Abstract: Business groups are important sources of innovation in emerging economies, but there is substantial heterogeneity in the extent of innovative activity by groups, both across groups and over time. Variation in the density of intra-group buyer-supplier ties that are common linkages among group affiliates may help explain the heterogeneity. Buyer-supplier ties create benefits for group innovativeness by offering access to resources, but also may constrain group innovativeness by creating an emphasis on local search. No research has examined how buyer-supplier ties affect group innovativeness, whether directly or conditional on factors that influence when local search will impose particularly strong constraints on group innovativeness and when any constraints will be less critical. We draw on evolutionary economic theory and related research to study how internal group structure and external market context affect the local search constraints of intra-group buyer-supplier ties. First, we argue that greater strategic scope of a group’s senior leadership structure relaxes the local search constraints that arise from closely-linked intra-group operations. Second, we argue that increased market development of the institutional environment increases the opportunity costs of local search. Our empirical contribution lies in demonstrating that strategic scope and market development affect the innovative impact of intra-group buyer-supplier ties through the local search mechanism, thereby increasing our understanding of business group innovativeness in an emerging market, both across groups and over time. Our conceptual contribution applies most centrally to the evolutionary economics literature, by identifying strategic scope as a means of escaping the constraints of local search and in examining how the institutional environment shapes the opportunity costs of local search.
Business groups are important sources of innovation in emerging market economies, which in turn contributes to economic and social development of those countries, but we understand little about why group innovativeness differs across groups and over time (Amsden and Hikino 1994; Hobday 1995; Chang, Chung, and Mahmood 2006). Business groups are sets of independent firms, operating in multiple industries, which are connected to each other by linkages such as buyer-supplier ties, director interlocks, and equity cross-shareholdings (Granovetter 1995; La Porta, Lopez-de-Silanes, and Shleifer 1999; Khanna and Rivkin 2001). A few studies have examined how intra-group buyer-supplier ties and other internal linkages affect group strategy and financial performance (Dyer 1996; Lincoln, Gerlach, Ahmadij 1996; Keister 1998, 2001), but no studies have examined how such ties affect group innovativeness. The technology studies literature offers a starting point for investigating differences in group innovativeness, by highlighting benefits and constraints on innovative activity that arise from operating linkages such as buyer-supplier ties. On the one hand, studies of buyer-supplier relationships among firms in developed economies by von Hippel (1988), Clark and Fujimoto (1991), and others suggest that extensive intra-group buyer-supplier ties might help groups combine disparate resources in novel ways. On the other hand, arguments about local search by Nelson and Winter (1982), Helfat (1994), and others in the evolutionary economics literature suggest that groups with extensive intra-group buyer-supplier ties may miss opportunities that arise outside the groups’ boundaries. The challenge, then, is to identify factors that shape the net innovative impact of resource benefits and local search constraints.

Evolutionary economic theory suggests two conditions under which internal group structure and external market context will either attenuate or increase the costs of local search. First, research arising from the behavioral theory of the firm (Cyert and March 1963), which underlies the intra-organizational arguments of evolutionary economics, suggests that the innovative benefits of intra-group buyer-supplier ties will be affected by what we refer to as a group’s strategic scope. We define strategic scope as the range of opportunities that the leaders of an organization can identify and assess, which will vary with the leadership structure of the organization (Ocasio 1997; Greve 2008). We predict that greater strategic scope will increase the innovative benefits of intra-group buyer-supplier ties, thereby reducing the costs of local search. Second, ideas from the literature on national innovation systems (Lundvall 1992; Nelson
1993), which provides an external context for evolutionary theory, suggest that the innovative benefits of intra-group buyer-supplier ties will be influenced by the level of market development of the institutional environment in which a group operates. The level of market development is the degree to which an institutional environment includes market-oriented institutions such as capital markets, labor markets, legal protections, and independent intermediaries (Nelson 1993; Khanna and Palepu 1997). We predict that greater market development will increase the opportunity costs of local search. We test the predictions by examining patenting activity by 263 business groups in Taiwan between 1981 and 2000.

