How Strategic Are Strategic Industries? A Network Approach to South Korea's "Big Push"

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Despite the decade-long debate surrounding the role of markets and states in NICs (newly industrialized countries) development, relatively little attention has been paid to defining the meaning of the term "strategic industries" and systematically evaluating the strategic value of the industries selected for government support. This paper uses theories and techniques of social network analysis to define the strategic value of an industry in four different ways: better export performance, better ability to facilitate resource flows between upstream and downstream industries (brokerage), more upstream spillover effects (upstream prominence), and more downstream spillover effects (downstream prominence). South Korea's "Big Push" is used as a sample case of state support for empirical analysis. Using Korea's input-output tables from 1980 to 1990, export performance and network variables representing brokerage and prominence characteristics of an industry are calculated and compared across HCIs (Heavy and Chemical Industries) and non-HCIs. In terms of export performance, HCIs were not necessarily strategic in 1980 but are becoming so in 1990. In terms of brokerage and prominence, "Big Push" was generally successful in the sense that variables, on which HCIs have significantly higher scores than non-HCIs, are positively correlated with export. However, "Big Push" was not a complete success, for it did not take full advantage of potential opportunities. As the Korean economy enters the 1990s, "Big Push" is largely becoming less effective than it was in the 1980s. There are signs that the strategic value of HCIs is changing from important broker industries to important supplier industries. However, HCIs have failed to establish significant backward linkages in the domestic economy. At the theoretical level, this paper makes one of the few attempts to productively combine development study and network analysis to generate empirically meaningful results.

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I. MARKETS, STATES, AND THE "BIG PUSH"

One of the main debates surrounding the East Asian development has revolved around the role of markets and states. Advocates of market explanation have stressed that the outward orientation, which is associated with characteristics, such as the neutral incentive regime, positive real interest rates, resource allocation through market mechanism, and exposure to foreign competition, has been the key factor to the East Asian economic success compared to the inward-looking strategy of Latin American NICs (Balassa and Associates 1982; World Bank 1993). However, a closer examination of the South Korean case, one of the key references of the market explanation, reveals that the validity of such an explanation is highly questionable. Balassa's study of incentive structures across six semi-industrial economies demonstrates that the distribution of incentives in Korea, measured by effective subsidy rates, is not neutral but balanced between a great amount of positive and negative incentives. Real interest rates on loans remained negative in Korea during the 1970s and 1980s (Park 1994). Resources, most importantly, financial ones, were never allocated through market mechanism (Woo 1991; Cho and Kim 1995).

Those who emphasize the role of the state in the process of the region's economic development argue that the market-conforming way of state intervention by means of industrial and financial policies has been instrumental (Johnson 1982; 1987; Luedde-Neurath 1988; Wade 1990). Aside from broader sociopolitical factors providing the environment with this kind of state intervention,¹ industrial policy has become the primary research focus. In spite of the heightened interest in industrial policy, evidence supporting effective intervention has largely come from anecdotal case studies of a few industries.² This lack in systematic evidence tends to render the whole research program vulnerable to criticisms which advocate that state intervention "has made a leap of faith from the existence of a policy having a certain goal to the achievement of the intended effects" (Haggard 1990, 14).

Evaluating more systematically the effects of sector-specific industrial policies provides a valuable opportunity to settle the decade-long debate between the two theoretical camps and opens up a fresh perspective. The key question here is whether, and in what sense, the so-called, "strategic industries" can be considered strategic. Johnson, for example, states that "the heart of [industrial structure] policy is the selection of the strategic industries to be developed or converted to other lines of work" (1982, 28). In Wade's "governed market" theory, one of the crucial ingredients in East Asian economic performance is "more investment in certain key industries than would have occurred in the absence of government intervention" (1990, 26). One thing that is less than clear in this argument is how the government planning agency Ministry of International Trade and Industry (MITI) in Japan and Economic Planning Board (EPB) in Korea could be so successful in selecting industries that were "strategic" for national development.

¹ Chalmers Johnson points out the coexistence of authoritarianism and capitalism in successful East Asian economies (1987). Wade's term for the same sociopolitical environment is authoritarian corporatism (1990).
² See Leipziger (1987) and Leipziger and Petri (1993) for a detailed case study of the Korean industrial policy. Saxonhouse (1983) has an economist's counterargument against the effectiveness of industrial policy.

Wade suggests that "[government] leadership is concentrated on industries that are expected to become internationally competitive but have not yet become so, and on industries which, though losing competitiveness, the government considers important for the economy's future growth" (1990, 304-5). Although it sounds reasonable, the task may be easier said than done even for, say, a Nobel economist when it comes to actually selecting those strategic industries.⁵

South Korea's "Big Push," or the Heavy and Chemical Industrialization (HCI) Drive, in the 1970s, provides an excellent research site for addressing the issue. It is not only one of the best known industrial policy episodes of East Asian development literature, but it also meets virtually all the criteria for being a classical case of industrial policy implementation. Existing literature finds that the Korean state was almost hyperactive in supporting the "Big Push" during the 1970s: real loan rates were set at negative levels to make HCI financing cheaper; external borrowings were guaranteed repayment by the state-owned banks; about half the total domestic credit was set aside as policy loans earmarked for HCI industries; special-purpose funds, including the National Investment Fund, were established to meet long-term financing needs (such as equipment purchases); and special-purpose banks and development institutions were founded (Cole and Park 1984; Frieden 1981; Woo 1991; Lee 1994; Cho and Kim 1995; Kim 1997).

The coexistence of this massive state intervention and Korea's continued economic performance to date has often been taken as evidence for the state's strategic industrial policy. Some authors contend that the success or failure of the "Big Push" should not be judged solely on economic grounds because there were extra-economic concerns like the development of the indigenous defense industry (Haggard 1990; Woo 1991). However, this still leaves the question unanswered because the fact that a certain industrial policy had extra-economic purposes does not explain how it led to impressive economic performances. Whether or not there were extra-economic concerns, were those industries selected as the strategic ones strategic in the context of the national economy? If so, in what sense were they strategic?

