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Two Faces: Effects of Business Groups on Innovation in Emerging Economies

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This paper shows that business groups in emerging economies exert dual effects on innovation. While groups facilitate innovation by providing institutional infrastructure, groups also discourage innovation by creating entry barriers for nongroup firms and thereby inhibit the proliferation of new ideas. This pattern reflects an evolutionary process in which the interplay of the availability of innovation infrastructure and variety of ideas influences the level of innovation in an industry. We show that group market share has an inverted-U impact on innovation in industrial sectors of both Korea and Taiwan during the 1981–1995 period. Institutional differences between Korea and Taiwan in terms of market structure and industrial policies lead to different innovation thresholds, the point at which the marginal costs of increasing group share begin to dominate the marginal benefits in the two countries.

Key words: business groups; innovation; emerging economy
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1. Introduction

This paper studies how business groups affect innovation in emerging economies. Diversified business groups dominate private sector activities in many emerging markets, arising in response to market failures (Leff 1978, Ghemawat and Khanna 1998, Toulan 2001) and policy inducements (Chang and Choi 1988). Business groups take names such as grupos economicos in Latin America, business houses in India, chaebols in South Korea, family holdings in Turkey, and mining houses in South Africa. Although precise definitions vary across countries, the common point is that business groups are conglomerations of nominally independent firms that operate under common administrative and financial management and often are controlled by families (Chang and Hong 2000). Groups often control a substantial fraction of a country's productive assets and account for the largest and most visible of the country's firms (Amsden and Hikino 1994, Granovetter 1995, Khanna and Palepu 1997).

Business groups may either facilitate or hinder innovation in industries of emerging economies. Groups can facilitate innovation by providing institutional infrastructure, such as internal capital markets in weak external capital markets (Teece 1996), business reputations and government ties that attract foreign technology providers (Hobday 1995), and concentrated ownership that provides long-term perspectives on R&D investments (Claessens et al. 2000). By contrast, groups can hinder innovation by creating barriers to new entrants and thereby limiting opportunities to experiment with new technology. Given their ubiquity, it is important to understand how groups affect innovation, which is critically important to economic and social development in emerging economies. To date, though, little research addresses the interface between business groups and innovation.

We argue that the positive effects of innovation infrastructures and the negative effects of entry barriers interact as group market share rises in an industry. At low levels of group market share, the marginal benefits of group infrastructure override marginal costs. As group share increases, however, the rising marginal cost in terms of lack of access to new ideas offsets the marginal benefits from access to infrastructure, so that beyond a threshold, higher group share leads to lesser innovation. When group share is at an intermediate stage, meanwhile, the mix of groups and independent firms provides both infrastructure and new ideas, resulting in the maximum amount of innovation. In addition, the point at which the negative effects begin to dominate will tend to come earlier as the degree of market-based innovation infrastructure in a country increases.

Recognition of the group structure-innovation linkage contributes to our understanding of innovation in the context of market imperfections. The argument highlights the trade-off between the need for new ideas and the need for resources and infrastructure to commercialize those new ideas. The empirical analysis examines data from two emerging economies with substantially different institutional settings, Korea and Taiwan.

2. Theory and Hypotheses

2.1. Groups Provide Innovation Infrastructures

We use the term *innovation infrastructure* to describe the set of resources—such as finances, talent, and technology—to which firms need access in order to undertake innovative activities. In developed economies, market-based transactions provide access to most needed elements of innovation infrastructure. Relatively efficient markets for capital and labor, easy access to complementary business services, and consistent enforcement of property rights, as well as relatively corruption-free government and independent judiciary, all permit individual entrepreneurs to raise capital, hire talent, learn about customer demands, and play by the rules of the game. In emerging economies, by contrast, where many of these institutions exist in relatively weak form, business groups can contribute to innovation by substituting for functions that stand-alone institutions provide in developed economies.

The descriptive literature on groups in emerging economies identifies intermediation functions that business groups provide in lieu of capital markets (Leff 1979) and labor markets (Khanna and Palepu 1997). The earliest econometric evidence concerning the prevalence of group intermediation came from studies of Japanese keiretsu (Caves and Uekusa 1976, Nakatani 1984). More recently, Lincoln et al. (1996) describe coordination mechanisms within Japanese keiretsu, and their role in reducing the variability of returns of affiliates. Chang and Hong (2000) suggested Korean chaebol create value through product and capital market intermediation. Other studies demonstrate that business groups in Chile and India add value through product, labor, and capital market intermediation (Fisman and Khanna 1998; Khanna and Palepu 1999, 2000).

Consider four elements of innovation infrastructure: capital, scientific labor markets, knowledge sourcing, and vertical intermediation. First, innovation requires access to capital. Most generally, firms that are seeking capital for new projects can use internal cash flow or external funds. When firms in advanced economies lack internal cash flow, they can turn to venture capital organizations or other external sources for funding. By scrutinizing firms before providing capital and then monitoring them afterward, external capital organizations alleviate information gaps and reduce capital constraints (Kortum and Lerner 2001). However, the information-limited, illiquid status of capital markets and lack of explicit market for corporate control in emerging economies mean that firms face a more difficult task in communicating the value of their ideas and their ability to execute their projects to the would-be investor (Allen 1993, Durnev et al. 2004). Under these circumstances, access to internal capital markets within multiproduct and multidivisional groups allows groups to act as de facto venture capitalists and allocate resources for new innovative opportunities more effectively than the available external markets (Servaes 1996).

In addition to allocating capital from internal funds, groups may be able to raise external capital more easily than unaffiliated entities, due to lower bankruptcy risks and greater ability to attract foreign capital. First, larger fixed assets tend to reduce bankruptcy risks, which is a substantial concern in nations with poor mechanisms for dealing with financial distress (Khanna and Yafeh 2000). Moreover, business groups can acquire new bank credits more easily if banks believe that governments will step in to prevent group bankruptcies that could jeopardize the banking system. Such government support of struggling business groups has been common in emerging economies. Further, foreign investors expect groups to evaluate new opportunities and to exercise auditing and supervisory functions. As a result, groups become conduits for large amounts of domestic and foreign investment.

Second, innovation requires good research facilities and a pool of talented scientists. In economies with an acute scarcity of scientific talent, groups can create value by acting as incubators for such talent. Business groups can incur the fixed costs of setting up infrastructure to develop scientific talent and then amortize the expenses over the businesses within the group. Groups can also facilitate innovation by developing efficient internal labor markets. As Khanna and Palepu (1997) point out, the flow of information within the group structure means that group management will be able to allocate available scientific talent to the most suitable jobs. To incubate scientific talent, groups sometimes concurrently perform the functions of research institutes, engineering universities, and vocational schools. Hence, groups develop extensive internal talent markets, which help counteract the rigidities and variations of the external labor market. Because groups offer desirable facilities and conditions, scientific personnel are willing to accept intragroup relocation, providing business groups with reliable intellectual human resources that they can use to launch new innovation activities. In contrast, unaffiliated firms in emerging markets usually must recruit publicly to build their operations, which is difficult in countries where the quality of labor varies widely and lacks certification from respected educational institutions.

Third, groups can use relationships with foreign firms to gain the knowledge needed to develop and commercialize new ideas (Reddy and Zhao 1990). Such relationships include research joint ventures, co-production, and co-marketing agreements (Chesbrough and Teece 1996). Hobday (1995) argues that it is important for firms in emerging markets to create technological linkages with firms in advanced economies. However, weak property rights in many emerging markets mean that firms have only limited ability to negotiate enforceable arms-length contracts. Fearful that they will lose intellectual property, firms from developed economies may hesitate to license technology in emerging economies. A group company may overcome this reluctance by putting the entire group's reputation at stake. In addition, groups may utilize their strong political and bureaucratic ties to protect property rights and enforce contracts more efficiently than independent counterparts. Foreign providers of technology often prefer to partner with groups that have a reputation of honoring contracts rather than with independent firms (Khanna and Palepu 1999, Amsden and Hikino 1994). Moreover, to the extent that group firms have better access to financial capital, research facilities, and talent, as we discussed above, they will be more productive sites for foreign firms to provide technological knowledge. Guillen (1997) emphasizes the role of business groups in Argentina, Spain, and South Korea as agents that combine factors of production within the country with resources from outside the country.

Fourth, developed economies tend to possess robust pools of vertical intermediaries such as suppliers and distributors. Such complementary firms often play key roles in a given firm's innovative efforts by providing access to skills, equipment, and customers (Afuah 2000). In emerging economies, by contrast, such complementary sectors of the economy tend to be much weaker. Rather than rely on complementary external firms, then, business groups often provide internal intermediation of such vertical business activities (Khanna and Palepu 1997, Khanna and Rivkin 2001). The internal vertical intermediation then provides innovation infrastructure.