**BUSINESS GROUPS AND INNOVATIVE ACTIVITY**

Business groups reflect elements of conglomerate holding companies and multidivisional corporations, creating what some theorists view as a network form of multi-business firm (Nohria and Eccles 1992; Powell and Smith-Doerr 1994; Podolny and Page 1998). Like conglomerates (Williamson 1985), groups provide corporate financial structures for businesses in multiple industries. Like multidivisional corporations (Chandler 1977), businesses within groups operate with a substantial degree of interdependence. Yet groups also differ from conglomerates and multidivisional corporations. Groups are more stable and coordinated than conglomerates, with founding families commonly exerting strong influence on affiliates (Hamilton and Biggart 1988). Groups are less centralized than most multidivisional firms (Granovetter 1995), meanwhile, because affiliates are responsible to their own shareholders, directors, and auditors. Thus, business groups in developing economies function as networks of loosely coupled firms (Powell and Smith-Doerr 1994), linked by formal economic arrangements such as intra-group buyer-supplier relationships, director interlocks, and equity cross-holdings, as well as by informal ties based on family, friendship, religion, language, and ethnicity (Khanna and Rivkin 2001; Gerlach 1992; Morck, Wolfenzon, and Yeung 2005; Chung and Luo 2008).

Scholars argue that the business groups substitute for weak market institutions in emerging economies (Caves and Uekusa 1976; Leff 1978). Groups help provide internal capital markets, labor markets, vertical intermediation, protection from opportunistic behavior, and other commercial support when a country lacks such market institutions (Khanna and Yafeh 2007). Chang and Hong (2000) show that group affiliation often assists individual firm financial performance in Korea by allowing resource
sharing among affiliates, while other studies demonstrate that groups in Chile and India can create value through product, labor, and capital market intermediation (Khanna and Palepu 2000a, 2000b).

A few studies have discussed business group innovation. Scholars studying the diffusion of industrialization argue that groups offer reputations and government ties that attract foreign technology providers, contributing to technological advance in their countries (Amsden and Hikino 1994; Hobday 1995; Kock and Guillen 2001). Claessens, Djankov, and Lang (2000) suggest that family ownership might provide long term perspectives, potentially creating a willingness to undertake R&D investments, although Morck, Stangeland, and Yeung (2000) find that Canadian firms controlled by heirs are significantly less active in R&D than comparable firms of the same age, size, and industry categories. Mahmood and Mitchell (2004) examine how group market share affects industry innovativeness in Korea and Taiwan from 1981 to 1995, showing that a mix of groups and independent firms provides infrastructure needed to carry out innovation as well as offer access to new ideas when groups have an intermediate market share in an industry. Chang, Chung, and Mahmood (2006) find that group affiliation in Korea and Taiwan offers greatest firm-level innovation benefits when a country has weak market-based institutional infrastructure, including restricted capital markets and limited availability of vertical intermediaries such as suppliers and distributors. Belenzon and Berkovitz (2008) demonstrate that group-affiliated firms in Europe tend to be more innovative than independent competitors. However, the literature has paid little attention to differences in groups’ innovative activity and how innovativeness varies over time.

**Intra-group buyer-supplier ties: Benefits and constraints on business group innovativeness**

The technology studies literature offers a starting point to explaining the differences in group innovativeness. This literature argues that innovative opportunities frequently arise by combining existing resources (Schumpeter 1934; Fleming 2001), which will be relevant for group affiliates that share operating ties. We are interested in the variation in opportunities for affiliates to exchange knowledge of goods and services. In turn, we focus on how buyer-supplier ties among affiliates will affect group innovativeness. By group innovativeness, we mean the aggregate innovative activity of a group’s affiliates. We examine aggregate group innovative activity because the benefits and costs of any given buyer-supplier tie can diffuse through a group, affecting innovative activity in multiple affiliates. We use
a density measure to assess how ties affect innovation, where intra-group buyer-supplier density
calculates the proportion of a group’s affiliated that have direct connections (Freeman 1977). Several
studies have used density measures to assess knowledge flows (e.g., Coleman 1990; Yamaguchi 1994).