This paper attempts to answer these questions by suggesting different meanings of an industry's strategic value in the national economy and examining the actual effects of South Korea's "Big Push" according to the various senses of strategic value. The theory and techniques of social network analysis are applied to Korea's input-output tables in 1980 and 1990. Network theory suggests two broad classes of variables representing the strategic position in a network of inter-industry transactions: centrality, or prominence on the one hand; and range or brokerage on the other. If the industries selected for HCI were, in fact, strategic, it is expected that they show, on average, significantly higher scores on these variables than the other industries. Another concern is whether the industries with high values on these variables contribute significantly more to export. It is widely recognized that relative export size is strongly and positively correlated with GNP growth (Michaely 1977). Just like organizations and people performing better when occupying strategic positions in the networks to which they belong (Burt 1992),

⁵ See Woronoff (1992) for some ethnographic descriptions on how industrial targeting was done in Japan. For the Korean case, however, such research is virtually nonexistent.

one can reasonably expect strategically located industries in the national economy to perform better by exporting more.

Section II explains the different meanings of an industry's strategic value in the national economy. Section III describes the data. Section IV provides topological maps of Korean markets in 1980 and 1990, giving some visual sense to the relative positions of HCI industries in the overall structure of the Korean economy. Section V compares HCI and non-HCI industries across various network variables. Section VI examines the network analysis results at the level of the individual industries, followed by the conclusion.

II. VARIOUS MEANINGS OF STRATEGIC INDUSTRIES

Export and Spillover

In East Asian development literature, one obvious meaning of the term "strategic" is directly linked to good export performance. In an economy following the so-called, "export-led-growth trajectory" (Haggard 1990), no other criteria can be more compelling in selecting strategic industries than export performance. For instance, confronting economists' claim that HCIs returned only meager results and, therefore, "Big Push" is a classic illustration of the follies of excessive state intervention, Wade argues that medium-term results are much better than short-term results as can be seen by the fact that by 1984, sixty percent of Korea's export came from HCIs (1990, 319-20).

There are, however, ways in which a certain industry can be strategic for the development of the national economy even if it does not generate a great amount of export. An industry may be highly strategic in the sense that, without its proper development, other upstream or downstream industries cannot perform as well (i.e., through positive spillover effects). This idea is also well-acknowledged in the East Asian development literature in statements like, "{in a plan-rational state} the government will give greatest precedence to industrial policy, that is, to a concern with the structure of domestic industry and with promoting the structure that enhances the nation's international competitiveness" (Johnson 1982, 19) and "sequential externalities occur where a large upstream plant would, if built, induce the entry of downstream firms to make use of new profit opportunities created by the upstream firm but not appropriable by it" (Wade 1990, 353).

Not all industries are equally qualified to make comparable degrees of positive spillovers. For the most part, the potential amount of positive spillover an industry can produce — hence its strategic value — is a function of its position in the network of inter-industry transactions. Network theory offers two broad classes of the strategic position concept. One is range and brokerage. The other is prominence.

Range and Brokerage

Seven variables measuring an industry's transaction range and brokerage potential are

of interest. An industry with a broad range of transactions with many other industries is strategic in that the positive spillover from this industry can affect many others. An industry which brokers transaction among many other industries is also strategic because, without the proper development of this industry, potential profit opportunities in other industries that need brokerage cannot materialize. Despite their strategic importance from the perspective of the national economy, these industries may not be profitable enough or may be too risky. Therefore, the private businesses are not willing to invest in these industries without government support. Variables measuring this characteristic of an industry are as follows:⁴

1. **ego-network size:** A number of industries that directly transact with (i.e., sell to or buy from) the industry under consideration.
2. **effective size of ego-network:** Ego-network size may overestimate an industry's spillover potential if many of its alter industries have transaction ties among themselves. Effective size of ego-network eliminates this redundant portion from the ego-network size.
3. **contact efficiency:** An industry may make positive spillovers more efficiently by having more nonredundant transaction ties relative to its total transaction ties. Contact efficiency is nonredundant contacts divided by the total number of contacts.
4. **alter network density:** If the alter industries are densely networked among themselves, it is likely that the ego-industry is just another member of the clique rather than being in a strategic position. Alter network density is the average marginal strength of relations between an ego-industry's contacts.
5. **proportional density of alter network:** Alter network density is affected by the strength of ties. However, it is possible that the proportion, rather than the strength, of alter network density is more important. Proportional density of alter network is the proportion of contact pairs that has some kind of connection with one another. In a network of contacts all connected by weak relations, alter network density is low and proportional density is high.
6. **network constraint:** An industry is strategically disadvantaged if it is highly constrained by its transaction network. Constraint comes from having an alter industry with exclusive relations along with ego-industry's other alters and there being no substitutes for the alter. The sum of this dyadic constraint across alter industries is the aggregate constraint on ego-industry.
7. **hierarchy:** A constrained industry is more severely disadvantaged if its network constraint is concentrated in the hands of a dominant alter industry. Hierarchy describes the distribution of constraint across transaction relations.

Prominence

Prominence and centrality measures have often been used to identify the "most important" actors which are, by definition, located in strategic locations within a network (Wasserman and Faust 1994, 169). Characteristics associated with actors who are central, or prominent, are prestige, visibility, power, and more demand from others in the network for their

⁴ See Burt (1992) and Schott (1991) for more detailed and technical discussions on these variables.

network time and energy (Knoke and Burt 1983). An actor which is the object of relations has something of interest to everyone sending the relations, which makes him prominent and, thereby, more powerful (Schott 1991, 188). In the context of inter-industry transaction network, an industry is considered highly strategic when its products are needed for production in many other industries (downstream; forward linkage effect) or it purchases a great deal from many other industries (upstream; backward linkage effect). Prominence is measured at different levels of sophistication as explained below.⁵

1. **choice status:** This is the number of industries that reach the ego divided by the number that could have done so.
2. **extensive relations prominence:** If two industries receive transaction ties from the same number of alter industries, the one receiving stronger ties is more prominent. Extensive relations prominence is obtained by weighing choice status relations with their strength.
3. **exclusive relations prominence:** In a densely connected network of transactions, it can be difficult to distinguish top from bottom of the structure because every industry receives about the same number and strength of ties. Exclusive relations prominence measures the extent to which the ego-industry is the object of exclusive relations from every other industry.
4. **power:** Power comes from being the object of exclusive relations from alters which are also powerful themselves. An industry is powerful in the inter-industry transaction network if it receives many strong and exclusive transaction ties from other powerful industries.

