Appendix D
Industry Networks

Network constraint in Chapter 5 is defined by a 2% of business criterion, and by company size approximations to four-firm concentration ratios in non-manufacturing industries. This appendix contains evidence for those two decisions.

Bounding the Immediate Network

The immediate network around an industry in Chapter 5 contains its direct suppliers and customers. Beyond them are the industry's indirect suppliers and customers. In theory, the immediate network consists of a producer industry plus every other industry with which it has business. How much business qualifies? For the 1992 benchmark input-output table, the Department of Commerce rounded dollar flows to the nearest million dollars. If a million dollars is the criterion in the 403-industry table, then the immediate network around an average manufacturing industry would contain 87.2 other industries as suppliers or customers, varying from a minimum of 16 to a maximum of 375. In the 1987 input-output table, dollar flows are rounded to the nearest $100,000. The 1987 table contains more non-zero dollar flows (56,763 among the 403 industries versus 43,472 in the 1992 table). The difference between the tables is almost entirely small dollar flows in 1987 that would not round up to a million dollars for the 1992 table (13,742 dollar flows in the 1987 table are .5 million or less). Using the $100,000 minimum dollar flow as a criterion, the immediate network around an average manufacturing industry would contain 122.3 other industries as suppliers or customers, varying from a minimum of 23 to a maximum of 400, which is almost every one of the other 402 industries in the table.

I prefer not to use “any business” as the criterion for inclusion in the immediate network around an industry. There would be inconsistency between the 1987 and 1992 tables, and immediate networks would be large, leaving little of the economy for the extended network. Large networks in a small population produce extended networks

Table D1: Defining the Immediate Network.

Criterion for Inclusion in the Immediate Network around Producer Industry	Year	Average Percent of Business in the Network	Network Size		
			Smallest Network	Average Network	Largest Network
Any Producer Buying or Selling	1987	100.0%	24	121.34	399
	1992	100.0%	17	86.31	375
One Percent of Producer Business	1987	84.3%	4	16.56	34
	1992	82.1%	4	16.90	31
Two Percent of Producer Business	1987	73.9%	2	9.30	19
	1992	73.5%	3	9.18	17
Three Percent of Producer Business	1987	66.8%	2	6.50	13
	1992	66.2%	2	6.29	12
Five Percent of Producer Business	1987	56.7%	1	3.97	8
	1992	56.3%	1	3.85	8
Ten Percent of Producer Business	1987	40.7%	0	1.71	5
	1992	40.4%	0	1.73	4

Note — These are counts for the 361 manufacturing industries. Percent of business in the network is the sum of p_{ij} that exceed the criterion, where p_{ij} is the percentage of producer buying and selling transacted with industry j. Each of the other 402 input-output sectors is a potential supplier or customer. Producer industry is not included in the counts.

that regress to the population mean since each extended network quickly includes every node in the population (see Table B1 for illustration with the investment bankers).

Table D1 above shows how industry network size would vary with five alternative boundary criteria: any buying or selling with the industry, 1% of industry buying and selling, 2%, 5%, and 10%. Criteria are expressed as percentages of producer buying and selling as is usual in studies of resource dependence. Dollar amounts large for one industry can be trivial for another.

Table D1 shows that the primary difference between 1987 and 1992 is in the small transactions and that even a small limit on what qualifies as business brings network size down to a practical number of supplier and customer markets that a manager could be expected to monitor. If immediate networks are limited to industries with which producers conduct at least one percent of their buying and selling, the immediate networks around manufacturing industries in 1987 average 16.6 other industries as suppliers or customers, varying from a minimum of 4, up to a maximum of 34. Network size is about the same in 1992. Increasing the criterion to two percent cuts network size in half; averages of 9.3 and 8.8 respectively in 1987 and 1992. Increasing

the criterion to five percent halves the networks once again to reach average sizes of 4.2 and 4.1 in 1987 and 1992.

Business is clearly concentrated in a few key supplier and customer industries, with smaller but substantial amounts of business conducted in other industries. The substantial amounts are indicated in Table D1 by the percent of business included in the networks. Even a low criterion of one percent excludes from the industry networks 17% of producer business on average (84.3% of producer business in 1987 is included in the one-percent networks, 82.1% of business in 1992). To cast a broad network, my instinct was to use a one-percent criterion. Networks would be a manageable size and roughly similar in 1987 and 1992, while retaining a high level of producer business. However, it is not clear that all those small one-percent transactions need to be included in the network.

