCCP1	-0.02	5.24"	-0.05'		0.63'
	8.7	LCNN1	3.91	-3.96			0.05
	8.6	RFGDN1	0.05				0.23
RLCCD1	8.9	CPCMT	0.11	0.88	0.0	-0.03	0.58
	8.8	RLCCD1	0.16	0.94	0.01		0.15
	8.7	LCNN1	3.91	-3.96			0.05
	8.6	RFGDN1	0.05				0.23
RLCCP2	8.9	CPCMT	0.11	0.56	0.0	0.03	0.49
	8.8	RLCCP2	0.30	-1.17	-0.02"		0.38
	8.7	LCNN2	4.69	64.57			0.13
	8.6	RFGDN2	0.03				0.17
RLCCD2	8.9	CPCMT	0.12	0.53	0.0	0.01	0.48
	8.8	RLCCD2	0.10	-0.54	0.0		0.02
	8.7	LCNN2	4.69	64.57			0.13
	8.6	RFGDN2	0.03				0.17
BLCCP3	8.9	CPCMT	0.21"	-0.36	0.0	0.03	0.54
	8.8	BLCCP3	-0.62"	2.43	-0.02'		0.65'
	8.7	LCNN3	-3.11	168.06			0.36
	8.6	BFGDN3	0.10*				0.53*
BLCCC3	8.9	CPCMT	0.18	-0.23	0.0	0.01	0.53
	8.8	BLCCC3	0.62'	-4.53"	0.01		0.46
	8.7	LCNN3	-3.11	168.06			0.36
	8.6	BFGDN3	0.10*				0.53*
BLCCP4	8.9	CPCMT	0.09	0.33	0.0	-0.05	0.49
	8.8	BLCCP4	-0.09	0.57	-0.005'		0.70'
	8.7	LCNN4	13.78	-56.85			0.12
	8.6	BFGDN4	0.13'				0.40'
BLCCC4	8.9	CPCMT	0.11	0.28	0.0	0.05	0.49
	8.8	BLCCC4	-0.29	0.34	-0.009"		0.56"
	8.7	LCNN4	-3.11	-56.85			0.12
	8.6	BFGDN4	0.13'				0.40'

Notes: See Figure 8.2 for path models and equations, and Table 7.1 for definitions of variables.
*significant at < 0.01.
'significant at < 0.05.
"significant at < 0.10.

(cont'd)

Table B.3b (cont'd)

(3) N = 22

	Eqn	Dependent variable	RVS4	FGDN	LCNN	LCDI	R^2
RLCCP1	8.9	CPCMT	0.05	1.02	0.0	0.0	0.13
	8.8	RLCCP1	0.04	8.93*	-0.02		0.39'
	8.7	LCNN1	1.61	45.29			0.11
	8.6	RFGDN1	0.04'				0.23'
RLCCD1	8.9	CPCMT	0.05	1.05	0.0	-0.03	0.13
	8.8	RLCCD1	0.03	2.35	0.02		0.28
	8.7	LCNN1	1.61	45.29			0.11
	8.6	RFGDN1	0.04'				0.23'
RLCCP2	8.9	CPCMT	0.05	1.38	0.0	0.11	0.21
	8.8	RLCCP2	-0.01	-0.44	-0.024'		0.34"
	8.7	LCNN2	4.54	76.39			0.16
	8.6	RFGDN2	0.03"				0.16"
RLCCD2	8.9	CPCMT	0.05	1.33	0.0	-0.01	0.14
	8.8	RLCCD2	0.06	-0.31	0.0		0.01
	8.7	LCNN2	4.54	76.39			0.16
	8.6	RFGDN2	0.03"				0.16"
BLCCP3	8.9	CPCMT	0.03	0.89	0.0	0.02	0.12
	8.8	BLCCP3	-0.17	-0.19	-0.015'		0.52*
	8.7	LCNN3	-6.78	209.37*			0.50*
	8.6	BFGDN3	0.10*				0.53*
BLCCC3	8.9	CPCMT	0.03	0.83	0.0	-0.02	0.12
	8.8	BLCCC3	0.06	-2.70	-0.01		0.12
	8.7	LCNN3	-6.78	209.37*			0.50*
	8.6	BFGDN3	0.10*				0.53*
BLCCP4	8.9	CPCMT	0.10	-0.06	0.0	0.74	0.22
	8.8	BLCCP4	-0.06	0.54'	-0.004*		0.58*
	8.7	LCNN4	6.51	-12.81			0.04
	8.6	BFGDN4	0.09'				0.22'
BLCCC4	8.9	CPCMT	0.07	0.33	0.0	0.07	0.12
	8.8	BLCCC4	-0.13	0.27	-0.006'		0.31"
	8.7	LCNN4	6.51	-12.81			0.04
	8.6	BFGDN4	0.09'				0.22'