Now there are at least three different ways for an industry to become strategic for the development of the national economy. The simplest and most obvious way is by exporting a great deal of its products. A second way is by brokering many transactions between other industries. A third way of being strategic is by being prominent. The rest of this paper demonstrates the ways in which these three senses of the term HCLs can be said to be strategic by analyzing Korea's input-output tables in 1980 and 1990.

III. INPUT-OUTPUT TABLES AND THE IDENTIFICATION OF "BIG PUSH" INDUSTRIES

In this paper, data for analysis come from Korea's input-output tables evaluated at producers' prices in 1980 and 1990. The year 1980 is an obvious choice for analysis because the "Big Push," launched in 1973, came to an official end in 1979 with the announcement of the Economic Stabilization Policy. The year 1990 is also chosen for analysis because, as in Wade's argument quoted earlier in this paper, there may be some time lag before the effects of industrial policy can materialize. In addition, existing research suggests that the positive association between export and economic growth is

⁵ See Freeman (1979), Knoke and Burt (1983), Schott (1991), and Wasserman and Faust (1994) for a more detailed and technical explanation of these variables.

conditioned by world-market situations (Kavoussi 1985; Singer and Gray 1988). Korea experienced a major turnaround toward favorable world market situations in 1986 thanks to the so-called, "three lows,"⁶ adding more possibility for the HCI policy to show its effects in the late 1980s (captured in the 1990 table).

The official definition of HCIs, as laid out in the plan, includes six three-digit SIC industries: industrial chemicals; other chemicals; petroleum and coal products; iron and steel; nonferrous metals; and machinery. Because SIC has a slightly different classification scheme from the input-output table, the two schemes are compared (industry by industry) to determine which input-output sectors belong to the above six SIC industries. Fifteen of the sixty-four input-output sectors in 1980 and twenty-one of the seventy-five input-output sectors in 1990 correspond to the HCIs as summarized in Table 1.

TABLE 1. INPUT-OUTPUT SECTORS CORRESPONDING TO HCIS, 1980 AND 1990

SIC Industry	1980 I-O Sectors	1990 I-O Sectors
industrial chemicals	basic chemical products	Petrochemical basic products and intermediate chemical products (organic chemical)
		Inorganic chemical basic products
	plastic material and synthetic rubber	Plastic material and synthetic rubber
	chemical fibers	Chemical fibers
other chemicals	chemical fertilizers and agricultural chemicals	Chemical fertilizers and agricultural chemicals
	drugs, cosmetics, and soap	Drugs, cosmetics, and soap
	miscellaneous chemical products	Miscellaneous chemical products
petroleum and coal products	petroleum refinery products	Petroleum refinery products
iron and steel	pig iron and steel	pig iron and crude steel
	primary iron and steel products	Primary iron and steel products
nonferrous metals	nonferrous metal ingots and primary nonferrous metal products	Nonferrous metal ingots and primary nonferrous metal products
	fabricated metal products	Fabricated metal products
machinery	general machinery	General industrial machinery and equipment
		Special industrial machinery and equipment
	electrical machinery	Electrical machinery, equipment, and supplies
	electronic and communications equipment	Household electric and electronic appliances
		Communications equipment
		Electronic components and accessories
		Computer and office equipment
	transportation equipment	Motor vehicles
		Shipbuilding and other transportation equipment

* Bank of Korea (1991) is followed for English-translation of sector definitions.

⁶ Three lows are low oil price, low dollar, and low inflation.

IV. MARKET BOUNDARIES AND "BIG PUSH" INDUSTRIES

Spatial maps of the Korean markets in 1980 and 1990 are generated in Figure 1 and Figure 2 to show the market boundaries and relative locations of HCIs. These are very close replications of the maps produced by Burt (1988) and Burt and Carlton (1989) in that the two sectors are close together in the map, so close that they involve identical purchase relations from each other (like that of a supplier market with its identical sales relations).⁷ In Figure 1 and Figure 2, each dot represents an input-output sector classified by the Bank of Korea. HCIs are marked with solid dots so that they can be easily distinguished from the hollow ones, which are the non-HCIs.

In both figures, the main orientation of the map is given by the flow of the factor input sectors located in the east to the final demand sectors of the west. Reading the maps from right to left, one begins with factor input and then moves on to the industries with a long chain of forward linkage effects, such as mining, synthetic materials, chemical products, service industries which should be close to every other sector, consumer goods and heavy industries which sell directly to private households and foreign markets, and final demand sectors.