This discussion suggests that groups have greater access than most independent firms to the resources needed to create innovation infrastructures in emerging economies. In addition, though, groups also require incentives to undertake the investment needed to create an innovation infrastructure suited to a specific industry. The infrastructure relevant to one industry, such as food, typically cannot be applied to innovation in another industry, such as electronics, without substantial additional industry-specific investment. Therefore, groups' contributions to innovation will vary by industry depending on industry-specific investment incentives rather than spread evenly across all industries in which groups participate.

The incentive to undertake industry-specific investment in innovation infrastructure will be higher when business groups hold larger aggregate market shares in the sector. High group share in an industry most commonly arises because there are a few dominant groups, but high group market share also may arise when several moderate-sized groups operate within an industry.

Whether group market share is high because there are dominant groups or because there are several moderate-sized groups, the groups have size-based and competitive incentives to invest in industry-specific innovation infrastructure. If there is one dominant group or a few leading groups, then the leaders have size-based incentives to invest. Size-based incentives arise because a firm can reduce the average fixed costs of creating industry-specific infrastructure. Size-based incentives will decline somewhat as the number of groups within a sector increases, because average shares will decline. Nonetheless, even if there are several moderate-sized groups in an industry, the groups have competitive incentives to invest in innovation infrastructure. Competitive incentives arise because groups will be reluctant to allow other groups to gain a lead on them in any given industry. Competitive incentives between business groups are strong because the same groups often compete in multiple industries, so that failure to keep up in one industry may expose them to attack in other industries. In addition, rivalry among groups' senior executives for prestige and honor means that groups want to avoid being overtaken by other groups. As a result, competition among groups often will be stronger than competition between groups and independent firms. Thus, incentives to invest in innovation infrastructure are high in industries with high group share.

By contrast, when groups hold small aggregate share in an industry, there are fewer incentives to invest in industry-specific innovation infrastructure. First, the available size-based gains will be limited. Second, there is no immediate competitive pressure to keep another group from gaining an edge. Although a group may be concerned that other groups may expand into the industry in the future, there is no threat to a current position and less incentive to invest in innovation infrastructure.

One also might expect that innovation infrastructure would increase with the number of groups operating in an industry. As we argued above, however, groups need incentives to create industry-specific infrastructure. The argument so far suggests that those incentives increase with the magnitude of group market presence, not simply with the number of groups in a market. Thus, when groups hold small aggregate market share, the availability of infrastructure relevant to that market will be low regardless of the number of groups operating in the sector. Nonetheless, any empirical analysis needs to control for number of groups.

A caveat arises here, though, which is that low group share does not always mean low availability of innovation infrastructure. In some cases, independent firms may have the resources and the incentives to build innovation infrastructures. Although this will be less common in emerging economies, we treat this as an empirical issue that the analysis will address in two ways. First, several control variables address industry-specific access to resources. Second, groups are likely to be more beneficial in industries where R&D costs are particularly high, suggesting a greater need for access to expensive infrastructures to deal with risks and uncertainties. We address this issue later in the paper.

2.2. Groups Reduce Variety

While groups may facilitate innovation by providing infrastructure, groups may also discourage innovation by erecting entry barriers. Entry barriers are facets of market structure or firm strategy that allow incumbent firms to earn positive economic profits while making it unprofitable for newcomers to enter the industry (Bain 1956). Structural barriers result when incumbent firms have cost advantages, marketing advantages, or benefits from a favorable policy regime. Strategic barriers arise when incumbent firms take actions that deter newcomers, such as capacity expansion, limit pricing, and predatory pricing. The presence of business groups tends to create both structural and strategic barriers in an industry.

Theoretical reasons for the existence of business groups emphasize how groups resolve several market imperfections in capital and intermediate product markets. First, large firms have the opportunity to secure financial resources at significantly lower interest rates from bankers who know them well and can assess their creditworthiness. According to Leff (1978), cost advantages in the procurement of funding provide groups with an incentive to diversify. Second, in the absence of markets for risk and uncertainty, product-line diversification provides an alternative to shareholder portfolio diversification and a way of eliminating problems that arise from bilateral monopoly or oligopoly. In many emerging economies, governments' preferential treatment of group firms in specific sectors also played a critical role in the origin and growth of groups. Thus, in the presence of market imperfections, group structure influences the appropriation of quasi rents that accrue from groups' access to scarce and imperfectly marketed resources like capital, information, and political connections.

The same resources that allow groups to earn rents in the presence of market imperfections also help groups to erect entry barriers, for at least three reasons. First, groups are diversified companies with access to deep pockets that enable them to drive out their competitors with preemptive price cutting in focal businesses (Berger and Ofek 1995). Second, groups that meet each other in multiple markets often recognize their interdependence and moderate their competition with each other, while deterring new competitors (Bernheim and Whinston 1990). Third, diversified groups may establish favorable reciprocal arrangements with firms that are simultaneously buyers and suppliers. Such interrelationships among diversified groups can foreclose markets to independent competitors.

The ability of groups to erect entry barriers that deter independent firms has implications for innovation. Innovation requires not only the access to effective infrastructure that we discussed earlier, but also access to new ideas. These new ideas can come either through recombination, which involves drawing together existing pieces of ideas into novel blends (Weitzman 1998), or by mutation, which involves the emergence of new ideas or variations of existing ideas (Mokyr 1994). The role of new entrants as innovators is an empirical regularity that emerges from many studies of technological innovation (Hirshleifer 1973, Acs and Audretsch 1988). Several models of technological competition also anticipate innovative roles for industry entrants (Reinganum 1989). While many studies suggest that established firms have significant advantages in producing incremental innovation, and some studies show that they also are common sources of major innovations (Methé et al. 1997), independent inventors, new firms, and diversifying entrants undoubtedly play key roles in conceiving major new ideas and radical breakthroughs (Mansfield 1996).

For instance, entrants pioneered two recent major areas of technological innovation in Europe and North America—biotechnology and the Internet—typically with the backing of venture capital investors (Lerner 1996). The entrants tended to be the first to seize upon the commercial opportunities. On some occasions, these entrants—utilizing the capital, expertise, and contacts provided by their venture capital investors—established themselves as market leaders. In other cases, they were acquired by other firms or entered into licensing arrangements with them. According to Mansfield (1996), such complementarities and interdependencies among incumbents and entrants are the key to successful innovation. Geroski (1991), meanwhile, shows that industry entry tends to lead to innovation, rather than the reverse relationship. Thus, if group members prevent independent firms from entering an industry, a lack of diversity in the existing source of ideas would lead to a lower rate of technological creativity and innovation (Mokyr 1994).

In parallel with the relationship between innovation infrastructure and business group market share in an industry, the prevalence of entry barriers will increase with group share in an industry. That is, the more the groups dominate a sector, the more difficult it will be for independent firms to enter, owing to the entrenched market and political positions of the groups.

We note that there may still be competition among incumbent groups even if there are high barriers to entry. The McKinsey Global Institute (1998), for instance, argues that a small number of large business groups compete fiercely with each other in the Korean semiconductor industry.

Nonetheless, competition among groups is not in itself a sufficient condition for sustainable innovation. The degree of innovation that a firm attains increases with its ability to recombine its own ideas and external ideas into new concepts. Repeated recombinations are possible only if there is an ongoing flow of ideas across firms—without such flow, innovation would be limited to mutation and, as such, subject to diminishing returns (Weitzman 1998). Hence, even if several groups operate in a sector, to the extent that group members are similar in terms of their access to capital, ability for risk sharing, and interorganizational ties, high group share will limit the generation of new ideas. Thus, group dominance of a sector will reduce the diversity in the source of ideas in that sector. Consequently, an industrial sector's access to new ideas will decline as barriers to independent firms increase, regardless of the number of groups operating in the sector.

Two additional issues arise here. First, we recognize that diversity might not be equally important for all industrial sectors. Specifically, diversity may be more important in sectors where technological opportunities are high, allowing new entrants with innovative ideas to compete with the incumbents. We use this insight to test the entry barriers argument. Second, because many of the Korean and Taiwanese groups in our study face global competition, one needs to ask how meaningful domestic entry barriers are for technological innovation. We address this issue in sensitivity analysis by controlling for the export intensity of a sector.