Greater density of intra-group buyer-supplier ties can both facilitate and constrain groups’
innovative activity. Buyer-supplier ties are a form of operating tie, in which people from different
business units exchange resources and typically work together over time to manage their activities. Other
forms of operating ties include ongoing inter-organizational product development activities.

Operating ties such as intra-group buyer-supplier links may facilitate innovative activity by
creating knowledge of opportunities to combine resources that arise in disparate lines of business. Nelson
(1959) suggested that linkages among different types of activities within a multi-business firm could
create innovative opportunities, while Cohen and Klepper (1996) suggested that such ties might help
firms share costs across projects and Servaes (1996) identified potential benefits from internal capital
markets. Although subsequent research more commonly finds no diversification benefits or a
conglomeration penalty (Scherer 1980; Link and Long 1981; Hoskisson and Hitt 1988; Baysinger and
Hoskisson 1989; Stimpert and Duhaime 1997), empirical studies of diversification and innovation
typically do not examine the structure of operating ties within multi-business firms.

The technology studies literature suggests that active operating ties may help firms take
advantage of opportunities that arise across businesses. Some studies have focused on external ties, which
may help firms leverage partners’ complementary resources (Shan, Walker, and Kogut 1994; Koza and
Lewin 1998) as well as create channels that allow firms to take advantage of ideas from customers (von
Hippel 1988) and suppliers (Teece 1989; Clark and Fujimoto 1991; Cusumano and Takeshi 1991; Dyer
1996). Within a firm, meanwhile, Hansen’s (2002) study of knowledge networks shows that the presence
of operating ties in the form of direct working relationships facilitates transfer of tacit knowledge between
product development project teams working in different business units. These benefits will tend to be
greatest in stable operating relationships, because much of the knowledge that underlies innovative
opportunities involves information and complex organizational relationships that require developing
hands on interactions over time (Kogut and Zander 1992).
Resource access benefits will be relevant for business groups in developing economies, which commonly have stable relationships among affiliates that generate knowledge of technology and markets (Amsden 1989; Hobday 1995). The buyer-supplier mechanism for group innovation resides at the operating level, in which managers who are responsible for day-to-day activities interact across affiliates within groups and take advantage of what they learn during those operating exchanges. Amsden and Hikino (1994) refer to this as a project execution capability, which both facilitates current activity and increases the overall ability of group affiliates to generate innovations by building on those activities.

By contrast, evolutionary economic theory suggests that buyer-supplier relationships might constrain innovative activity by creating an emphasis on local search, potentially offsetting any resource access benefits. Local search is the tendency to seek new ideas within an organization’s existing activities, rather than look more broadly, whereas distant search involves looking beyond existing activities (Nelson and Winter 1982; Stuart and Podolny 1996). Local search occurs because firms attempt to preserve time and other resources by seeking ideas in the easiest locations, which typically fall within existing activities (Helfat 1994; Rosenkopf and Almeida 2003). Hansen (1999) shows that the presence of strong working relationships among actors across subunits of a firm can limit the scope of the actors’ search for ideas outside firm boundaries; he argues that the limits arise because close working relationships restrict time and energy available for search beyond familiar activities. In a related argument in the network literature, Uzzi and Spiro (2005) find that creativity (as measured by artistic reviews of motion pictures) eventually declines with the density of prior relationships among people engaged in creating a new product, although creativity initially increases until density reaches a threshold of over-embeddedness.