Note that final demand sectors are very different from each other while the factor input sectors are closely tied together. Three things are worth mentioning with regard to the final demand sectors. First, government demand sectors - government fixed capital

These are very close, but not exact, replications due to different theoretical as well as technical considerations when explaining different economies. First, exogenous sectors are included in these figures. Exogenous sectors include four factor input (or value-added) and six final demand sectors. Factor input sectors are wage, business earnings, fixed capital input, and government subsidy. Final demand sectors are export, increases in inventory, private consumption, government consumption, private fixed capital formation, and government fixed capital formation. All the other sectors representing intermediate goods markets are called "endogenous" or "intermediate" sectors. The table size usually referred to as NXN table indicates the number of these endogenous sectors. Like in any other network analysis tasks, analyzing input-output tables with network analytic techniques raises a subtle question of boundary specification. In case of input-output tables, the major decision is whether to include exogenous sectors in calculating network variables. There are trade-offs in going either way. I chose to include exogenous sectors because of three reasons: (1) it can bring the foreign market and the government, which are the loci of the East Asian development script, into the map; (2) it gives a better substantive interpretation to the map; and (3) the exogenous sectors being excluded from the analysis, the market parameters are more ambiguous. By market parameters becoming more ambiguous, I mean two things. First, by disregarding the factor input (value-added) sectors, cross-column comparisons (i.e., comparisons of input structure across sectors) and network parameters based on them become ambiguous. Second, by disregarding the final demand sectors, cross-row comparisons (i.e., comparisons of output structure across sectors) and network parameters based on them become more ambiguous. It is hard to interpret, for example, the market constraint imposed on sector A coming from buyer sector B when eighty percent or more of sector A's output is sold in the foreign markets, which is actually the case with dairy, textile and apparel, electronic and telecommunications equipment industries in 1980. The downside for including exogenous sectors is that one has to treat them as if they were industries, but this is simply not true. However, there has to be more gains than losses by including exogenous sectors because there already exist hypothetical sectors among the endogenous sectors such as business consumption. Second, transactions are measured in somewhat different ways when calculating structural equivalence for generating the maps. Preceding studies report that specialized markets are obtained when proportional transaction data are used and diversified markets are emphasized when marginal transaction data are employed (Burt 1988; Burt and Carlton 1989). Since the differences in the volume of trade greatly conceal the inter-sectoral structure of the medium and low-volume markets, each relation is divided by the standard deviation of the corresponding sector's relations. This treatment has similar effects with dividing each relation with the maximum strength relation of the corresponding sector in the sense that both can eliminate the "level difference" so that diversified markets can be better presented in the map.

FIGURE 1. SPATIAL MAP OF KOREAN MARKETS, 1980

FIGURE 2. SPATIAL MAP OF KOREAN MARKETS, 1990

formation and government consumption - are segregated toward the northern boundary of the economy, whereas the private demand sectors - private fixed capital formation and private consumption - are located in the middle. Because government demand sectors, like other final demand sectors, do not sell their output to any other sectors, they are located on the west side of the map. They are pushed toward the northern boundary because, unlike private demand sectors, they purchase little from only a small number of industries. In 1980, for example, the combined amount of purchases by the two government demand sectors accounted for only 7.38% of the total output, whereas the two private demand sectors purchased some 36.45% of it. Moreover, only seventeen of the sixty-four intermediate sectors sold their output to one or both of the government demand sectors in the same year, while fifty-five of the sixty-four intermediate sectors sold their output to private demand sectors. This indicates that government demand sectors and sectors adjacent to them should have relatively little upstream or backward linkage effects.⁸ Second, compared to the government demand sectors, private demand sectors are understandably closer to the consumer goods markets (such as food, apparel, and home appliances). Third, the export sector is close to machinery and textile industries, reflecting the fact that these are the major players in the markets abroad.

The vertical axis of the map gives a tour from old to new technologies (from south to north in 1980; from north to south in 1990). Alternatively, it can be seen as moving from the primary industries which collect resources directly from nature (e.g., mining market and agricultural products market) to the secondary and tertiary industries (e.g., machinery and chemical). This orientation of the vertical axis is the same as reported by existing literature for the American markets (Burt 1988; Burt and Carlton 1989). In 1990, the southern half of the map could be further divided into southeast and southwest quadrants. The southeast quadrant is populated with chemical industries and the southwest quadrant by heavy machinery and electronics. This detailed division was

⁸ There are essentially two ways sector i can be located close to sector j in the map. Structural equivalence as Euclidean distance used for generating Figure 1 and Figure 2 is defined by the following equation: $d_{ij} = \{ \sum_k (z_{ik}/R_i - z_{jk}/R_j)^2 + \sum_k (z_{ik}/C_i - z_{jk}/C_j)^2 \}^{1/2}$, $i \neq k \neq j$, where d_{ij} is the Euclidean distance, z_{ik} is the amount of sales in millions of Korean won from input-output sector i to sector k , and R_i and C_i represent standard deviations of i -th row and i -th column, respectively. Let us say in this case that sector j is one of the government demand sectors and sector i an intermediate sector. Since sector j , as a final demand sector, does not sell its output to any other sectors, the z_{jk} term in the structural equivalence equation should always be zero. This means that an intermediate sector i is close to sector j to the extent that the z_{ik} term is also close to zero. Therefore, sector i can be close to sector j to the extent that it sells a large proportion of its output to the government demand sector j . One obvious example of this mechanism is the heavy construction industry in 1980 and 1990. In 1990, for example, the industry sold its output to only four other sectors which are "public administration and defense," "private fixed capital formation," "public fixed capital formation," and "export." It is, therefore, readily understood that the industry is close to final demand sectors. Another way in which sector i can be close to sector j is by sector i 's having a similar purchase transactions profile to that of sector j , adjusted for the standard deviation of each industry. This characteristic puts sector i close to sector j by making the second term of the structural equivalence equation close to zero. An example of this second mechanism is "crude petroleum and natural gas" in 1990, which were purchased from no other industries. A similar reasoning can be applied to factor input sectors. Since they do not purchase outputs from any other sectors, the z_{ik} term in the structural equivalence equation should always be zero. This means that an intermediate sector i is close to a factor input sector j to the extent that z_{ik} term is also close to zero. Therefore, intermediate sectors that purchase a large proportion of their input from the factor input sectors are located toward the east side of the map. Also, industries with similar sales transactions profile to that of factor input sectors are also close to them in the map.

less clear in 1980, although there were some distinction between chemical industries in the northeast quadrant and heavy industries (iron and steel; machinery) in the northwest quadrant.