2.3. Group-Share Thresholds: Within and Across Countries

In summary, we argue that business groups have offsetting influences on innovation in emerging economies. First, access to innovation infrastructure increases with business groups' aggregate share in an industrial sector. Second, access to new ideas decreases with groups' share in an industrial sector.

Combining these two arguments, one can trace a link between business groups' share in a sector and that sector's innovation performance. When group share in a sector is very high, firms in that sector often have the infrastructure needed to carry out innovation, but lack access to new ideas. When group share is very low, the sector has access to new ideas, but lacks the innovation infrastructure needed to commercialize those ideas. By contrast, when group share is at an intermediate stage, the mix of groups and independent firms provides both infrastructure and new ideas, resulting in greater innovation.

Thus, group share both facilitates and inhibits innovation in an industry. At low levels of group share, the marginal benefits of group structure for innovation in an industry tend to override associated marginal costs. As group share increases, however, increasing marginal costs in terms of lack of access to new ideas will begin to offset marginal benefits from access to infrastructure, so that beyond a threshold, higher level of group share leads to a decrease in innovation in the industry. This suggests an inverted-U relationship between group share and innovation.

Hypothesis 1. *Innovation in an industry first increases with the market share that business groups hold in that industry, and then declines after group share crosses a threshold.*

The inverted-U relationship is a useful starting point for understanding how the group-share threshold may vary across countries. As long as the marginal benefit of infrastructure declines with the level of group share while the marginal cost of group share increases with it, there is an optimal level of group share beyond which groups are no longer innovation maximizing, which we refer to as the innovation threshold.

We expect innovation thresholds to vary across countries, depending on the availability or lack of market-based institutions. Nelson (1993) shows that countries differ substantially in the nature of their innovative infrastructures, with some depending on internal firm infrastructures while others have more extensive market-based support for innovation. This difference will affect the benefit of group-based innovation infrastructure.

For at least four reasons, which parallel our earlier discussion of business group benefits, the stronger the market institutions in a country, the earlier that business groups will reach their peak contribution to innovation. First, benefits from access to internal capital markets will be least critical when alternative sources of capital such as venture capital are available. Second, more robust labor markets and greater availability of external research facilities will limit the scientific labor market benefits of group structure. Third, greater penetration by multinational companies provides alternative sources of technology, making groups less critical for industrial development. Fourth, greater availability of complementary firms such as suppliers and distributors can help foster innovation. Thus, when there are alternative institutions needed for innovation, the marginal benefits from group structure will be lower for every level of group share, suggesting that the innovation threshold will decline with the presence of alternative providers of innovation infrastructure.

Hypothesis 2. *The greater the presence of alternative sources of innovation infrastructure in a country, the earlier the threshold at which increasing group share will lead to lower innovation.*

The comparison of institutional infrastructures in Taiwan and South Korea is relevant for testing Hypothesis 2. While the development-oriented governments in both South Korea and Taiwan chose to "lead" rather than "follow" the market in terms of encouraging business development and innovation, the two countries used strikingly different policy packages. The logic of the South Korean approach was hierarchical, unbalanced, and command oriented, calling for the intensive use of resources to foster a select and obedient business sector to carry out the specific tasks the leadership assigned (Cheng 1990, p. 142). In this approach, the chaebols provided most of the business infrastructure in South Korea's corporate landscape (Kim 1997). By contrast, the logic of the Taiwanese approach was horizontal, balanced, and incentive oriented, implying a more pluralistic economy and more varied use of resources within the broad parameters that the state delimited (Cheng 1990, p. 142). In turn, Taiwan has a more varied infrastructure, comprising independent companies and government bodies, as well as business groups. In line with our discussion, then, we expect the group-share threshold for Taiwan to be lower than for South Korea.

3. Data

Archival sources provided data for innovation and group market share. We use a patent-based measure of innovation, provided by CHI Research, Inc. The CHI dataset used a concordance between the U.S. Patent Office Classification (USPOC) and the U.S. Standard Industrial Classification (SIC). The concordance mapped U.S. patents granted to South Korean and Taiwanese residents with 42 SIC-based manufacturing industry groupings.[1] U.S. patents provide a useful measure of innovative activity because the country is a highly desirable market, and firms tend to file their most important innovations in the United States as well as, or instead of, in their home country. The patent data cover the period 1980–1998.

An important empirical issue regarding the use of patent data relates to the appropriate unit of analysis. If the sectors of analysis are too broadly defined, they may conceal specialization processes occurring within them. On the contrary, too detailed a disaggregation based on classes with widely different size and importance would thin out the analysis and limit the interpretation of the results. In determining our definition for industries, we start with CHI's 42 SIC-based industries and then aggregate some industries to give a total of 21 sectors. This aggregation accords with the SIC codes in U.S. patent office data and ensures that we do not split the data into a finer level than four-digit International SIC (ISIC) codes as defined by United Nations Industrial Development Organization (UNIDO) (e.g., ISIC code 3511 includes SIC codes 281 and 286, so our classification combines them) in order to maintain a concordance with ISIC coding (Mahmood and Singh 2003). Finally, 21 sectors provided a reasonable trade-off between the richness of sectoral data and the number of patents per sector as a reliable measure of innovativeness in that sector. The appendix reports the mapping of sectors to SIC and ISIC codes.

For the sector market share of business groups in South Korea, we rely on a database developed by the Korea Investors Services, Inc. (KIS), and previously used by Chang and Hong (2000). KIS is a leading credit-rating agency in South Korea, equivalent to Standard & Poor's or Moody's of the United States. The KIS database includes annual financial data on the listed companies as well as unlisted companies with assets of more than 6 billion won (known as the statutory audited companies). The database goes back to 1983, but data before 1985 mainly covered the listed firms while data on the statutory audited firms were incomplete. The data on group affiliation is based on the Korean Fair Trade Commission (KFTC) database.

[1] We use the SIC rather than the International Patent Classification (IPC) because our variables match more accurately with the SIC.

The KFTC defines a business group as "a group of companies, more than 30% of whose shares are owned by some individuals or by companies controlled by those individuals" (Chang and Hong 2000, pp. 437–438).

As of 1996, KFTC identified 461 business groups. In computing group market shares, we distinguish between large and small business groups. The prevalence of market imperfections in South Korea implies that large groups may have access to resources that would be unavailable to smaller groups (Kang 1996). Thus, we conduct our basic analyses based on a sample of 44 large business groups. In addition, as a robustness check, we conducted sensitivity analyses that added the smaller South Korean business groups (Kang 1996).

Our list of 44 large business groups stems from the *1990 Chaebol Analysis Report*, also published by KIS. The report provides information on the 50 largest business groups (measured in terms of assets) in South Korea in 1989, but data are incomplete for six of the groups. In calculating our group market shares, we rely on the remaining top 44 business groups. Feenstra (1997) used the same 44-group sample to measure sectoral shares in 1989; we compared our 1989 group-share values to Feenstra's calculations, finding similar numbers for comparable sectors. Since the data in the KIS database are organized according to the South Korean SIC, we needed to map them according to our 21 categories. The KIS database, along with the list of firms affiliated with these top 44 groups, allowed us to determine the sectoral measures for group market share and other relevant industry-specific data at five points: 1983, 1986, 1989, 1992, and 1995.[2]

We collected data for business groups in Taiwan from five editions of the directory *Business Groups in Taiwan* (BGT): 1982, 1988/89, 1992/1993, 1996/97, 2000. BGT is a common data source for academic research (Khanna and Rivkin 2001, Chung 2001). This directory is compiled by China Credit Information Service in Taipei (CCIS), the oldest and most prestigious credit-checking agency in Taiwan and an affiliate of Standard & Poor of the United States. CCIS started publishing data for the top 100 business groups (in terms of annual sales) biennially in 1972. For credit checking in the private sector, CCIS maintains a database listing more than 30,000 of the largest firms in Taiwan. CCIS constructs the database of business groups by examining interorganizational relationships among these firms. BGT's definition of business group is a "coherent business organization including several independent groups." Since its second edition in 1974, BGT has maintained the following criteria in selecting business groups: (1) more than 51% of the ownership was native capital; (2) the group had three or more independent firms that identified themselves as group constituents; (3) the group had more than NT$100 million group total sales; and (4) the core firm of the group was registered in Taiwan.

For industry-specific data, we use the Tian Xia Survey of Top 1,000 Firms in Taiwan, which bases size on firm sales. Published annually by *Commonwealth* magazine, the Tian Xia Survey is a well-respected source of financial information in Taiwan. The survey contains financial data on public and private firms, as well as government-owned and foreign-controlled enterprises. The Tian Xia industrial categories are based on the Standard Industrial Classification System of the Republic of China. We take the weighted average of the firm-specific data for all firms within a particular sector to determine the sectoral values for each of our 21 industries.[3] The Tian Xia database, along with the list of top 100 group-affiliated firms based on the BGT directory, allowed us to determine the sectoral measures for group market share and other relevant industry-specific data at five points: 1983, 1986, 1989, 1992, and 1995.