Given the lack of a clear criterion for the immediate network around an industry, I estimated effects in the baseline network model for four alternative criteria — one percent, two percent, three percent, and five percent — to determine where the boundary should be drawn.

The results are presented below in Table D2. I draw three conclusions from the results. First, the negative effect of rivalry within the industry is stable across all the alternatives. The coefficient is consistently about negative five and a half with a standard error of about one and a half.

Table D2: Baseline Model Predictions of Price-Cost Margins for Alternative Boundaries around the Immediate Network

Criterion Business for Inclusion in the Immediate Network:	**Dollar Flows Normalized across the Whole Economy**				**Dollar Flows Normalized within Immediate Network**			
	1%	2%	3%	5%	1%	2%	3%	5%
Log(100-O)	-5.58** (1.45)	-5.60** (1.45)	-5.66** (1.47)	-5.57** (1.44)	-5.56** (1.42)	-5.42** (1.41)	-5.33** (1.41)	-5.17** (1.41)
Log(C)	-2.31** (.62)	-2.03** (.56)	-2.06** (.64)	-1.61** (.43)	-4.22** (.75)	-4.39** (.80)	-3.79** (.80)	-3.37** (.77)
1987	2.33** (.40)	2.33** (.40)	2.40** (.40)	2.31** (.40)	2.50** (.40)	2.38** (.41)	2.30** (.41)	2.36** (.41)
Intercept	40.72	40.29	40.34	39.37	47.13	48.41	47.37	46.29
R^2	.12	.12	.11	.12	.16	.15	.14	.14

Note — These are ordinary least-square regression equations predicting nonnegative price-cost margins in manufacturing industries corresponding to unique four-digit SIC categories in 1987 and 1992 (N = 632). Log(100-O) measures the constraint of severe competition between producers in an industry (O is the four-firm concentration ratio). Network constraint C measures dependence on concentrated supplier-customer industries. Standard errors (in parentheses) are corrected for autocorrelation across repeated observations of same industry ("cluster" option in STATA). * P < .05 ** P < .001

Second, the 2% criterion seems to me to be the right criterion to define the immediate network around industries in Chapter 5. The results for 2% in Table D2 are about the same as the results for the more extensive 1% criterion, and slightly stronger than the slightly more restrictive criteria of 3% and 5%. Given substantial producer business excluded from the networks by a two-percent criterion (about a quarter of producer business on average), I tested for industry differences in the amount of business excluded, and report in Chapter 5 that controlling for the percent of producer business included in an industry's network adds nothing to the Table 5.1 predictions.

Third, after defining the boundary of a network, I normalize connections to the relative proportion of business transacted within the network. The four models to the left in Table D2 use p_{ij} normalized to sum to one across all production industries in the economy. The four models to the right in Table D2 use p_{ij} normalized within the immediate network around an industry: $p_{ij} = p_{ij} / \Sigma_k p_{ik}$, $i \neq j$, where the sum is across all industries k in the immediate network excluding industry i itself. This assumes that the connections most relevant to the focal industry are the connections within its immediate network, not connections across the economy. Normalizing within the immediate network is exactly what is done with manager networks defined by survey network data, so I am comfortable using the same operationalization with industry networks to obtain stronger network effects. The final result is that the shaded column in Table D2 is the baseline network model used in Chapter 5 (model C in Table 5.1).

Non-Manufacturing

Aggregation is not an actionable issue for the manufacturing industries in Chapter 5 because I use the most detailed input-output categories available. Non-manufacturing categories and a measure of producer organization within the categories are taken from an unpublished report in which structural equivalence between detailed input-output categories was used to test the boundaries around U.S. Department of Commerce aggregate categories (Burt, 1998b).