Another interesting observation is that much finer market boundaries can be defined in 1990 relative to the 1980 result: "iron and steel" market is further divided into "metal ore processing" and "primary iron and steel"; "miscellaneous manufacturing" into "apparel," "textile," and "wood products"; and "machinery" market into "machinery and electronics," and "autos and home appliances." Market boundaries will be better defined as the economy matures.

Now let us turn to the location and distribution of HCIs. In both research years, HCIs belong to the "newer technology" half of the map (northern half in 1980; southern half in 1990). In terms of their distribution, one can see that HCIs are somewhat more clustered together in 1990 than they were in 1980. Considering that in both maps industries are clustered together to the extent that they have an identical purchase and sales profile, this change suggests that by 1990, HCIs will have come to share more similar transaction patterns than they did in 1980. Remarkable changes are observed in the relative locations of some broadly defined HCI markets, such as "primary iron and steel" (from west to east) and "chemical" (from around the center to east). This kind of change is also observed in some non-HCI markets, such as "food" (from around the middle to west) and "petroleum, coal, and gas" (from east to the middle). To the extent that the relative locations of industries in the maps are determined by the structural equivalence among them (explained in detail in footnote 7), industries moving toward the west (such as "food") are expected to have increasing upstream spillover effects and decreasing downstream spillover effects. Industries moving toward the east (such as "primary iron and steel" and "chemical") are expected to have increasing downstream spillover effects and decreasing upstream spillover effects. Industries located around the center may have higher brokerage potential. Still another finding is that HCIs are more or less widely scattered in the economy rather than concentrated around a certain sector (e.g., around the export sector). This suggests that a relatively wider variety of industries was selected as HCIs than the term "strategic" sometimes implies.

V. HEAVY AND CHEMICAL INDUSTRIES, STRATEGIC NETWORK POSITIONS, AND EXPORT

I begin by comparing the average export amount of HCIs with non-HCIs. Descriptive statistics and ANOVA tables are summarized in Table 2. In both research years, HCIs have exported more on average than non-HCIs. However, the difference was far from significant in 1980. Although the *p*-value is still slightly above the conventional level of .05 in 1990, it seems obvious that the difference in export amount between HCIs and non-HCIs has become much more distinguished in 1990 than in 1980, supporting Wade's argument that medium-term results of "Big Push" are much better than short-term results. If we use export amount as the criterion of strategic industries, there is not enough evidence to say that HCIs were strategic in 1980.

TABLE 2. AVERAGE EXPORT OF HCIS VS. NON-HCIS IN 1980 AND 1990:
DESCRIPTIVE STATISTICS AND ANOVA TABLE

		(unit: million won)			
		1980		1990	
HCIs	Mean	269180.40		1112616	
	N	15		21	
	SD	298500.07		1148788	
non HCIs	Mean	172030.43		551663.85	
	N	49		54	
	SD	352366.10		1096512	
Total	Mean	194799.95		708730.35	
	N	64		75	
	SD	340764.61		1132302	
1980					
	Sum of Squares	df	Mean Square	F	Sig.
Between	1.1E+11	1	1.1E+11	.932	.338
Within	7.2E+12	62	1.2E+11		
Total	7.3E+12	63			
1990					
Between	4.8E+12	1	4.8E+12	3.854	.053
Within	9.0E+13	73	1.2E+12		
Total	9.5E+13	74			

Table 3 shows whether HCIs are on average higher or lower than non-HCIs on various network variables, and the correlation coefficients of these variables with export amount. It is remarkable that many of the network variables which represent different meanings of the strategic position in inter-industry transactions are systematically correlated with export. As explained earlier in this paper, there are seven variables capturing range and brokerage potential of an industry for both 1980 and 1990. Since prominence is a directional concept,⁹ the four prominence variables are further divided into upstream and downstream variables, increasing the number of variables to eight for each year.

The variable most strongly correlated with export is extensive relations prominence in both years (.499*** in 1980; .329*** in 1990). Note, however, that the direction of spillover effect is reversed in the ten-year period from upstream to downstream, which means that the extensive relations prominence industries as buyers were exporting more in 1980 and extensive relations prominence industries as sellers are now exporting more in 1990. This reversal of direction also holds for exclusive relations prominence. It seems that receiving exclusive transaction ties from other industries matters less than receiving extensive transaction ties in terms of contributing to export, as can be seen by the fact that correlation coefficients with an export for exclusive relations prominence variables

⁹ For a directional network variable, the meaning of incoming ties is different from that of outgoing ties. Likewise, buying from an adjacent industry is different from selling to the same industry. In the ordinary format of an input-output table, seller industries are located across rows and buyer industries across columns. Prominence in this context thus measures prominence as a buyer industry (upstream spillover effect). Because spillovers can take place downstream as well, the data are transposed to calculate prominence as a seller industry (downstream spillover effect).

TABLE 3. NETWORK CHARACTERISTICS OF HCIS AND EXPORT PERFORMANCE

	Mean HCI	p	1980	
			Corr. with Export	p
ego-network size	H [*]	.081	.365***	.003
effective ego-network size	H***	.006	.273**	.029
contact efficiency	H***	.006	-.140	.270
alter network density	L [*]	.064	-.214*	.090
alter network proportional density	L	.275	-.379***	.002
network constraint	L**	.050	-.213*	.092
hierarchy	L**	.031	-.195	.123
choice status (upstream)	H [*]	.084	.239*	.057
choice status (downstream)	H [*]	.064	.338***	.006
extensive relations prominence (upstream)	H	.800	.499***	.000
extensive relations prominence (downstream)	H**	.030	.300**	.016
exclusive relations prominence (upstream)	H	.832	.427***	.000
exclusive relations prominence (downstream)	H [*]	.083	.123	.332
power (upstream)	L	.428	.325***	.009
power (downstream)	H	.435	-.027	.835
1990				
ego-network size	H [*]	.093	.263**	.023
effective ego-network size	H**	.019	.149	.201
contact efficiency	H**	.048	-.306***	.008
alter network density	L [*]	.088	-.116	.320
alter network proportional density	L [*]	.082	-.303***	.008
network constraint	L	.145	-.167	.153
hierarchy	L	.182	-.076	.519
choice status (upstream)	H	.122	.221*	.057
choice status (downstream)	H**	.029	.301***	.009
extensive relations prominence (upstream)	H	.696	.248**	.032
extensive relations prominence (downstream)	H	.222	.329***	.004
exclusive relations prominence (upstream)	H	.926	.170	.146
exclusive relations prominence (downstream)	H	.467	.196*	.093
power (upstream)	L	.340	.138	.237
power (downstream)	L	.537	-.073	.532

a) H: HCIs are on average higher than non-HCIs; L: HCIs are on average lower than non-HCIs.