Notes: See Figure 8.2 for path models and equations, and Table 7.1 for definitions of variables.
*significant at < 0.01.
'significant at < 0.05.
"significant at < 0.10.

APPENDIX C

Glossary of symbols and abbreviations

#	Boolean algebra
A	gross book value of depreciable assets
A	number of edges in a graph or network
BFGCD01	centralization of degree on the full graph of binary-valued DD ties for TOT 3
BFGCD02	centralization of degree on the full graph of binary-valued DO/OO ties for TOT 3
BFGCD04	centralization of degree on the full graph of binary-valued DD ties for TOT 4
BFGCD05	centralization of degree on the full graph of binary-valued DO/OO ties for TOT 4
BFGCD07	centralization of degree on the full graph of binary-valued DD ties for TOT 1
BFGCD08	centralization of degree on the full graph of binary-valued DO/OO ties for TOT 1
BFGCD10	centralization of degree on the full graph of binary-valued DD ties for TOT 2
BFGCD11	centralization of degree on the full graph of binary-valued DO/OO ties for TOT 2

BFGCD13	centralization of degree on the full graph of binary-valued DD ties for TOT 5
BFGCD14	centralization of degree on the full graph of binary-valued DO/CO ties for TOT 5
BFGCD16	centralization of degree on the full graph of binary-valued DD ties for TOT 6
BFGCD17	centralization of degree on the full graph of binary-valued DO/OO ties for TOT 6
BFGDN01, BFGDN3	density on the full graph of binary-valued DD ties for TOT 3
BFGDN02	density on the full graph of binary-valued DO/OC ties for TOT 3
BFGDN04	density on the full graph of binary-valued DD ties for TOT 4
BFGDN05, BFGDN4	density on the full graph of binary-valued DO/OC ties for TOT 4
BFGDN07	density on the full graph of binary-valued DD ties for TOT 1
BFGDN08	density on the full graph of binary-valued DO/OC ties for TOT 1
BFGDN10	density on the full graph of binary-valued DD ties for TOT 2
BFGDN11	density on the full graph of binary-valued DO/OC ties for TOT 2
BFGDN13	density on the full graph of binary-valued DD ties for TOT 5
BFGDN14	density on the full graph of binary-valued DO/OC ties for TOT 5
BFGDN16	density on the full graph of binary-valued DD ties for TOT 6
BFGDN17	density on the full graph of binary-valued DO/OC ties for TOT 6
BLCCC01, BLCCC3	centralization of compactness on the largest component of the graph of binary-valued DD ties for TOT 3