Local search can reduce innovativeness in two ways. First, local search limits the range of resources that a firm identifies to use in generating innovations (Nelson and Winter 1982). Second, local search limits the number of opportunities that a firm identifies to profit from potential innovations it might create, thereby reducing incentives to innovate (Nelson 1959). Empirical research shows that firms that emphasize local search face constraints on innovativeness (Rosenkopf and Nerkar 2001).

In the context of business groups, the idea of local search suggests that extensive intra-group buyer-supplier ties may reduce the degree to which firms seek ideas beyond group boundaries and so
deflate innovative activity. When groups have many buyer-supplier ties to manage, operating managers will have little time to expend on seeking ideas beyond the scope of those ties. Because of the conflicting resource access benefits and local search constraints, the issue lies in assessing contingencies that influence the benefits and costs of the ties.

**Using strategic scope to overcome the constraints of local search: Many eyes and minds**

Greater strategic scope may help groups with dense buyer-supplier ties avoid the constraints of local search. Scholars have long argued that senior managers play a key role in identifying opportunities, including innovation objectives (e.g., Chandler 1962; Levinthal and March 1981; Hambrick and Mason 1984; Huber 1991; Gavetti 2005). Clearly, potential opportunities arise throughout the customer (Von Hippel 1988; Christensen and Bower 1996), technological (Mishina, Pollack, and Porac 2004), and other external environments in which an organization operates, but organizations differ in their ability to take advantage of such opportunities. We draw on Ocasio’s (1997) attention based view of the firm to define strategic scope as the range of opportunities that the leadership of an organization can identify and assess.

The attention based view, which builds on the concept of bounded rationality within the behavioral theory of the firm (Simon 1955; March and Simon 1958; Cyert and March 1963) and evolutionary theory, suggests that individual managers face limits in their ability to focus on different opportunities and objectives. This point has arisen in the organizational strategy literature since at least Barnard’s (1939) seminal arguments. More recently, Greve (2008) argues that an organization’s leadership can focus on only a limited number of issues at a time. However, differences in organizational structure will lead to differences in the range of opportunities that organizations are able to consider.

Ocasio (1997) highlights the idea that variation in the division of labor within an organization will affect the opportunities that the organization recognizes and responds to. In our terms, variation in an organization’s senior management structure will cause differences in the degree of strategic scope that a firm possesses. A multi-divisional firm with several divisional heads who each have strategic responsibilities, for instance, will tend to see more opportunities than a more hierarchically-organized firm in which a single senior manager is responsible for strategic activities (Burns and Stalker 1961). Similarly, a business group with separate and independent leadership of most affiliates will tend to
recognize a wider range of opportunities that arise in both the internal and external environment than a group with a more centralized and overlapping structure. In turn, such variation in leadership structure will lead to variation in the opportunities that the organization pursues.

In the business group context, the number of people who serve as senior directors of affiliates will influence the degree of strategic scope that a group enjoys. The director of an affiliate with the title “chairman of the board” is comparable to a chief executive officer of a firm (Chung and Luo 2008). One of the main tasks of the board chair is to identify and respond to opportunities and threats in the competitive environment, in contrast with the job of operating managers who focus more directly on implementing current activities. Some business groups have a single board chair or small number of people who serve as the equivalent of CEOs for all affiliates. In other groups, by contrast, different people act as board chairs for most or all affiliates.

To foreshadow the analysis, we will use a centralization calculation based on the structure of intra-group interlocks of the board chairs (the senior directors) as the measure of strategic scope. Lower centralization (greater sparseness of senior director interlocks) corresponds to greater strategic scope of the group. That is, groups with proportionally fewer shared board chairs among their affiliates have lower senior director centralization, which means that a larger proportion of affiliates have independent senior leaders. In turn, the independent leaders provide greater strategic scope for the groups.