For each product category, we divide the patent data into five three-year time periods. This creates a three-year "patenting window" following each of the five points at which we have group market share data. Aggregating patent data over several years reduces variations in annual patenting data (Archibugi and Pianta 1992). Moreover, the mean lag between when a patent application is filed and when it is granted in the United States is about one to two years (Scherer 1983), so that patents granted in a particular year may be driven by factors that occurred up to two years earlier. By including patent data for up to two years following a year for which group-share data exists, we account for the two-year lag effect in patenting. This procedure provides 105 observations for each of the two countries (5 periods $\times$ 21 categories).

4. Model Specification

We use the following baseline specification to test the hypothesized inverted-U relation between group

[2] KIS provides incomplete 1983 data on the unlisted statutory audited firms. To check the reliability of the 1983 group market share values, we compared group shares of the largest 44 groups in KIS against Feenstra's (1997) group-share values for 1983, finding similar numbers.

[3] The SIC for Taiwan differs slightly from the U.S. SIC (e.g., Tian Xia treats "Food" and "Beverage" as separate groups, whereas the U.S. SIC combines them). To match Tian Xia with our 21 sectors, we assigned each of the 1,000 firms in Tian Xia an industrial code based on our 21-sector classification, resulting in a few changes (e.g., a firm in the Tian Xia classification "Beverage" moved to our "Food, Other Related Products & Beverage" sector).

share and innovation as measured by TRCA:

$$\begin{aligned}\text{TRCA}_{i,t+1} &= \alpha_0 + \alpha_1(\text{GroupShare}_{it}) + \alpha_2(\text{GroupShare}_{it})^2 \\ &\quad + \alpha_3(\text{Number}_{it}) + \alpha_4(\text{C5}_{it}) + \alpha_5(\text{CurrentRatio}_{it}) \\ &\quad + \alpha_6(\text{Electronics}_{it}) + \alpha_7(\text{Chemicals}_{it}) \\ &\quad + \alpha_8(\text{Machinery}_{it}) + \alpha_9(\text{Metals}_{it}) \\ &\quad + \alpha_{10}(\text{Traditional}_{it}) + \varepsilon_i.\end{aligned}$$

TRCA and GroupShare are our focal measures. The dependent variable TRCA measures a sector's relative technological specialization in patenting. A problem with patent data is variation across sectors in patenting propensity (Scherer 1983). To address this problem, we follow research that uses the Technology Revealed Comparative Advantage (TRCA) index as the sector measure of innovation (Soete 1987, Archibugi and Pianta 1992). The TRCA index measures the relative distribution of a country's inventive activity in each field, compared to its own total patents and to the overall distribution of patents in the United States. This makes the specialization index independent of country size and specific fields, thereby determining relative strengths and weaknesses across industries and nations. Formally, the TRCA index for country i in sector j is defined as the ratio of country i's share of total world patents in sector j to country i's share of total world patents, such that,

$$\text{TRCA}_{ij} = \frac{(n_{ij}/\sum_i n_{ij})}{(\sum_j n_{ij}/\sum_i \sum_j n_{ij})},$$

where n_{ij} is the number of patents of country i in sector j.

By definition, the TRCA index equals 1 if the country holds the same share of worldwide patents in a given technology as in the aggregate, and is below (above) 1 if there is a relative weakness (strength). A value of the index greater than 1 indicates a relative advantage only (i.e., relative to the existing patenting of the country), rather than an absolute advantage. Shifts in the TRCA over time show whether a country has increased its strength in selected areas or shifted its relative advantage to new fields.

GroupShare is the ratio of total sales of firms that belonged to business groups within each sector to the sales of all firms in that sector during a particular year. To account for the hypothesized nonmonotonicity, we also include a squared term for GroupShare. We expect to find a positive coefficient for GroupShare and a negative coefficient for its squared term.

Several measures address alternative explanations. Group share might not capture the level of competition among groups. Given the same group share, the incentive for innovation may differ depending on the degree of competition among group-affiliated companies. The number of group companies in a sector (GroupNumber) is a conventional market-structure measure of intergroup competition.

We also include a five-firm concentration ratio, C5, defined for each sector. Empirical studies often focus on the relationship between market structure and innovation, with market structure measured in terms of concentration ratios (the concentration ratio measure assumes that firms' monopoly power increases with industry concentration). There is little consensus regarding the effects of concentration on innovation (Cohen and Levin 1989), although concentration sometimes demonstrates the inverted-U effect that we predict for group share.

To the extent that innovation must rely on internal financing, only firms with high liquidity can support sizable R&D efforts (Himmelberg and Petersen 1994, p. 49). We control for liquidity by including a sector's sales-weighted average current ratio, defined as the ratio of a firm's current assets to its current liabilities. We calculate the sector-specific values by taking a weighted average of all the firm-specific values of our sample firms within a particular sector and weighting them by each firm's share of sales in the total sales of the sector. We expect the CurrentRatio variable to have a positive impact on innovation.

A firm's debt burden, measured by the ratio of its debt to equity (Debt/Equity), may influence the level of accessible funds that the firms can use for research and development. We use sector-specific sales-weighted average Debt/Equity ratio for our sample firms as a measure of capital market access. Debt/Equity commonly has a negative impact on innovation.[4]

Finally, unobservable sector-specific effects might correlate with both TRCA and the sector share of groups. Technological opportunity will not only increase the possibilities for innovation, it may also increase the sector share of groups. For instance, the South Korean government's use of the chaebols to create high-technological capabilities led to preferential credits for chaebols that entered high-opportunity

[4] High debt/equity ratios might not limit firms' access to new debt in emerging economies. Capital structure theory holds that lenders are more willing to supply new loans when a balance sheet has a high proportion of tangible assets, because tangible assets offer collateral and retain more value due to their liquidity, thereby diminishing the risk that a lender will incur agency costs of debt. In emerging economies, however, government intervention, information asymmetries, and lack of transparency mean that creditors may also consider a firm's intangible resources, such as management reputation and access to connections. Debt/equity ratios may reflect firms' access to intangible resources. Anecdotal evidence from the Asian financial crisis suggests that banks provided new credit to some highly leveraged groups.

sectors (Kang 1996). Failing to account for such sector-specific effects could create a specification error that might bias the estimates of the effects of group share. We use sector-specific dummy variables to control for variation in technological opportunity and propensity to patent, aggregating the sectors into five major classifications: Electronics, Machinery, Chemicals, Metals, and Traditional (Scherer 1965).[5]

Dummy variables are blunt measures that can create an errors-in-variable problem, possibly biasing our estimates. As an alternative, therefore, we also use a continuous measure of technological opportunity that is available for South Korea, which helps us examine the way technological opportunity moderates the effects of group market share on innovation.

We calculated the continuous industry-specific measure of technological opportunity based on data about technology life cycles in South Korean manufacturing industries, using a Technology Innovation Survey that South Korea's Ministry of Commerce, Industry, and Energy conducted in 1995. (This technological opportunity measure is comparable to Levin et al. 1987, who surveyed R&D managers about current and anticipated rates of product technology advance in their industries.) The South Korean survey asked companies to select one of four stages of their main technology's life cycle—the Cradle, Growth, Maturity, or Declining stages. We aggregated the firm-level technology life-cycle information to the industry level and converted the responses to a four-point scale, with one point for the Declining Stage, two points for the Maturity Stage, three points for the Growth Stage, and four points for the Cradle Stage. We then calculated technological opportunity by averaging the points weighted by the response frequencies for each of the four stages. We use this technological opportunity measure to check the robustness and boundary conditions of the results.

5. Statistical Analyses

5.1. Descriptive Statistics

Table 1A summarizes the data for South Korea. TRCA has a mean of 0.67, varying from a minimum of zero (no patents were granted to the Agricultural Chemicals sector firms during Period I) to a maximum of 3.15 (the TRCA of the Electronics and Electrical sector during Period V). Following the terminology of panel data analysis, "between-sectors" in Table 1A refers to differences in sector-specific averages across the 21 sectors, with the averages taken by sector over time. The "between-sectors" numbers demonstrate that the sector-specific averages vary from a minimum of 0.06 (Petroleum & Coal) to 2.63 (Electronics). In turn, "within-sectors" refers to the deviation of variables from all-period sector means. TRCA "within-sector" numbers, which measure the deviation from sector means, vary from −0.29 to 2.25.