ELCCC02	centralization of compactness on the largest component cf the graph of binary-valued DO/OO ties fcr TOT 3
ELCCC04	centralization of compactness on the largest component cf the graph of binary-valued DD ties for TOT 4
ELCCC05, BLCCC4	centralization of compactness on the largest component cf the graph of binary-valued DO/OC ties fcr TOT 4
ELCCC07	centralization of compactness on the largest component cf the graph of binary-valued DD ties for TOT 1
ELCCC08	centralization of compactness on the largest component cf the graph of binary-valued DO/OO ties fcr TOT 1
ELCCC10	centralization of compactness on the largest component cf the graph of binary-valued DD ties for TOT 2
ELCCC11	centralization of compactness on the largest component cf the graph of binary-valued DO/OO ties for TOT 2
ELCCC13	centralization of compactness on the largest component cf the graph of binary-valued DD ties for TOT 5
ELCCC14	centralization of compactness on the largest component cf the graph of binary-valued DO/OO ties fcr TOT 5
ELCCC16	centralization of compactness on the largest component cf the graph of binary-valued DD ties for TOT 6
ELCCC17	centralization of compactness on the largest component cf the graph of binary-valued DO/OO ties fcr TOT 6
ELCCD01	centralization of degree on the largest component of the graph of binary-valued DD ties for TOT 3
ELCCD02	centralization of degree on the largest component of the graph of binary-valued DO/OO ties for TOT 3
ELCCD04	centralization of degree on the largest component of the graph of binary-valued DD ties for TOT 4

BLCCD05	centralization of degree on the largest component of the graph of binary-valued DO/OO ties for TOT 4
BLCCD07	centralization of degree on the largest component of the graph of binary-valued DD ties for TOT 1
BLCCD08	centralization of degree on the largest component of the graph of binary-valued DO/OO ties for TOT 1
BLCCD10	centralization of degree on the largest component of the graph of binary-valued DD ties for TOT 2
BLCCD11	centralization of degree on the largest component of the graph of binary-valued DO/OO ties for TOT 2
BLCCD13	centralization of degree on the largest component of the graph of binary-valued DD ties for TOT 5
BLCCD14	centralization of degree on the largest component of the graph of binary-valued DO/OO ties for TOT 5
BLCCD16	centralization of degree on the largest component of the graph of binary-valued DD ties for TOT 6
BLCCD17	centralization of degree on the largest component of the graph of binary-valued DO/OO ties for TOT 6
BLCCP01, BLCCP3	compactness on the largest component of the graph of binary-valued DD ties for TOT 3
BLCCP02	compactness on the largest component of the graph of binary-valued DO/OO ties for TOT 3
BLCCP04	compactness on the largest component of the graph of binary-valued DD ties for TOT 4
BLCCP05, BLCCP4	compactness on the largest component of the graph of binary-valued DO/OO ties for TOT 4
BLCCP07	compactness on the largest component of the graph of binary-valued DD ties for TOT 1

BLCCP08	compactness on the largest component of the graph of binary-valued DO/OO ties for TOT 1
BLCCP10	compactness on the largest component of the graph of binary-valued DD ties for TOT 2
BLCCP11	compactness on the largest component of the graph of binary-valued DO/OO ties for TOT 2
BLCCP13	compactness on the largest component of the graph of binary-valued DD ties for TOT 5
BLCCP14	compactness on the largest component of the graph of binary-valued DO/OO ties for TOT 5
BLCCP16	compactness on the largest component of the graph of binary-valued DD ties for TOT 6
BLCCP17	compactness on the largest component of the graph of binary-valued DO/OO ties for TOT 6
BLCDN01	density on the largest component of the graph of binary-valued DD ties for TOT 3
BLCDN02	density on the largest component of the graph of binary-valued DO/OO ties for TOT 3
BLCDN04	density on the largest component of the graph of binary-valued DD ties for TOT 4
BLCDN05	density on the largest component of the graph of binary-valued DO/OO ties for TOT 4
BLCDN07	density on the largest component of the graph of binary-valued DD ties for TOT 1
BLCDN08	density on the largest component of the graph of binary-valued DO/OO ties for TOT 1
BLCDN10	density on the largest component of the graph of binary-valued DD ties for TOT 2
BLCDN11	density on the largest component of the graph of binary-valued DO/OO ties for TOT 2