Limited strategic scope can inhibit innovativeness, while greater scope can facilitate innovative activities. Information overload among leaders may inhibit ability to share information among affiliates. By contrast, groups with more widely dispersed senior leadership (i.e., groups with greater strategic scope) will tend to be able to identify and assess a wider range of opportunities. This idea is consistent the idea that organizational autonomy creates the ability to seek independent opportunities (Weick 1976; Daft 1982). In turn, greater strategic scope helps overcome the constraints of local search because having more strategic eyes and minds helps groups conduct distant search.

Distant search creates two opportunities. First, distant search helps identify external opportunities to use innovations that arise from a group’s internal resources, thereby increasing incentives to pursue the internal innovations. Second, distant search identifies external resources that the group can combine with
internal resources in order to create new goods and services, again increasing the potential for innovation.

In turn, strategic scope will help to overcome the two innovative limits of local search by facilitating distant search. First, groups with greater strategic scope will be better able to identify a wider range of technologies that they can combine with the knowledge that arises from their intra-group buyer-supplier ties. Second, the groups will be able to identify a wider range of market opportunities for the innovations they create, thereby increasing incentives to use resources for innovation. In a non-group setting, Schilling and Phelps (2007) identify innovative advantages for firms that have both a dense set of focal partners and a more widely dispersed set of other partners; in our logic, this combination provides knowledge of local opportunities together with the distant search benefits that arise from strategic scope.

In business groups, board chairs are particularly well positioned to provide the vision needed to take advantage of operating ties, because their job typically involves extensive interactions with a wide range of external and internal constituents (Chung and Luo 2008). Strategic scope based on senior director autonomy helps match innovation opportunities with market opportunities. Because strategic scope helps address the two constraints of local search, the net innovative benefits of intra-group buyer-supplier ties will increase, where the net innovative benefits are the degree to which a given density of buyer-supplier ties contributes to business group innovativeness. Thus, for a given level of buyer-supplier density, greater strategic scope reduces the marginal cost of density by reducing local search constraints.

**Hypothesis 1.** The greater the strategic scope of a business group, the greater the net innovative benefits of intra-group buyer-supplier ties.

We note that strategic scope by itself has uncertain impact on group innovativeness. Although strategic scope facilitates distant search, greater strategic scope may also increase coordination costs within groups, which could counteract the innovative benefits of distant search. Coordination costs commonly increase as the number of decision makers increases (Ahuja 2000; Dhanaraj and Parke 2006). Rather than a direct effect, then, greater strategic scope has a predictive impact via its influence on the innovative impact of intra-group buyer-supplier ties. This prediction assumes that any rise in coordination costs would not affect the net innovative impact of buyer-supplier density because the costs and benefits of density arise from local search and resource access, rather than from coordination. In turn, though, the aggregate innovative impact of greater strategic scope for a given level of buyer-supplier density would
combine the joint effect of strategic scope and buyer-supplier density (positive) with the main effect of strategic scope (uncertain), which we will examine empirically.

**Market development of the institutional environment: The opportunity costs of local search**

Studies of national innovation systems suggest four institutional factors that support innovative activity: availability of capital markets, labor markets, vertical intermediaries, and reliable legal frameworks. Capital markets offer financial support for innovative ideas (Lundvall 1992; Ghemawat and Khanna 1998; Gompers and Lerner 2001). Labor markets facilitate movement of people needed to develop ideas (Saxenian 1994; Mahmood and Mitchell 2004). Vertical intermediaries such as suppliers, complementary firms, and distributors help identify and take advantage of innovative ideas (Caves and Uekusa 1976; Porter and Stern 2002). Reliable legal frameworks create incentives to innovate because firms believe that they will profit from successful efforts (Edquist 1997; Kortum and Lerner 2000).

Markets with limited institutional development will have two characteristics. First, overall innovative activity will tend to be lower (Nelson 1993). Second, business groups will be common, because the group organization helps substitute for the missing market-level institutions. That is, groups provide internal capital markets, internal labor markets, and business intermediation, as well as offering protected environments in which to conduct business (Leff 1978; Khanna and Palepu 1997).