The 42 non-manufacturing industries from the 1998 report are listed at the end of this appendix, in Table D3. The first nine industries describe agriculture, mining, and construction. The nine correspond to aggregate categories in the 1987 printed benchmark input-output table. For example, the first row of Table D3 lists data on

the “Livestock and livestock products” industry in 1987. The row lists year, “1987,” then a concentration score of “0.538” explained in a moment. The column labeled “N” in Table D3 lists the number of detailed input-output categories combined in each aggregate category. The “Livestock and livestock products” industry contains four detailed categories in 1987: 10100 “Diary farm products,” 10200 “Poultry and eggs,” 10301 “Meat animals,” and 10302 “Miscellaneous livestock.” Detailed categories within each aggregate category are published with the input-output tables (Lawson and Teske, 1994:93-97; Lawson, 1997:58-62). Identification codes for each industry are listed in the column labeled “ID” in Table D3. The final column contains the industry name (followed in parentheses by SIC categories combined in the aggregate category, also published with the benchmark tables).

The other 33 industries in Table D3 are subdivisions of, or combinations across, the 27 aggregate distribution and service sectors distinguished in the 1987 and 1992 benchmark input-output tables. In theory, detailed categories combined in an aggregate category have nearly identical patterns of buying and selling. Detailed categories with similar patterns of buying and selling are “structurally equivalent” in network terminology (see Figure 8.5 in Chapter 8 for numerical illustration). Where the structural equivalence analysis of buying and selling among detailed categories revealed segregated clusters within an aggregate category, I divided the aggregate category down to separate categories for the different clusters. The Department of Commerce distinguished 77 aggregate categories in the benchmark input-output tables just before the 1987 table, then 88 aggregate categories in the 1987 and 1992 benchmark tables. The 88 aggregate categories were revised to 123 in the structural equivalence analysis. The revised industry categories have more reliable boundaries and higher construct validity (Burt, 1998b): Structural equivalence within industry categories increases across the three partitions (65.7% on average for the 77 categories, 70.1% for the 88 categories, 78.4% for the 123 categories). Variation in price-cost margins is increasingly between, rather than within, industries across the three partitions (48.9% between industries for the 77 categories, 49.8% between for the 88 categories, 71.1% between for the 123 categories).

The ID codes in Table D3 show where Department of Commerce categories were expanded. Identification codes follow the convention used by the Department of Commerce, and are the codes with which non-manufacturing industries are identified in the source network data available on my university research website. The initial two digits are the industry ID in the Department of Commerce 77-category partition. For example, “65” is the transportation industry. A capital letter following a digit indicates an industry expanded from the 77-category partition. For example, the transportation industry was expanded by the Department of Commerce for the 1987 benchmark input-output table to distinguish five industries: railroads (65A), trucking and warehousing (65B), water transportation (65C), air transportation (65D), and a residual category of pipelines, freight forwarders, and travel agents (65E). Where there is no capital letter following the digit, the category continued unchanged from the initial 77-category partition. For example, industry 67 continued to be radio and TV broadcasting. Finally, a lower-case letter at the end of an ID number in Table D3 marks an industry expanded from the 88-category partition. For example, the residual transportation category contained a pipeline industry (65Eb) with a pattern of buying and selling distinct from the pattern for freight forwarders and travel agents (65Ea).

I tried three measures of concentration in non-manufacturing. For each, I computed a network constraint variable based on four-firm concentration in the manufacturing industries and a concentration approximation in the 42 non-manufacturing industries, then estimated a network constraint effect in the baseline network model.

The first alternative was approximations based on company size distributions as used in previous research and described in Chapter 5. These data yield the estimates reported in Chapter 5 for the baseline network model (shaded model in Table D2, model A in Table 5.1), reproduced here as a reference point:

$$\underset{}{PCM = 48.41} \underset{(1.41)}{- 5.42 \text{ Log } (100\text{-}O)} \underset{(.80)}{- 4.39 \text{ Log } (C)} + \underset{(.41)}{2.38 \text{ D87}},$$

which generates a squared multiple correlation of .15, a -3.83 t-test for the negative effect of rivalry within the industry, and a -5.47 t-test for network constraint from industry suppliers and customers.