BLCDN13	density on the largest component of the graph of binary-valued DD ties for TOT 5
BLCDN14	density on the largest component of the graph of binary-valued DO/CO ties for TOT 5
BLCDN16	density on the largest component of the graph of binary-valued DD ties for TOT 6
BLCDN17	density on the largest component of the graph of binary-valued DO/OO ties for TOT 6
BFGDN3	see BFGDN01
BFGDN4	see BFGDN05
BLCCC3	see BLCCC01
BLCCC4	see BLCCC05
BLCCP3	see BLCCP01
BLCCP4	see BLCCP05
C	costs of production
C (A)	closeness (reachability) of node A to all other nodes in a graph or network
CC	(Freeman's) centralization of compactness (closeness, reachability)
CD	(Freeman's) centralization of degree in a graph or network
CO	concentration in an industry, market, or market area
CP	(Beauchamp's) compactness in a graph or network
CPCM	(Burt's) corrected price-cost margin
CPCMT	corrected price-cost margin for all enterprises in an industry
CPCM4	corrected price-cost margin for top 4 enterprises in an industry
CPCM8	corrected price-cost margin for top 8 enterprises in an industry

CR	capital-output ratio
CRS	capital-output ratio where output = sales of products and services
CRSP	capital-output ratio where output = sales of products only
D	member of the board of directors
D(I,J)	distance between nodes I and J in a graph or network
DD	director-director interlock (may subsume other ties--see Chapter 6)
DE	director-executive board interlock
dfR	residual degrees of freedom
DG(A)	degree of node A in a graph or network
DI	degree of interlocking
DN	density of edges in a graph or network
DO	director-officer interlock
DO/OO	combined director-officer and officer-officer interlocks (subsumes other types of interlocks--see Chapter 6)
E	executive board member
ED	executive board-director interlock
EE	executive board-executive board interlock
EO	executive board-officer interlock
FG, FULL	full graph (i.e. all nodes and edges included)
FGDN	density of ties on the full graph
[illegible]	Anscombe and Tukey statistic for regression residual Pattern 2
HVS	Herfindahl index for an industry or market area, based on value of shipments
II, IN-IN	interlock where both interlocked firms operate in the market area

IO, IN-OUT	interlock where only the sending firm operates in the market area
I	payroll
IC, LCC	largest component (i.e. component with largest number of nodes) in a graph or network
ICDI	degree of interlocking in the largest component
ICNN	number of nodes in the largest component
ICNNi	number of nodes in the largest component of the graph or network for TOT i
ICG	logarithm
M	adjacency matrix for a graph
MAX	maximum
NN	number of nodes in a graph or network
O	officer
C.	output (e.g. sales, value of shipments, etc.)
CD	officer-director interlock (may subsume other interlocks--see Chapter 6)
OE	officer-executive board interlock
OI, OUT-IN	interlock where only the receiving firm operates in the market area
CC	officer-officer interlock
OO, OUT-OUT	interlock where neither firm operates in the market area
P	profit, profit margin
PCM	price-cost margin
PCMT	price-cost margin for an industry
PCM4	price-cost margin for the top 4 enterprises in an industry
PCM8	price-cost margin for the top 8 enterprises in an industry

R	Pearson product-moment correlation
RFGCD01	centralization of degree on the full graph of real-valued DD ties for TOT 3
RFGCD02	centralization of degree on the full graph of real-valued DO/OO ties for TOT 3
RFGCD04	centralization of degree on the full graph of real-valued DD ties for TOT 4
RFGCD05	centralization of degree on the full graph of real-valued DO/OO ties for TOT 4
RFGCD07	centralization of degree on the full graph of real-valued DD ties for TOT 1
RFGCD08	centralization of degree on the full graph of real-valued DO/OO ties for TOT 1
RFGCD10	centralization of degree on the full graph of real-valued DD ties for TOT 2
RFGCD11	centralization of degree on the full graph of real-valued DO/OO ties for TOT 2
RFGCD13	centralization of degree on the full graph of real-valued DD ties for TOT 5
RFGCD14	centralization of degree on the full graph of real-valued DO/OO ties for TOT 5
RFGCD16	centralization of degree on the full graph of real-valued DD ties for TOT 6
RFGCD17	centralization of degree on the full graph of real-valued DO/OO ties for TOT 6
RFGDN01	density on the full graph of real-valued DD ties for TOT 3
RFGDN02	density on the full graph of real-valued DO/OO ties for TOT 3
RFGDN04	density on the full graph of real-valued DD ties for TOT 4
RFGDN05	density on the full graph of real-valued DO/OO ties for TOT 4