b) * = $p < .10$; ** = $p < .05$; *** = $p < .01$.

c) Detailed descriptive statistics and ANOVA tables are available from the author upon request.

are systematically smaller than the corresponding coefficients for extensive relations prominence variables. Power, which comes from receiving exclusive relations from other industries who themselves are also powerful, matters even less than exclusive relations prominence in terms of export. This makes sense because bringing products into outside markets is different from, for instance, negotiating price-cost margins. Unlike the other prominence variables, the reversal of spillover direction is not observed for choice status,

which suggests that dichotomizing volumes of inter-industry transactions may be too simplistic.

What is interesting about the seven range and brokerage variables is that five of them (contact efficiency; alter network density; alter network proportional density; network constraint; and hierarchy) are negatively correlated whether significant or not with export, whereas only two (ego-network size; and effective size of ego-network) are positively correlated. This result is also expected from the variable descriptions. The negative coefficients for constraint and hierarchy variables are readily understood because, if an industry is severely constrained by its domestic transactions or, even worse, the sources of the constraint reduce to a handful of powerful industries, it would be hard for the industry to become internationally competitive. The negative coefficients for density variables indicate that an industry with high scores on these variables is just another member of a densely connected transaction clique, therefore, far from being strategic. Given these results, it is not easy to interpret the negative coefficients for contact efficiency variable because the negative coefficients for alter network density seemingly contradict the negative coefficients for contact efficiency. One interpretation might be that being a member of a "dense" network is different from being a member of a "redundant" network. A transaction network can be dense but still not redundant. Although redundancy is often bad for the efficiency of information-gathering, it may represent vertical linkages in transaction networks. Too much non-redundancy in the ego-network means that the positive spillover effect is disconnected after a very short path distance.

From the correlation between network variables and export performance, one would expect that HCIs, if strategic, have higher scores on prominence variables and two of the range and brokerage variables (ego-network size; and effective size of ego-network) compared to non-HCIs. They should also have lower scores on five of the range and brokerage variables (contact efficiency; alter network density; proportional density of alter network; network constraint; and hierarchy) relative to non-HCIs. In Table 3, the mean scores of HCIs generally behave as expected. Of the thirty variables (in terms of which the mean scores of HCIs and non-HCIs are compared), there are only five deviations: contact efficiency in both 1980 and 1990; upstream power in both 1980 and 1990; and downstream power in 1990. However, the mean power differences between HCIs and non-HCIs are far from significant in both research years. Although the contact efficiency of HCIs was significantly higher than non-HCIs in 1980, it does not bother us too much because the correlation between contact efficiency and export was not significant in the same year. The only variable that poses a real problem is contact efficiency in 1990 because in this year, HCIs have on average significantly higher scores than non-HCIs on this variable which is negatively and significantly correlated with export. Using network characteristics of an industry as the criterion for strategic value, it seems that industries selected as HCIs are largely strategic for both years (with the exception of contact efficiency in 1990).

Now let us reverse the order of reasoning to see if potentially strategic industries (in terms of their network position) have been selected as HCIs. For this purpose, we start with network variables having a significant correlation with export performance

in Table 3, and find out whether HCIs have a significant mean difference from non-HCIs with the expected direction of differences. Of the thirty variables in Table 3, nineteen have a significant correlation with export performance (ego-network size, alter-network proportional density, upstream and downstream choice status, and upstream and downstream extensive relations prominence for both years; effective ego-network size, alter-network density, network constraint, upstream exclusive relations prominence, and upstream power in 1980; contact efficiency and downstream exclusive relations in 1990). Heavy and Chemical Industries do not show a significantly different mean value from non-HCIs for eight out of these nineteen variables (upstream extensive relations prominence for both years; upstream exclusive relations prominence in 1980; upstream power in 1980; upstream choice status in 1990; downstream extensive relations prominence in 1990; downstream exclusive relations prominence in 1990; and alter-network proportional density in 1980).

Two observations are worth mentioning from this pattern. First, although "Big Push" took excellent advantage of strategic network positions in terms of range and brokerage, it did less well in terms of prominence. Of the eight variables for which HCIs do not show a significant difference from non-HCIs, only one (alter-network proportional density in 1980) comes from the range and brokerage class. All the other seven variables are among the prominence variables category. These are opportunities not taken advantage of, and, therefore, wasted. Second, it seems that wasted opportunities are shifting from upstream to downstream. Of the seven wasted opportunities measured with prominence variables (three in 1980 and four in 1990), all three were upstream in 1980 and two out of four are downstream in 1990. Recall once again that upstream opportunities are created by a buyer industry for its supplier industries, and that downstream opportunities are created by a seller industry for its buyer industries. The pattern suggests that in 1980 many of the prominent buyer industries with their upstream, or backward-linkage, effects were not selected as HCIs, and, therefore, did not receive proper government support. In 1990, some of the seller as well as the buyer industries were not selected as HCIs. Judging from the exhaustive use of potential opportunities, "Big Push" does not seem to have been a complete success.