Table 1A shows that the mean overall GroupShare across sectors and over time in South Korea was about 44%. The share of groups varied from 0.9% (Drugs & Medicine) to 99% (Petroleum & Coal). These figures are reasonable when we consider the firms that belong to the sectors. For instance, the firms that dominate the Petroleum & Coal sector are all members of a group; e.g., Yukong is affiliated with the SKC group, SsangYong Oil Refining belongs to the SsangYong group, Hanwha Energy is affiliated with the Hanwha group, and Kukdong Oil and Chemical is a member of the Kukdong Oil group. We also observe that, despite a low sector share of groups, a sector can have a high concentration ratio. For instance, none of the four firms that dominate the Precision Instruments sector in South Korea (Orient Watch Industries, Pan Korea, Shinhung, and Medison) belongs to a group. The "within-sector" results for the variable GroupShare range from 18% to 72%. The maximum fluctuation over time in the sector share of groups takes place within the Miscellaneous Chemical Products sector. The mean debt-to-equity ratio of 376% reflects the highly leveraged state of South Korean corporate structure.

Table 1B summarizes the Taiwan data. TRCA has a mean value of 1.10 with a minimum of 0.03 (for Food & Beverages) and a maximum of 3.71 (the TRCA of the Transportation Equipment sector during Period IV). Table 1B shows that the mean GroupShare across sectors and over time was about 25%, much lower than in South Korea. Group share varied from 11% (Miscellaneous Chemical Products in Period I) to 50% (Textile & Apparel in Period V). The overall C5 of 38% for Taiwan is smaller than for South Korea. Both low average GroupShare and low average C5 values suggest greater rivalry among firms in Taiwan than in Korea. The mean Debt/Equity ratio of 206% shows that the Taiwanese firms were somewhat less leveraged than their South Korean counterparts.

Tables 2A and 2B report variable correlations. The GroupShare measure provides reasonable independence relative to the control variables, other than the C5 measure, especially for South Korea. The

[5] Electronics has one category: "Electronics, Radio, TV & Communications Equipment." Machinery has five categories: "Machinery," "Electrical Machinery," "Office Computing & Accounting Machinery," "Transportation Equipment," and "Precision Instruments." Chemicals has eight categories: "Basic Industrial Chemicals," "Agricultural Chemicals," "Misc. Chemical Products," "Drugs & Medicine," "Soaps & Detergents," "Plastic Materials & Synthetic Resins," "Rubbers & Plastics," and "Petroleum." Metals has two categories: "Primary Metals" and "Fabricated Metals." Traditional has two categories: "Food & Beverages" and "Textiles."

Table 1A Summary of the Panel Data for South Korea

Variable	Mean	Standard deviation	Minimum	Maximum
TRCA				
Overall	0.67	0.65	0	3.15
Between-sectors		0.55	0.06	2.63
Within-sectors*		0.35	−0.29	2.25
GroupShare				
Overall	43.81(%)	25.58	0.9	99
Between-sectors		24.75	12	94.80
Within-sectors		8.06	18.41	72.21
GroupNumber				
Overall	21.81	17.71	2	65
Between-sectors		15.44	3.4	43.6
Within-sectors		9.19	−7.79	48.21
C5				
Overall	53.26(%)	22.23	12.03	98.56
Between-sectors		21.52	14.27	97.26
Within-sectors		6.96	37.04	72.64
Debt/Equity				
Overall	376.32(%)	335.71	55.14	2,697.65
Between-sectors		161.99	168.48	828.93
Within-sectors		293.67	−236.96	2,245.05
Current Ratio				
Overall	123.00(%)	27.99	76.71	189.09
Between-sectors		24.90	93.01	180.45
Within-sectors		13.68	92.47	169.22

Table 1B Summary of the Panel Data for Taiwan

Variable	Mean	Standard deviation	Minimum	Maximum
TRCA				
Overall	1.10	0.85	0.03	3.71
Between-sectors		0.78	0.08	3.06
Within-sectors*		0.34	0.04	2.04
GroupShare				
Overall	25.05(%)	10.08	11.14	50.25
Between-sectors		9.27	14.38	47.17
Within-sectors		4.37	5.25	39.89
GroupNumber				
Overall	9.15	10.10	0	56
Between-sectors		9.68	0	39.60
Within-sectors		3.49	0.55	25.11
C5				
Overall	38.17(%)	12.91	11	66
Between-sectors		10.92	18.20	60.60
Within-sectors		7.01	13.97	58.50
Debt/Equity				
Overall	206.53(%)	122.87	66.2	790.2
Between-sectors		60.74	138.31	337.5
Within-sectors		106.55	−18.66	665.07
Current Ratio				
Overall	125.15(%)	75.85	14.1	362.5
Between-sectors		43.28	76.65	209.37
Within-sectors		62.60	−42.90	357.09

*The "within-sector" figures are deviations from the sector means, with the overall mean added back to provide greater comparability to the other statistics. For instance, the within-sector TRCA values in Taiwan vary from 0.04 to 2.04; the mean deviations range from −1.06 (0.04 − overall mean of 1.10) to 0.94 (2.04 − 1.10).

Table 2A Correlation Matrix for South Korea

	TRCA	GroupShare	Number	C5	Current Ratio	Debt/Equity
TRCA	1.00					
GroupShare	0.14	1.00				
GroupNumber	0.03	−0.16	1.00			
C5	−0.21	0.56	−0.50	1.00		
Current Ratio	0.14	−0.33	−0.40	−0.15	1.00	
Debt/Equity	0.08	0.12	0.21	−0.10	−0.27	1.00

Table 2B Correlation Matrix for Taiwan

	TRCA	GroupShare	Number	C5	Debt/Equity	Current Ratio
TRCA	1.00					
GroupShare	−0.07	1.00				
GroupNumber	0.06	0.37	1.00			
C5	0.06	0.12	0.35	1.00		
Debt/Equity	−0.02	−0.03	0.22	−0.16	1.00	
Current Ratio	−0.01	−0.06	−0.03	−0.19	0.50	1.00

moderate correlation between GroupShare and C5 influences how we structure the analysis.

5.2. Regression Results Using Sector Dummies on Pooled Data

Table 3A reports the results for the South Korean data, using OLS regression. Column (1) in Table 3A omits C5 as an explanatory variable, owing to the moderate collinearity between GroupShare and C5 that we noted above. In Model 1, both GroupShare and GroupShare^2 take the expected positive and negative signs and are statistically significant, consistent with the prediction in Hypothesis 1 that group share would lead to an inverted-U impact on innovation in a sector. The TRCA innovation benefit in South Korea reaches its peak when the sector share of groups is 65%. When we consider these figures in light of the sector share of groups, the results are sensible. Electronic Products and Transportation Equipment have 60%–70% of their total sales coming from firms that belong to business groups. The Electronics and Transportation Equipment sectors have some of the highest values for TRCA innovation measure.

Column (2) in Table 3A adds C5 as an explanatory variable to the specification in Column (1). The results continue to support Hypothesis 1, as the GroupShare variables retain statistical significance. C5, meanwhile, has a significant negative coefficient.

Column (3) of Table 3A replaces GroupShare and its squared term with C5 and its squared term. The goodness-of-fit suffers, however, as the *R*-square value declines. Therefore, GroupShare performs better than C5 as a market-structure measure.

Table 3B reports the results for Taiwan, again supporting Hypothesis 1. The statistically significant positive sign for GroupShare and the negative sign for GroupShare^2 in Models 1 and 2 are consistent with the prediction of an inverted-U relation between group structure and innovation.

Comparing the points of GroupShare at which innovation measured by TRCA reaches its peak in South Korea and Taiwan tests Hypothesis 2. Recall that we expected a lower innovation threshold in Taiwan, owing to the greater presence of nongroup innovation infrastructure. The results are consistent with the prediction. As we noted, innovation reaches its peak at about 65% to 74% group share in South Korea (Table 3A). By contrast, innovation in Taiwan reaches its peak when the sector share of groups is about 30% (Table 3B).

We note that reverse causation, in which innovation TRCA causes GroupShare, is not likely to arise in these analyses. The first two values for GroupShare are for the years 1983 and 1986, whereas the first two periods for the TRCA variable are for the periods 1983–1985 and 1986–1988. Even if patenting were to influence GroupShare, it would take a substantial lag, implying only a modest possibility of contemporaneous impacts of patenting on group share. Moreover, Amsden (1989) also argues that the latecomer business groups in South Korea generally did not emerge on the basis of Schumpeterian technological breakthroughs, unlike their counterparts in developed economies, suggesting that there is little possibility of reverse causality from innovation to group share.