Second, I tried network constraint assuming that non-manufacturing industries (farming, mining, construction, services, and distribution) are so full of competitors that concentration in non-manufacturing can be treated as zero. I get the following estimates for the baseline model:

$$\underset{}{PCM = 48.41} \underset{(1.41)}{- 5.42 \text{ Log } (100\text{-}O)} \underset{(.80)}{- 4.39 \text{ Log } (C)} + \underset{(.41)}{2.38 \text{ D87}},$$

which generates a squared multiple correlation of .09, a -3.41 t-test for the negative effect of rivalry within the industry, and a negligible -1.21 t-test for network constraint.

Third, I tried an approximation more sophisticated than the one based on company size. The unpublished report provides a measure of producer organization in 1987 and 1992 (Burt, 1998b:Table 3) from which I derived scores in non-manufacturing analogous to the concentration ratios in manufacturing.

"Effective organization" (EO) was introduced to measure how well competition within an industry, as competition affected profits, was captured for organization research by traditional concentration data (Burt, et al. 2002). EO scores are obtained by reversing the baseline network model. Instead of predicting price-cost margins from O and C as measures of industry structure, the observed price-cost in an industry and its dependence weights on other sectors are held constant (i.e., the data provided by an input-output table are held constant), and producer concentration in each industry is obtain numerically so as to align observed profit margins with the level expected from industry structure. In industries where margins are higher than expected, producers are "effectively" more organized than they appear to be. Such industries tend to be regional markets (versus national) or subject to government regulation (Burt et al., 2002). For example, there are numerous hotels operating in the United States, but only one down the street from your business, so your local hotel can enjoy profits higher than would be expected from the number of hotels operating nationally. In industries where margins are lower than expected from observed industry structure, producers are "effectively" less organized than they appear to be, which is primarily correlated with imports increasing the level of competition within an industry above the level implied by concentration among American producers (Burt et al., 2002).

Using EO scores to approximate concentration in non-manufacturing, I get the following estimates for the baseline model:

$$PCM = 46.78 - 5.16 \underset{(1.47)}{\text{Log}}(100-O) - 3.26 \underset{(1.13)}{\text{Log}}(C) + 2.19 \underset{(.40)}{D87},$$

which generates a squared multiple correlation of .11, a -3.50 t-test for the negative effect of rivalry within the industry, and a -2.89 t-test for network constraint from industry suppliers and customers. The one change I made to the EO scores was to adjust them to a metric comparable to the four-firm concentration ratios in manufacturing. EO scores average .551 in 1987, and .535 in 1992, across the 80 aggregate manufacturing industries distinguished in Burt (1998b). Four-firm concentration ratios average .395 in 1987, and .405 in 1992, across the 361 detailed manufacturing industries analyzed in Chapter 5. To convert the non-manufacturing EO scores in Burt (1998b:Table 3) to a scale comparable to the manufacturing four-firm concentration ratios used in Chapter 5, EO scores in non-manufacturing were multiplied by .717 in 1987 and .757 in 1992 (mean EO in manufacturing divided by mean four-firm concentration in manufacturing).

The network constraint effect in the above equation based on the EO approximation to O in non-manufacturing is significantly negative, but weaker than the effect estimated with size-based approximations, so I returned to the size-based approximations for the analysis in Chapter 5 and report them in Table D3 in the column labeled "O."

Table D3: Aggregate Non-Manufacturing Industries

Year	O	N	ID	Aggregate Input-Output Industry (SIC codes)
1987	0.538	4	1	Livestock & livestock products (*019, 0251-3, 0211-4, *0219, 024, *0259, 0271-3, *0279, *029)
1992	0.627	4		
1987	0.639	13	2	Other agricultural products (011, 013, 016, 017, 018, *019, *0219, *0259, *029)
1992	0.667	13		
1987	0.626	2	3	Forestry & fishery products (081, 083, 097, 091)
1992	0.667	2		
1987	0.369	2	4	Agricultural, forestry, & fishery services (0254, *0279, 071-2,075-6, 078, 085, 092)
1992	0.560	2		
1987	0.417	3	5-6	Metallic ores mining (iron, copper & other; 101-4, 106, *108, 1094, 1099)
1992	0.303	3		
1987	0.620	1	7	Coal mining (122-3, *124)
1992	0.690	1		
1987	0.681	1	8	Crude petroleum & natural gas (131-2, *138)
1992	0.700	1		
1987	0.580	5	9-10	Nonmetallic minerals mining (141-2, 144, 145, 147, *148, 149)
1992	0.584	5		
1987	0.272	5	11-12	Construction (15, 16, 17, *108, *124, *138, *148, *6552)
1992	0.239	15		
1987	0.347	2	65A	Railroads & related services (40,41, 474)
1992	0.375	2		
1987	0.342	1	65B	Motor freight transportation & warehousing (421-3)
1992	0.312	2		
1987	0.173	1	65C	Water transportation (44)
1992	0.345	1		
1987	0.335	1	65D	Air transportation (45)
1992	0.328	1		
1987	0.408	2	65Ea	† Freight forwarders & travel agents (472-3, 478)
1992	0.496	2		
1987	0.694	1	65Eb	† Piplines (except natural gas; 46)
1992	0.740	1		