One final observation from Table 3 is that, although the absolute amount of HCI export has been increasing (Table 2), "Big Push" seems to be becoming less effective in terms of the supporting industries occupying the strategic network positions. The correlation coefficients are either getting smaller in absolute value (ego-network size from .365*** to .263*; alter-network proportional density from -.379*** to -.303***; upstream choice status from .239* to .221*; downstream choice status from .338*** to .301***; and upstream extensive relations prominence from .499*** to .248**), or losing significance (effective ego-network size from .273** to .149; alter-network density from -.214* to -.116; network constraint from -.213* to -.167; upstream exclusive relations prominence from .427*** to .170; and upstream power from .325*** to .138). There were only two variables that were not significant in 1980 but gained significance in 1990 (contact efficiency from -.140 to -.306***; and downstream exclusive relations prominence from .123 to .196*).

More importantly, HCIs are losing more and more of their desirable network, hence spillover, characteristics. In 1980, HCIs had significant differences from non-HCIs as desired (i.e., significantly higher mean for variables with positive correlation for export, and a significantly lower mean for variables with negative correlation for export) for eight (ego-network size; effective ego-network size; alter-network density; alter-network proportional density; network constraint; upstream and downstream choice status; and downstream extensive relations prominence) of the eleven variables that had a significant correlation with export. This number is decreased to only three in 1990 (ego-network size; alter-network proportional density; and downstream choice status). Heavy and Chemical Industries even have an undesirable network characteristic, such as high contact efficiency, in 1990. Using the correspondence of network characteristics of HCIs and the correlation between those characteristics and export, "Big Push" as a strategic industrial policy is becoming obsolete.

VI. INDUSTRY RESULTS: STRATEGIC INDUSTRIES, WRONG CHOICES, AND WASTED OPPORTUNITIES

This section examines the network analysis results at the level of individual industries rather than comparing the aggregate results of HCIs with non-HCIs, in order to find out which of the HCIs were indeed strategic or wrong choices, and, on the other hand, which potential opportunities were wasted. Tables 4.1 through 4.3 show the list of industries that have significantly different values on the three classes of network variables: brokerage; upstream prominence; and downstream prominence.¹⁰

In each of the three tables, the upper-left cell contains strategically located industries that are HCIs at the same time. The lower-right cell is of least interest because it represents poorly located industries that are not selected as HCIs. It is more interesting to see which industries appear in the lower-left and upper-right cells because they are wrong choices and wasted opportunities, respectively. In Table 4.1, it is remarkable that six of the fifteen HCIs in 1980 were indeed well-informed choices in terms of their ability as broker industries. Two HCIs (chemical fiber; pig iron and steel), however, were wrong choices in both 1980 and 1990. Wasted opportunities exist in industries such as "fabricated textile products," "miscellaneous manufacturing products," "transportation and warehousing," "building construction and repair," and "wood and wooden products" in 1980 and "wholesale and retail trade," and "transportation and warehousing" in 1990. The six HCIs that were highly strategic in 1980 are losing their strategic value in 1990.

¹⁰ The industries listed in Tables 4.1 through 4.3 are selected by the following criteria. The mean value and standard deviation are calculated for every variable with significant correlation with export. Industries more than one standard deviation away from the mean in the desirable direction (i.e., above the mean when the variable is positively correlated with export; below the mean when the variable is negatively correlated with export) and undesirable direction (i.e., below the mean when the variable is positively correlated with export; above the mean when the variable is negatively correlated with export) are identified. Of these industries, only those appeared more than once in the list are selected as either "strategically located (if they are in the desirable direction)" or "poorly located (if they are in the undesirable direction)." Hypothetical sectors and government sectors are deleted.

TABLE 4.1. INDUSTRIES IN STRATEGIC OR POOR BROKERAGE POSITIONS

	1980	
	HICs	non-HICs
strategically located	fabricated metal products general machinery transportation equipment electrical machinery nonferrous metal products basic chemical products	fabricated textile products miscellaneous manufacturing products transportation & warehousing building construction & repair wood & wooden products
poorly located	chemical fiber pig iron and steel	heavy construction restaurants & lodging tobacco products sugar manufacture fishery products metal ores vegetables & fruits gas, steam, & hot water supply crops crop milling
	1990	
	HICs	non-HICs
strategically located		wholesale & retail trade transportation & warehousing
poorly located	chemical fiber pig iron and steel	agricultural services restaurants & lodging metal ores fiber yarn crude petroleum & natural gas

Comparing these results to the market structure maps in Figure 1 and Figure 2, one can find that industries with high brokerage scores are clustered together around the center, while poorly located industries such as "chemical fiber" and "pig iron and steel" are near the periphery. The six HICs that were highly strategic in 1980, and hence around the center of the map, generally moved toward the southeast corner in 1990. This is also consistent with the results in Table 3, where HICs lose part of their strategic value as broker industries by 1990. Recall, however, that one of the main orientations in the maps is given by the resource flow from the factor input sectors in the east to the final demand sectors of the west. Although this move of HICs (from the center to the east) cost them their brokerage ability, it may have rendered them strategic in terms of downstream spillover effects.

In Table 4.2, it is striking to find that none of the HICs were either strategically or poorly located in both research years, consistent with the results in Table 3 where HICs have a significantly different value from non-HICs for only one (upstream choice status in 1980) of the eight variables measuring upstream prominence. In some cases, it is understandable because many HICs (e.g., iron and steel market; chemical market) are upstream industries located toward the beginning of the chain of vertical inter-industry

TABLE 4.2. INDUSTRIES IN STRATEGIC OR POOR UPSTREAM PROMINENCE POSITIONS

	1980	
	HICs	non-HICs
strategically located		commerce building construction & repair transportation & warehousing fabricated textile products fiber yarn dairy products & fruit processing
poorly located		social services forestry products water supply gas, steam, & hot water supply nonmetallic minerals precision instruments sugar manufacture cash crop flour metal ores
	1990	
	HICs	non-HICs
strategically located		
poorly located		crude petroleum & natural gas