Table 3A OLS Regression Results with the Pooled Data for South Korea (Dependent Variable: TRCA)

Independent variables	(1)	(2)	(3)
Constant	−0.434 (−1.057)	−0.011 (−0.028)	0.564 (1.388)$^\#$
H1: GroupShare	2.754 (3.522)**	2.546 (3.449)**	
H1: GroupShare^2	−2.116 (−3.045)**	−1.723 (−2.494)**	
GroupNumber	−0.005 (−1.905)*	−0.007 (−2.428)**	−0.008 (−2.294)*
C5		−0.546 (−1.703)*	0.567 (0.669)
C5-square			−0.707 (−0.929)
Current Ratio	0.004 (1.666)*	0.003 (1.283)	0.0008 (0.355)
Debt/Equity	0.00001 (0.113)	1.16e−06 (0.010)	0.00008 (0.611)
Electronics (v. Traditional)	1.014 (3.366)**	0.990 (3.372)**	1.099 (3.043)**
Metals (v. Traditional)	0.445 (2.631)**	0.467 (2.740)**	0.336 (1.712)*
Chemicals (v. Traditional)	−0.387 (−3.201)**	−0.332 (−2.716)**	−0.335 (−2.456)**
Machinery (v. Traditional)	0.171 (1.310)$^\#$	0.184 (1.391)$^\#$	0.275 (1.983)*
Cases (R-square)	105 (0.501)	105 (0.514)	105 (0.420)
GroupShare when TRCA is at peak	65.2%	73.9%	

**$p < 0.01$, *$p < 0.05$, $^\#p < 0.10$ (1-tailed tests; t-stats in parentheses).

Table 3B OLS Regression Results with the Pooled Data for Taiwan (Dependent Variable: TRCA)

Independent variables	(1)	(2)	(3)
Constant	−1.559 (−2.398)**	−2.074 (−2.718)**	0.614 (1.627)
H1: GroupShare	0.176 (4.061)**	0.183 (3.938)**	
H1: GroupShare^2	−0.003 (−4.101)**	−0.003 (−3.946)**	
Number of groups	0.021 (2.389)**	0.016 (1.575)$^\#$	0.025 (1.808)*
C5		1.230 (1.684)*	−1.345 (−0.974)
C5-square			3.703 (1.880)*
Current Ratio	0.001 (0.949)	0.001 (0.992)	−0.0003 (−0.247)
Debt/Equity	−0.001 (−1.403)$^\#$	−0.001 (−1.289)$^\#$	−0.0009 (−0.779)
Electronics (v. Traditional)	0.537 (2.315)*	0.636 (2.347)**	0.726 (2.968)**
Metals (v. Traditional)	0.867 (3.040)**	0.964 (3.034)**	1.026 (3.192)**
Chemicals (v. Traditional)	0.369 (1.732)*	0.212 (0.787)	0.186 (0.789)
Machinery (v. Traditional)	0.978 (3.818)**	0.926 (3.210)**	1.033 (3.701)**
Cases (R-square)	150 (0.402)	150 (0.427)	150 (0.342)
GroupShare when TRCA is at peak	29.33%	30.5%	

**$p < 0.01$, *$p < 0.05$, $^\#p < 0.10$ (1-tailed tests; t-stats in parentheses).

5.3. Sensitivity Analyses

We carried out extensive sensitivity analyses, finding robust results for the inverted-U impact of group share on innovation.

Panel Data and Nonparametric Estimation Techniques. We used four panel data techniques to check whether the results were sensitive to the statistical method. These included (1) fixed-effects OLS (using the sector-specific components of the error terms as fixed effects in place of sector dummy variables), (2) between-sector OLS (regressing the sector means of TRCA on the sector means of the covariates), (3) Weighted Generalized Least-Square (WGLS) random effects (random-effects analysis is appropriate because the Hausman test fails to reject random effects in favor of the fixed-effects estimators), and (4) General Estimating Equation (GEE) random effects. The panel data analyses produced inverted-U results for GroupShare and GroupShare^2 in all cases, with statistical significance for all but the fixed-effects OLS in South Korea (much of the variance in GroupShare is cross-sectional, so that the fixed-effects OLS specification discards most of the variance that our model seeks to explain). The innovation thresholds were similar to the figures in Table 3, ranging from 32% to 44% in Taiwan and from 62% to 70% in South Korea.

We used two nonparametric approaches to determine the shape of the functional form without a priori parametric constraints. First, kernel regression provided "nearest-neighbor" nonparametric regression estimates of the GroupShare–TRCA plot (Cleveland 1979; Altman 1992, p. 179). Second, a semiparametric analysis estimated the GroupShare–TRCA plot nonparametrically while controlling for sector-specific characteristics that have a parametric relationship with TRCA (Robinson 1988, Aw and Batra 1998). Both approaches produced plots that were consistent with the parametric regression results. The innovation threshold for TRCA was about 25% in Taiwan and 70% in South Korea.

Results Excluding the Petroleum Sector and Including Smaller Groups. We conducted two types of sensitivity tests with regard to our choice of sample. First, we noted that the petroleum sector has a high group market share and low innovation, particularly in South Korea, which would pull the curve down. The petroleum industry may be an artifact because most countries in the world have heavy government involvement in petroleum while, in South Korea, groups take up the role of government. Moreover, this is a sector that might have little patenting because of the nature of the industry. When we drop the petroleum industry from the analysis, though, we continue to find significant inverted-U effects in both countries.

Second, as the results in South Korea are based on large groups, one might argue that the inclusion of smaller groups reduces the negative effects from entry barriers and thereby invalidates the inverted-U result. Especially for South Korea, there are many smaller groups that we have not included so far. We checked the robustness of the inverted-U result for South Korea using a sample from KIS data that combines large and small groups (304 groups in 1983, 316 in 1986, 382 in 1989, 412 in 1992, and 439 in 1995). Table 4 shows that the inverted-U result of GroupShare and GroupShare^2 continues to hold, reporting GEE random-effects estimates (other estimators produced materially equivalent magnitudes, signs,

Table 4 **Random Effects GEE Panel Data Regression Results for South Korea Including Large and Small Groups**

Independent variables	Impact on TRCA	
Constant	−0.471	(−0.882)
H1: GroupShare	0.036	(2.668)**
H1: GroupShare^2	−0.0002	(−2.353)**
Number of groups	−0.009	(−1.600)
Current Ratio	0.008	(0.354)
Debt/Equity	0.0007	(0.398)
Electronics (v. Traditional)	1.036	(1.488)#
Metals	0.212	(0.865)
Chemicals	−0.459	(−2.507)**
Machinery	0.162	(1.111)
Cases	105	
GroupShare with TRCA at peak	90.0%	

**$p < 0.01$, *$p < 0.05$, #$p < 0.10$ (1-tailed tests; t-stats in parentheses). Positive coefficient = higher TRCA.

and significance of GroupShare and GroupShare^2).[6] The one material difference is that the innovation threshold increases to 90%, suggesting that smaller groups may add greater technological variety that helps attenuate the marginal costs of entry barriers to nongroup firms.

Are Entry Barriers Within the Domestic Market Relevant? The inverted-U hypothesis assumes that group structure provides an indicator of entry barriers. Because many of the South Korean and Taiwanese firms face global competition, one might question how meaningful domestic entry barriers are for technological innovation. In practice, this depends on the importance of the domestic market as a source of competition as well as new ideas. In South Korea, for instance, even though many of the sectors are export oriented, a substantial portion of the groups' sales comes from the South Korean domestic market, where various types of entry barriers continue to shield them from external competition.

A recent report by the McKinsey Global Institute (1998) argues that domestic competition is the dominant factor in South Korea, noting that "The most important driver for productivity growth is intense competition, notably with global best practice [domestic] companies. Although many [South] Korean companies feel that they are subject to intense competition both in [South] Korea and export markets, they were in fact relatively protected, especially from foreign best practice companies, by the prevailing regulatory environment" (p. 26). In the manufacturing sectors, for instance, explicit or implicit (e.g.,

[6] The General Estimating Equation estimator is asymptotically equivalent to WGLS (Liang and Zeger 1986). GEE uses a quasi-likelihood approach that assumes repeated observations from the same subject are independent. GEE estimates within-group correlations (rather than requiring observations for all subjects to have the same correlation structure) and calculates robust standard errors.

limited access to distribution channels) barriers to imports of manufactured goods and FDI effectively kept foreign companies out of the South Korean markets. The automotive industry provides an example. In the late 1980s, import tariffs of up to 50% protected the South Korean auto industry. As part of the General Agreement on Tariffs and Trade (GATT) and World Trade Organization process, these tariffs declined to 10% in 1996, but nontariff barriers continue to limit the penetration of imported cars. In 1998, imported cars still accounted for less than 1% of the South Korean domestic market. Examples of nontariff barriers include an outright ban on importing cars assembled in Japan, limitations on the size and ownership of dealer networks, advertising restrictions, and tax audits of foreign-car owners. Thus, even though globalization has intensified, entry barriers to domestic markets still played an important role in the competitive intensity of these sectors during the study period.