As a country increasingly adopts market-oriented institutions, greater availability of external resources will reduce the marginal benefits of intra-group buyer-supplier ties. Firms that emphasize internally-generated innovation will miss opportunities to use resources that are increasingly available in the external environment. Hence, local search imposes few opportunity costs when there are few external opportunities, but the opportunity costs increase as the market environment develops.

The increased opportunity cost of local search arises for two reasons. First, it is difficult simply to add distant search to existing local search routines. Hansen (1999) argues that limited availability of managerial time restricts the ability to add search activities that would identify opportunities beyond the boundaries of an operating unit. Second, path dependencies and inertia of organizations create constraints in substituting distant search for local search, because firms become trapped in prior relationships and prior ways of operating (Hannan and Freeman 1989; Uzzi 1996). Thus, faced with limited time, money,
and people to use for search activities, coupled with path dependencies in traditional local search activities, local search will tend to crowd out distant search activities (Dosi 1988). If a high reliance on intra-group buyer-supplier ties causes an inward focus on internal operations, then such groups will incur innovation constraints relative to groups that do not have an internal focus when the number of external opportunities increases. By contrast, groups that have few buyer-supplier ties and so are less likely to emphasize local search will have more alternative sources of resources that they can use for innovation as market development proceeds, so that the innovative benefits of distant search will increase.

As a result, although market development may raise the overall level of innovative opportunities in the environment, it will reduce the net innovative benefits of intra-group buyer-supplier ties. Whether intra-group buyer-supplier ties cease to offer benefits at some level of market development is an empirical question; the key point is that the marginal benefits will decline as market institutions develop.

**Hypothesis 2.** The greater the market development of the institutional environment in which a business group operates, the lesser the net innovative benefits of intra-group buyer-supplier ties.

The analysis will investigate additional combinations of these factors. Market development might increase the benefits of strategic scope by offering more innovative opportunities for business leaders to identify. Whether a combination of strategic scope and market development alone is sufficient to generate opportunities for a group, however, or whether the group also needs to have internal resources to apply to the opportunities is an open question. That is, greater strategic scope might help eliminate the opportunity costs of local search that arise for groups with extensive buyer-supplier ties in developed markets.

In sum, we expect the innovative benefits and costs of local search that arise from intra-group buyer-supplier ties to vary depending on strategic scope and the market development of the environment in which a group operates. Greater strategic scope among the senior leaders of a group reduces the constraints of local search, while greater market development of the institutional environment increases the opportunity costs of local search. Group innovativeness will vary across groups, based on differences in buyer-supplier ties and strategic scope, and over time, based on changes in market development.

**BUSINESS GROUPS IN TAIWAN**

Groups play important roles in Taiwan. Group activity in Taiwan involves many industries, including electronics, industrial equipment, chemicals, plastics, construction, wholesale trade, data
processing, food, financial services, real estate, and life sciences (Orru, Biggart, and Hamilton 1991). Sales of the top 100 groups accounted for about 85% of GDP in 2002 (Chung and Mahmood 2006).

Of interest to this study, groups played key roles as innovators during a period in which Taiwan moved from being primarily a technology importer to becoming an important global source of technical advance in many industries during the 1980s and 1990s (Hobday 1995; Ernst 1998). Between 1990 and 1999, business group affiliates received about 40% of the US patents awarded in Taiwan. Moreover, between 1970 and 1999, the U.S. Patent and Trademark Office reports that seven of the top ten Taiwan-based recipients of U.S. patents were affiliates of six business groups, including the UMC, TSMC, Walsin Lihua, Hon Hai, Mosel Pacific, and Acer groups. Many of the top patenters operated in the semiconductor, electronics, and industrial equipment sectors; in addition, some of the groups are leading patenters in sectors such as metals (China Steel Group), bicycles (Giant Group), and chemicals (Formosa Plastics Group). There is substantial variation in patenting for different groups within industries.