Table D3: Aggregate Non-Manufacturing Industries, continued

Year	O	N	ID	Aggregate Input-Output Industry (SIC codes)
1987	0.525	1	66	Communication (except radio & TV; 481-2, 484, 489)
1992	0.581	2		
1987	0.522	1	67	Radio & TV broadcasting (483)
1992	0.646	1		
1987	0.582	1	68A	Electric services (utilities; 491, 4931)
1992	0.632	1		
1987	0.577	1	68B	Gas production & distribution (utilities; 4922-5, 4932, 4939)
1992	0.664	2		
1987	0.007	2	68C	Water & sanitary services (494, 4952-3, 4959, 496-7)
1992	0.475	2		
1987	0.395	1	69A	Wholesale trade(50, 51)
1992	0.406	1		
1987	0.499	1	69B	Retail trade(52-7, 59)
1992	0.592	1		
1987	0.301	3	70A	Finance (60, 61, 62, 67, excluding 6732)
1992	0.516	3		
1987	0.477	1	70Ba	† Insurance carriers (63)
1992	0.548	1		
1987	0.663	1	70Bb	† Insurance agents (64)
1992	0.703	1		
1987	0.704	1	71A	Owner-occupied dwellings (—)
1992	0.747	1		
1987	0.644	1	71Ba	† Real estate agents (65, excluding 6552)
1992	0.680	1		
1987	0.717	1	71Bb	† Royalties (—)
1992	0.757	1		
1987	0.411	1	72A	Hotels & lodging places (701-4)
1992	0.475	2		
1987	0.402	6	72B	Personal & repair services (except auto; 721-6, 729, 762-4)
1992	0.518	6		

Table D3: Aggregate Non-Manufacturing Industries, continued

Year	O	N	ID	Aggregate Input-Output Industry (SIC codes)
1987	0.388	1	73A	Computer & data processing services (737)
1992	0.467	1		
1987	0.466	1	73Ba	† Legal services (81)
1992	0.542	1		
1987	0.449	1	73Bb	† Engineering services (871)
1992	0.529	1		
1987	0.197	2	73BC	† Management, accounting, & testing services (872, 873, 874, 89)
1992	0.483	3		
1987	0.462	6	73Ca	† General business services (7331, 732, 7334, 7338, 734-6, 7381-3, 7389, 769)
1992	0.567	6		
1987	0.507	1	73Cb	† Photographic services (7335-6, 7384)
1992	0.647	1		
1987	0.425	1	73D	Advertising services (731)
1992	0.526	1		
1987	0.339	1	74	Eating & drinking places (58)
1992	0.412	1		
1987	0.446	3	75	Automotive repair & services (751-3, 7542, 7549)
1992	0.491	3		
1987	0.419	8	76	Amusements (781-4, 791-3, 7941, 7948, 7991-3, 7996-7, 7999)
1992	0.547	8		
1987	0.342	4	77A	Health services (074, 801-3, 8041-3, 8049, 805-6, 807-9)
1992	0.453	6		
1987	0.223	11	77B	Educational & social services (6732, 821-4, 829, 832-3, 835-6, 839, 84, 861-6, 869, 8733)
1992	0.408	11		

Note — Data are explained in the text. Asterisk indicates that partial SIC category is in the row industry. Dagger (†) indicates a row industry disaggregated from a broader input-output category.