Primarily, then, this is an empirical question that we can address by controlling for variation in export intensities across sectors. As sensitivity analysis, we added export intensity as a control variable. The results remained materially equivalent to those that we report.

5.4. Causality Tests Using Multiple Kernel Regressions

The inverted-U result is highly robust across sensitivity checks. Thoughtful readers might, however, offer arguments against attributing causality. First, both group share and innovation might derive from a third unobserved variable, such as the arrival of technological opportunities. Second, patents themselves constitute a source of technological entry barriers for new entrants, suggesting that using patents as a measure of innovation might cause a bias because reduced-form regressions will overstate the effects of group share on innovation in the presence of such endogeneity.

To make progress on the issue of causality, we follow an econometric approach that calls for identifying the specific theoretical mechanisms by which group market share affects innovation, and then documenting their working as moderating effects (Rajan and Zingales 1998). We identified two separate channels by which the presence of groups can affect innovation: through providing greater access to innovation infrastructures and by creating entry barriers that reduce plurality. The importance of either infrastructures or entry barriers is likely to vary across industries. For instance, the need for infrastructure will rise with the cost of R&D. The innovation literature suggests that basic research tends to be highly uncertain, making the cost of R&D very high. Hence, access to infrastructures for dealing with risks and uncertainty will be most important for industries where basic research is especially important for innovation. In other words, if group market share acts as a proxy for available resource infrastructure, the benefits of high group market share will be highest for industries where basic research is particularly important for innovation. We can test the underlying resource argument that group market share matters by examining how the importance of basic research moderates the relation between group share and innovation.

Similarly, the importance for entry barriers is likely to vary across industries. If high market share of business groups were to deter innovation by creating entry barriers, the negative effects of entry barriers would be strongest in sectors where technological opportunities were high. The underlying logic is the following: When the technological environment is fertile, the cost of developing new products declines, allowing independent players with good ideas to compete with the incumbents. Here, high group share is no longer warranted and may reduce the level of research investment by reducing plurality and/or inducing collusion among the incumbents. By examining the moderating effects of technological opportunity on the relation between group market share and innovation, we can test the entry barrier argument.

We use R&D intensity as a measure of innovation to examine the moderating effects of share of basic R&D and technological opportunity. Both R&D intensity and patents have pros and cons as measures of innovation. We use R&D intensity at this point in the analysis instead of patents because it is more directly linked with the cost of R&D. Using R&D intensity also provides an additional robustness check for the inverted-U relationship with group share.

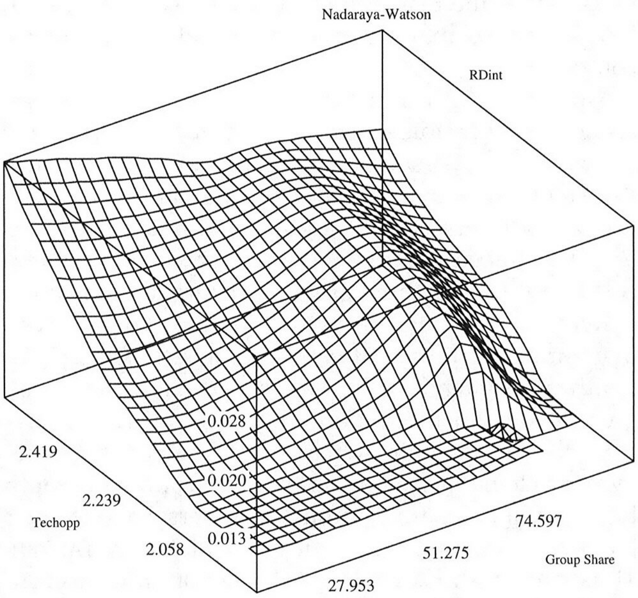
We use multiple kernel regression (Hardle 1990) as an alternative to the conventional parametric model, which adds an interaction term into the basic model, to directly trace the interaction with a three-dimensional illustration. The illustration zooms in with a closer view on how two explanatory variables interact with each other.[7] We are able to conduct this analysis only for the South Korean data, for which industry-level measures of technological opportunity and basic R&D importance are available.

[7] Multivariate nonparametric regression estimates the functional relation between a univariate response variable Y and a d-dimensional explanatory variable X, i.e., the conditional expectation $E(Y \mid X) = E(Y \mid X_1, \ldots, X_d) = m(X)$. Suppose that we have independent observations $(x_1, y_1), \ldots, (x_n, y_n)$; then the multivariate Nadaraya-Watson estimator is defined as follows, with $K(\cdot)$ denoting a kernel function, and h the bandwidth (Hardle 1990):

$$\widehat{m}_h(x) = \frac{\sum_{i=1}^{n} K((x_{i1} - x_1)/h_1, \ldots, (x_{ip} - x_p)/h_p) y_i}{\sum_{i=1}^{n} K((x_{i1} - x_1)/h_1, \ldots, (x_{ip} - x_p)/h_p)}.$$

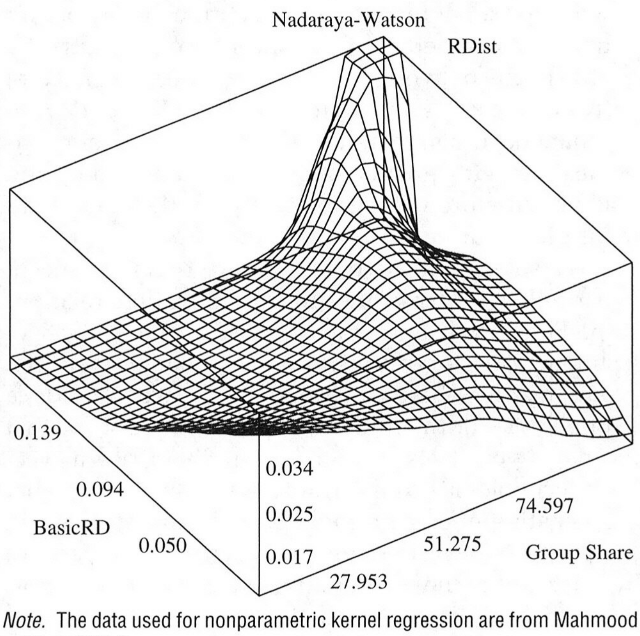
Figure 1A uses multivariate kernel regressions to illustrate the moderating effects of share of technological opportunity in the effects of GroupShare on R&D intensity. The measure of technological opportunity is the continuous variable that we described earlier. Figure 1A suggests that, at low levels of technological opportunity, GroupShare does not matter much for R&D intensity. At medium technological opportunity levels the relationship takes on an inverted-U shape. At high levels of basic technological opportunity, meanwhile, the GroupShare impact becomes negative.

Figure 1A Moderating Effects of Need for Variety (Techopp) on the Effects of Group Share on R&D Intensity (RDint) in South Korea (Multivariate Kernel Regression with Nadaraya-Watson Estimator)



Note. The data used for nonparametric kernel regression are from Mahmood and Lee (2004).

Figure 1B Moderating Effects of Share of Need for Infrastructure (BasicRD Share) on the Effects of Group Share on R&D Intensity (RDint) in South Korea (Multivariate Kernel Regression with Nadaraya-Watson Estimator)



Note. The data used for nonparametric kernel regression are from Mahmood and Lee (2004).

Figure 1B uses multivariate kernel regressions to illustrate the moderating effects of basic R&D in the effects of GroupShare on R&D intensity. We measure an industry's share of basic R&D as the ratio of total private and government expenditure on basic R&D to total R&D expenditure by all private and public sources in Korea, using industry data from the Survey of Research and Development in Science and Technology (published by South Korea's Ministry of Science and Technology). At low share of basic R&D, increasing GroupShare has a negative effect on R&D intensity. The effect then becomes an inverted U at moderate levels of basic R&D. Finally, GroupShare facilitates R&D intensity at very high levels of basic R&D.