RFGDN07, RFGDN1	density on the full graph of real-valued DD ties for TOT 1
RFGDN08	density on the full graph of real-valued DO/OO ties for TOT 1
RFGDN1	see RFGDN07
RFGDN10	density on the full graph of real-valued DD ties for TOT 2
RFGDN11, RFGDN2	density on the full graph of real-valued DO/OO ties for TOT 2
RFGDN13	density on the full graph of real-valued DD ties for TOT 5
RFGDN14	density on the full graph of real-valued DO/OO ties for TOT 5
RFGDN16	density on the full graph of real-valued DD ties for TOT 6
RFGDN17	density on the full graph of real-valued DO/OO ties for TOT 6
RFGDN2	see RFGDN11
RICCC01	centralization of compactness on the largest component of the graph of real-valued DD ties for TOT 3
RICCC02	centralization of compactness on the largest component of the graph of real-valued DO/OO ties for TOT 3
RICCC04	centralization of compactness on the largest component of the graph of real-valued DD ties for TOT 4
RICCC05	centralization of compactness on the largest component of the graph of real-valued DO/OO ties for TOT 4
RICCC07	centralization of compactness on the largest component of the graph of real-valued DD ties for TOT 1
RICCC08	centralization of compactness on the largest component of the graph of real-valued DO/OO ties for TOT 1
RICCC10	centralization of compactness on the largest component of the graph of real-valued DD ties for TOT 2

RLCCC11	centralization of compactness on the largest component of the graph of real-valued DO/OO ties for TOT 2
RLCCC13	centralization of compactness on the largest component of the graph of real-valued DD ties for TOT 5
RLCCC14	centralization of compactness on the largest component of the graph of real-valued DO/OO ties for TOT 5
RLCCC16	centralization of compactness on the largest component of the graph of real-valued DD ties for TOT 6
RLCCC17	centralization of compactness on the largest component of the graph of real-valued DO/OO ties for TOT 6
RLCCD01	centralization of degree on the largest component of the graph of real-valued DD ties for TOT 3
RLCCD02	centralization of degree on the largest component of the graph of real-valued DO/OO ties for TOT 3
RLCCD04	centralization of degree on the largest component of the graph of real-valued DD ties for TOT 4
RLCCD05	centralization of degree on the largest component of the graph of real-valued DO/OO ties for TOT 4
RLCCD07, RLCCD1	centralization of degree on the largest component of the graph of real-valued DD ties for TOT 1
RLCCD08	centralization of degree on the largest component of the graph of real-valued DO/OO ties for TOT 1
RLCCD1	see RLCCD07
RLCCD10	centralization of degree on the largest component of the graph of real-valued DD ties for TOT 2
RLCCD11, RLCCD2	centralization of degree on the largest component of the graph of real-valued DO/OO ties for TOT 2

RLCCD13	centralization of degree on the largest component of the graph of real-valued DD ties for TOT 5
RLCCD14	centralization of degree on the largest component of the graph of real-valued DO/OO ties for TOT 5
RLCCD16	centralization of degree on the largest component of the graph of real-valued DD ties for TOT 6
RLCCD17	centralization of degree on the largest component of the graph of real-valued DO/OO ties for TOT 6
RLCCD2	see RLCCD11
RLCCP01	compactness on the largest component of the graph of real-valued DD ties for TOT 3
RLCCP02	compactness on the largest component of the graph of real-valued DO/OO ties for TOT 3
RLCCP04	compactness on the largest component of the graph of real-valued DD ties for TOT 4
RLCCP05	compactness on the largest component of the graph of real-valued DO/OO ties for TOT 4
RLCCP07, RLCCP1	compactness on the largest component of the graph of real-valued DD ties for TOT 1
RLCCP08	compactness on the largest component of the graph of real-valued DO/OO ties for TOT 1
RLCCP1	see RLCCP07
RLCCP10	compactness on the largest component of the graph of real-valued DD ties for TOT 2
RLCCP11, RLCCP2	compactness on the largest component of the graph of real-valued DO/OO ties for TOT 2
RLCCP13	compactness on the largest component of the graph of real-valued DD ties for TOT 5