TABLE 4.3. INDUSTRIES IN STRATEGIC OR POOR DOWNSTREAM PROMINENCE POSITIONS

	1980	
	HICs	non-HICs
strategically located		commerce transportation & warehousing
poorly located		gas, steam, & hot water supply
	1990	
	HICs	non-HICs
strategically located	petroleum refinery products primary iron & steel products electronic components & accessories basic organic chemical products	wholesale & retail trade finance & insurance transportation & warehousing business services electric power services crops
poorly located		tobacco products processed seafood products agricultural services wood furniture social services

linkages. In other cases (e.g., machinery industries; electronic and transportation equipment industries), however, the pattern suggests that necessary linkages between these industries and the supplier industries have been absent. It is likely that much of the upstream spillover generated by these industries has benefited exporters in other countries rather than the domestic suppliers. Again, there were wasted opportunities in 1980. Industries like "fabricated textile products," and "fiber yarn" suggest that these industries were not only major exporters in the 1960s and 1970s, but were still highly strategic in the 1980s. Industries such as "building construction and repair," "transportation and warehousing," and "fabricated textile products" are worth special mention because they are strategic in both brokerage and upstream prominence scores (see Table 4.1). In Figure 1, these industries tend to be located toward the western boundary of the intermediate sectors.

Table 4.3 probably gives the most interesting results. Despite the fact that many HCIs were upstream industries with much downstream spillover, none of the HCIs were strategic in 1980. Four HCIs have become strategic in terms of downstream spillover in 1990. This is a finding that the aggregate correlation coefficients in Table 3 could not reveal. It is consistent, however, with the fact that HCIs have moved from around the center in the 1980 map to the southeast in the 1990 map (see Figures 1 and 2). This change signals that, although HCIs have failed to establish upstream linkages (see Table 4.2), they are becoming more successful in establishing downstream linkages. There are wasted opportunities in terms of downstream spillovers as well. The most obvious missed opportunity lies in "transportation and warehousing," which is strategic in all three dimensions of industry network characteristics. The appearance of "finance and insurance" in 1990 seems to reflect the rapid expansion of Korea's financial sector since the introduction of financial liberalization policies in the early 1980s (Park 1994).

To summarize the industry-level analysis, the big trend is that HCIs are moving from important broker industries to important supplier (i.e., downstream-prominent) industries. This observation is supported by these facts: none of the six HCIs that were highly strategic in brokerage ability in 1980 remained so in 1990 (Table 4.1); the mean differences of HCIs from non-HCIs on brokerage variables have become less significant in 1990 than they were in 1980 (Table 3); while no HCIs were strategic in downstream prominence in 1980, four are strategic in 1990 (Table 4.3); in terms of relative position in the market structure, HCIs have generally moved from around the center to the southeastern corner of the map (Figures 1 and 2).

There are other findings as well. Some of the opportunities (most obviously in industries such as "fabricated textile products," "transportation and warehousing," and "building construction and repair") are wasted. Many HCIs do not have significantly different network characteristics from non-HCIs. Two of the HCIs "chemical fiber" and "pig iron and steel" are wrong choices in terms of brokerage potential. They are isolated industries whose transaction profiles are not well-mixed with those of the rest of the economy. More service-oriented industries like "wholesale and retail," "finance and insurance," and "business services" are gaining in significance as supplier industries in 1990.

VII. CONCLUSION: HOW STRATEGIC ARE STRATEGIC INDUSTRIES?

In this final section, I briefly summarize what I consider the theoretical contributions of this paper, if any, and the major empirical findings. So far, the economic development literature and network theory have evolved independently of each other. The main debate in the former has been the one between market advocates and statisticians, while the latter has largely been the realm of organization theorists. Yet, I suggest that the two branches of inquiry have much more in common than they seemingly do. For example, consider the following statements by Evans (1979, 26):

While the income from these few products is absolutely central to the process of accumulation in the dependent country, for the center each product represents only a tiny fraction of total imports, and can usually be obtained from several different sources. The development of the dependent country, however, requires the continued acceptance of its products in the center. Therefore, economic fluctuations in the center may have severe negative consequences for the periphery, whereas an economic crisis in the periphery offers no real threat to accumulation in the center.

With the term "country" replaced by "organizations," it will not be easy to tell whether this paragraph is from Evans or Pfeffer and Salancik (1978). This obviously similar way of thinking tells us that there is much to be gained by bringing the theories and techniques of network analysis into the development arena.

One such arena is the unsolved problem regarding the efficacy of state economic policy in the development of East Asian NICs, including South Korea's "Big Push," where little attention has been paid to systematically investigating the strategic value of the so-called, "strategic industries." Although "strategic industry" is a key concept in the debate surrounding the role of the market and the state of NICs' development, no one has ever tried to define the term in a specific way so that one can put it to an empirical test. This paper aimed to do exactly this by bringing the network theory to define the various meanings of an industry's strategic value and analyzing the input-output tables of Korea for 1980 and 1990.

The aggregate comparisons of HCIs with non-HCIs provide four conclusions. First, if we use export performance as the criterion of strategic industries, HCIs were not strategic in 1980 and becoming to be so in 1990. Second, using the network, hence spillover, characteristics of HCIs as the criterion, HCIs are largely strategic in that the variables for which the HCIs have a significantly different mean from non-HCIs have significant correlation with export in expected directions. Third, in terms of taking advantage of potential opportunities, "Big Push" was not a complete success for it failed to successfully take advantage of the opportunities that were associated with prominent industries. Fourth, no matter what the level of strategic value of HCIs in 1980, "Big Push" is becoming less effective in 1990.

The industry-level analysis adds a few more observations to the above conclusions.

While on the one hand HCIs are exporting significantly more in 1990 than they did in 1980, the meaning of their strategic value in the inter-industry transaction network, on the other, is changing from brokers to suppliers. There are some wrong choices and obviously wasted opportunities. In spite of their move from brokers to suppliers, HCIs have generally failed to establish backward, or upstream, linkages.

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