The results of the kernel regressions refine our understanding of the relationship between group structure and innovation. The inverted U holds at moderate levels of technological opportunity and basic R&D. When there is high need for variety (high-technological opportunity), groups often hinder innovation. By contrast, with high need for infrastructure (high basic R&D), groups make particularly strong contributions to innovation. Thus, the inverted-U relationship tends to hold in conditions of moderate technological opportunity and/or basic R&D, which is characteristic of many industries.

6. Discussion and Conclusions

The core idea of this paper is that there is a trade-off between the benefits of having a critical mass of innovation infrastructure in an industry and the gains from diversity. We focus on two types of actors in a technological system, business groups and independent firms, where the two types play different innovative roles. Groups provide infrastructure needed to support innovation when market-based institutions are weak. At the same time, though, groups tend to converge in their technological variety and so limit the possible adaptations and mutations possible in an industry. As a result, independent firms provide the diversity of ideas needed to expand the range of possible innovations. Thus, we expect that increasing group dominance in an industry will have a nonmonotonic impact on innovation, first promoting innovation by creating infrastructure and then inhibiting innovation by creating entry barriers for independent firms. Using data from South Korea and Taiwan, we find robust evidence of an inverted-U relationship between groups' share of sector sales and the sector's innovation performance. This pattern reflects an evolutionary process in which the interplay in the availability of innovation infrastructure and variety of ideas influences the level of innovation in an industry.

The argument implies that the trade-off will vary depending on the availability of market-based innovation institutions in a country. The variation in the trade-off emerges clearly in the analysis of the two countries in this paper. A key difference between South Korea and Taiwan is the much lower innovation threshold level for group share in Taiwan than for South Korea. While the optimal group share for South Korea is about 65%, the threshold is only 30% for Taiwan. This comparison is plausible when we consider the differences in institutional landscapes of the two countries, with Taiwan having a much more extensive market infrastructure than South Korea.

The group-innovation relationship is robust to alternative explanations. The core analysis includes controls for industry structure factors such as concentration and number of groups, as well as for financial factors such as current and debt/equity ratios. In sensitivity analyses, we examined the impact of industry outliers, smaller business groups, and industry export intensity.

Traditional innovation studies in mature markets suggest another alternative explanation for the quadratic link between the sector share of groups and TRCA. In this view, group share might act only as a proxy for entry barriers, rather than as a combination of entry barriers and institutional infrastructure. If this is the case, then the nonlinearity in the relationship between group share and innovation might capture a nonlinearity in the relation between entry barriers and innovation. The theory and evidence on technological innovation suggest a threshold of the most favorable climate for rapid technological change (Scherer and Ross 1990, p. 660). The early game-theoretic treatment by Scherer (1967) predicted that rivalry, approximated by lower concentration indices, invigorates R&D spending up to a point, but that too atomistic a market structure discourages R&D by allowing would-be innovators to capture an insufficient share of innovation payoffs. More recent decision-theoretic models (Kamien and Schwartz 1982, pp. 105–145) are consistent with Scherer's hypothesis that an intermediate market structure may promote the greatest innovative activity. In this paper, however, group share remains statistically significant when we add a measure of industry concentration (C5) to the analysis. Moreover, we do not find a significant inverted-U relationship between C5 and innovation for either South Korea or Taiwan (Tables 3A and 3B). Thus, the results suggest that both infrastructure and entry barriers affected innovation in the two countries, rather than simply concentration-based barriers.

This difference from concentration-innovation results in studies of more mature economies suggests that the competitive focus of concentration arguments is most relevant when market-based innovation infrastructures are present. In emerging economies, by contrast, the availability of firm-based innovation infrastructures may be at least as relevant as simple competition.

Moreover, both industry concentration and a second control variable—denoting the number of groups in an industry—show divergent results in South Korea and Taiwan. In South Korea, greater concentration and the presence of a greater number of groups each inhibits innovation. In Taiwan, by contrast, more concentration and more groups encourage innovation. Differences of group structure in the two countries may underlie these different influences. Groups in South Korea tend to be larger and more vertically integrated than their counterparts in Taiwan. Moreover, the group chair exercises nearly absolute power over strategic decisions in many groups in South Korea, while separate family members have greater independence to operate group affiliates in Taiwan. Thus, the South Korean *chaebol* function much as centralized hierarchies of large integrated corporations, while groups in Taiwan act more as coordinated networks of smaller specialized firms (Orrù et al. 1991). The greater hierarchy and intergroup similarity of South Korean groups may induce rigidities that make them more likely to attempt to maintain a competitive truce when they face the potential disruption of widespread intergroup competition or encounter entrenched competitors in a concentrated industry. By contrast, the network form and greater diversity of Taiwanese groups may provide flexibility and variety that encourage them to use innovation as a means of dealing with greater intergroup competition and make them more willing to attempt to dislodge dominant players in a concentrated industry.

We also provide two tests for the causal mechanisms that underlie the group-innovation relationship. First, by examining the moderating effects of technological opportunity on the relation between group market share and innovation, we provide a stronger test for the trade-off argument. We show that the negative effects of high group share rise as sector's technological opportunity rises, suggesting that the negative effects of entry barriers intensify when the benefits of variety are particularly high. Second, by examining the moderating effects of the importance of basic research on the relationship between group market share and innovation, we provide a test for the underlying argument that groups create innovation infrastructure. We observe that group share is particularly beneficial when basic R&D is high, which is when the need for innovation infrastructure is most pronounced. These two tests both provide a stronger case for causality and shape our understanding of how groups influence innovation.

The study has policy implications. Confronted with the recent economic crisis in Asia, business groups are under great pressure to restructure. The International Monetary Fund demands more transparent accounting practices as a condition for bailout, which might make it harder for groups to transfer funds internally via loans, debt guarantees, equity participation, and transfer pricing. This, in turn, may lead groups to break into independent companies. Despite the recent antigroup rhetoric in Asia, the inverted-U innovation curve suggests caution in this approach: As long as groups provide institutions that do not exist in developing economies, it may not be desirable to break them into independent companies, at least as long as market institutions remain weak. Instead, governments in emerging economies should promote rivalry and dissemination of new ideas, encouraging the groups to be more innovative. As countries such as South Korea and Taiwan approach their technological frontiers, the role of groups in enhancing technological advance may be as important as, if not more important than, their role in providing second-best solutions to market imperfections. At the same time, of course, it is important to recognize that groups contribute less as market imperfections decline and market-based institutions emerge. At some point of market evolution, groups may tend to have a primarily negative impact on innovation.

Clearly, additional research needs to examine innovation in emerging economies. We have focused on the positive and negative roles of business groups. In addition, of course, other actors may provide resources for innovation. For instance, multinational corporations or government-financed institutes sometimes can supplement or substitute for groups as providers of innovation infrastructure. Moreover, technological specializations within countries may arise from factors rooted in the structure of their economies. Important factors include sectoral specialization in industrial production and trade, the existence of domestic industries focused on exploitation of particular natural resources, specific structures of national demand and consumer tastes, and industrial policies that focus national activity in specific technological fields. Nonetheless, given the widespread presence of business groups in developing economies, we believe that this research provides useful assessment of their impact on innovation.

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Appendix 1. Industry Classifications

Industry name	SIC code(s)	ISIC code(s)
Food, other related products & beverages	20	311–313
Textiles, apparel, leather & footwear	22, 23, 31	321–324
Basic industrial chemicals (organic & inorganic)	281, 286	3511
Plastic materials & synthetic resins	282	3513
Agricultural chemicals	287	3512
Soaps, detergents, cleaners, perfumes, cosmetics, and toiletries	284	3523
Miscellaneous chemical products	289	3529
Drugs & medicine	283	3522
Petroleum, natural gas & related products	29	353–354
Rubber & plastic products	30	355–356
Stone, class, glass & nonmetal minerals	32	361, 362, 369
Ferrous & nonferrous metals	33	371, 372
Fabricated metal products	34(ex. 3462, 3463, 348)	381
Machineries (industrial & nonelectrical machineries)	351, 352, 353, 354, 355, 356, 358, 359	3821, 3822, 3823, 3824, 3829
Computers & office	357	3825
Electric industrial machinery, electric appliances & electrical misc.	361, 362, 363, 364, 369	3831, 3833, 3839
Electronics, radio, TV & communications equipment	365, 366, 367	3832
Motor vehicles & other transportation equipment	371, 372, 374, 375, 379	3843, 3842, 3844, 3845, 3849
Ship, boat building & repairing	373	3841
Professional & scientific equipment	38	385
Other manufactured products	99	390

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