Groups in Taiwan have extensive variety in buyer-supplier and director ties, which offers a rich context in which to study how operating linkages and strategic scope affect innovativeness. Moreover, Taiwan offers clear definitions of group membership for identifying ties. Khanna and Rivkin (2006) suggest that group boundaries are ambiguous in countries such as Chile, while Saxonhouse (1993) and Weinstein and Yafeh (1995) note that *keiretsu* boundaries in Japan are often obscure. In Taiwan, by contrast, strong cultural foundations such as regional kinship and family connections delineate group boundaries clearly (Numazaki 1986). The major coordination mechanisms inside most Taiwanese groups involve relationships among leaders (Hamilton and Kao 1990; Hamilton 1997:265). Buyer-supplier ties and interlocking board chairs facilitate coordination and are likely to influence innovative activities within Taiwanese business groups, as well as groups in many other emerging markets. Supplemental material available from the authors provides examples of benefits and constraints in Taiwan.

Taiwan underwent a substantial market-based evolution in its institutional environment during the period of study. Amsden and Chu (2003) and Chung and Mahmood (2006) highlight advances in capital

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1 Taiwan’s Industrial Technology Research Institute (ITRI) also contributes to innovation by supporting small and medium sized enterprises, but groups initiate innovative activity independent of ITRI (Mahmood and Singh 2003).
markets and other elements of market infrastructure that occurred between the 1970s and the late 1990s. These changes offer an opportunity to study how market development affects group innovativeness.

**DATA, MEASURES, AND STATISTICAL METHOD**

Our major data source is the *Business Groups in Taiwan* (BGT) directory, compiled by the China Credit Information Service (CCIS) in Taipei (an affiliate of Standard & Poor’s). BGT offers the most comprehensive and reliable source of business group data in Taiwan. BGT reports data on the top 100 or more groups (sales), assessing groups whose principal firms are registered in Taiwan. CCIS defines a business group as a *coherent business organization including several independent enterprises*. According to BGT, the top 100 groups contributed 42% of national GDP in the 1990s. The BGT records supply links, interlocking directorates, and cross-shareholdings. Several studies rely on BGT (Hamilton and Biggart 1988; Claessens, Djankov, Lang 2000; Chung 2001; Khanna and Rivkin 2001; Feenstra 1997), although none has translated and coded the intra-group ties.

The BGT provides information about groups in Taiwan for five calendar years: 1981, 1986, 1990, 1994, and 1998. Our initial sample included 592 group-year cases (267 unique groups, with 3,500 unique affiliates). Manufacturing sector affiliates produce about three-quarters of total group revenue, with the balance from service sector affiliates. We included service firms in the measures of ties because service activities can contribute knowledge needed for innovation. The final sample, after excluding cases with missing data, included 576 group-year observations (263 unique groups).

The BGT includes figures for each group that depict intra-group buyer-supplier relationships, shared directorships, and equity cross-holdings. The figures report the information in traditional Chinese script, Fan-ti-zi (mainland China uses a simplified form of Mandarin script, Jian-ti-zi). One of the co-authors, who reads Fan-ti-zi fluently, led the translation. Translators read the volumes, identified groups and affiliates, and transcribed financial information about each affiliate.

**Dependent variable**

We use Taiwan patent data to measure innovative activity. Patents are imperfect measures because they record only portions of firms’ innovative activities and are used differentially across industries (Schilling and Phelps (2007) discuss the limits of patents). Nonetheless, patents provide a comparison of
activities across firms, with meaningful results if one controls for as many sources of heterogeneity as possible and interprets the results carefully. Patents are most relevant for industrial sectors that rely on relatively discrete innovation in products and processes, rather than innovation in more complex business models. Fortunately, in our case, patenting activity is common across many industrial sectors in Taiwan. Yu’s (1998) study of Taiwan’s Hsinchu Science Park found effectiveness across a wider variety of industries than in the U.S., where patents are most common in chemical-based industries (Levin, Klevorick, Nelson, and Winter 1987; Cohen, Nelson, and Walsh 2000). We focus on local patents because we are interested in overall innovative activity rather than activity only by Taiwanese firms registered in the U.S. Because patenting abroad is more expensive than patenting domestically, focusing on U.S. patents would bias the analyses toward larger firms and firms that export heavily to the U.S.