RLCCP14	compactness on the largest component of the graph of real-valued DO/OO ties for TOT 5
RLCCP16	compactness on the largest component of the graph of real-valued DD ties for TOT 6
RLCCP17	compactness on the largest component of the graph of real-valued DO/OO ties for TOT 6
RLCCP2	see RLCCP11
RLCDN01	density on the largest component of the graph of real-valued DD ties for TOT 3
RLCDN02	density on the largest component of the graph of real-valued DO/OO ties for TOT 3
RLCDN04	density on the largest component of the graph of real-valued DD ties for TOT 4
RLCDN05	density on the largest component of the graph of real-valued DO/OO ties for TOT 4
RLCDN07	density on the largest component of the graph of real-valued DD ties for TOT 1
RLCDN08	density on the largest component of the graph of real-valued DO/OO ties for TOT 1
RLCDN10	density on the largest component of the graph of real-valued DD ties for TOT 2
RLCDN11	density on the largest component of the graph of real-valued DO/OO ties for TOT 2
RLCDN13	density on the largest component of the graph of real-valued DD ties for TOT 5
RLCDN14	density on the largest component of the graph of real-valued DO/OO ties for TOT 5
RLCDN16	density on the largest component of the graph of real-valued DD ties for TOT 6
RLCDN17	density on the largest component of the graph of real-valued DO/OO ties for TOT 6

RMS	residual mean square
RVS4	top 4 concentation ratio for an industry or market area, based on value of shipments
RVS8	top 8 concentation ratio for an industry or market area, based on value of shipments
RVS4M	top 4 concentration ratio for a market area, based on value of shipments
RVS4(I)	top 4 concentration ratio for S.I.C. 4-digit industry I
R1, R2, R3, R4	regression residual terms
S	market share of a firm or enterprise
SKLOGM	skewness of LOG(x), where x is the raw value of the variable
SKLOGXP1	skewness of LOG(x + 1), where x is the raw value of the variable
SKMISS	skewness, where cases with a value of 0 for this variable are excluded
SKRAW	skewness
SKRECIPM	skewness of 1/x, where x is the raw value of the variable
SKRECXP1	skewness of 1/(x + 1), where x is the raw value of the variable
SQRT	square root
SSC	sum of squares attributed to the model
SUM	summation
T12	Draper and Smith approximation of Anscombe and Tukey's k statistic for regression residuals Pattern 3
TOT 1	type of tie 1: directly horizontal ties between enterprises (i.e. both interlocked firms operate in the market area)
TOT 2	type of tie 2: TOT 1 plus indirectly horizontal ties between enterprises (i.e. at least one of the interlocked

	firms does not operate in the market area)
TOT 3	type of tie 3: TOT 1 plus directly horizontal bank ties (i.e. ties between an industrial enterprise and a bank where the firm in the enterprise operates in the market area)
TOT 4	type of tie 4: TOT 2 plus directly and indirectly horizontal bank ties (the latter are industrial-bank ties where the firm in the industrial enterprise does not operate in the market area)
TOT 5	type of tie 5: TOT 3 plus directly horizontal bank-mediated P2 ties (i.e. P2 ties between enterprises mediated by a bank, where the two firms tied to the bank both operate in the market area)
TOT 6	type of tie 6: TOT 4 plus directly and indirectly horizontal bank-mediated P2 ties (the latter are P2 bank-mediated ties where at least one of the firms tied to the bank does not operate in the market area)
v	residual degrees of freedom
V	intensity of a tie, or a matrix of such intensities
V(A,B; X1,X2...Xk)	value of a path between nodes A and B through nodes X1, X2, etc. to Xk
VA	value added
VS	value of shipments
VST(I)	total value of shipments for S.I.C. 4-digit industry I
VS4(I)	value of shipments of top 4 enterprises in S.I.C. 4-digit industry I
W	Shapiro-Wilk normality statistic
YBAR	mean of observed Y
YHAT	predicted Y