Taiwan established its patent system in 1945. Taiwanese patent examiners follow standards similar to U.S. examiners regarding patentable inventions (Yang 2004). In accordance to the Trade Related Aspects of Intellectual Property Rights agreement of the World Trade Organization, Taiwan restructured its patent systems in 1994, extending a patent’s life from 15 to 20 years.

We collected information about patenting by business group affiliates from online databases of the Intellectual Property Office (http://www.patent.org.tw), which covers all patents filed in Taiwan since 1950. We entered the name of each affiliate in traditional Chinese script into the database to identify patent applications. We coded patent identification numbers, application and approval dates, and patent types. We focused on “New Invention Patents”, which the Intellectual Property Office of Taiwan defines as innovations involving wholly new products, materials, or manufacturing processes.

The dependent variable (Group patent applications) is the aggregate patent application counts by all affiliates of each group over a two-year period following each of the five years for which the BGT directory provided data. We identified new invention patent applications for ten years (1982-1983, 1987-1988, 1991-1992, 1995-1996, 1999-2000). The two-year periods provide sufficient activity for analysis (sensitivity analyses found equivalent results with one-, three-, and four-year patent windows). We lagged the independent variables because patents applications typically correspond to activity preceding the application. For explanatory variables in 1981, for instance, the dependent variable includes patent
applications for 1982 and 1983. In total, the study uses 2,562 new invention patent applications.

**Focal covariates: Buyer-supplier density, strategic scope, market development**

*Buyer-supplier density* measures intra-group buyer-supplier ties. Buyer-supplier density is the ratio of actual buyer-supplier relationships to the number of potential ties among affiliates in a given year.

Strategic scope used a centralization measure based on shared board chairs. Centralization reflects the extent to which intra-group ties are organized around the most central point or points (Freeman 1977). Centralization is an extension of the concept of point centrality, which refers to the centrality of individual affiliates in the network. For a given group network, network centralization is given by:

\[
NC_g = \frac{\sum_{i=1}^{N_g} (C_{\text{max},g} - C_{ig})}{\max\left[\sum_{i=1}^{N_g} (C_{\text{max},g} - C_{ig})\right]}
\]

\(C_{ig}\) is the centrality (number of direct ties) of affiliate \(i\) of business group \(g\); \(C_{\text{max},g}\) is the largest centrality of an affiliate within group \(g\); \(N_g\) is the number of affiliates of group \(g\). The measure gauges homogeneity and heterogeneity in the centralities of affiliates (Wasserman and Faust 1994). Centrality lies between 0 and 1: 0 when all affiliates have the same centrality index and 1 if one affiliate dominates the others.

Among the various measures of centrality, we chose degree centrality (the number of direct ties) rather than other measures (e.g., closeness or betweenness centrality) due to the small size of our networks (the mean number of affiliates in our data is 9.0). In small networks, centrality measures that include indirect ties are less efficient than degree centrality (Freeman 1977). We created a degree centrality measure by counting the number of cases in which affiliates had a common board chair (functionally equivalent to a CEO). We operationalized *Strategic scope* as a sparseness measure equal to one minus the average difference between the centrality of the most central affiliate and that of all other affiliates.

Table 1 summarizes the sample, reporting time trends in number of groups and affiliates, patent applications, intra-group buyer-supplier density, strategic scope, and market development. The later data, especially 1998, includes more groups because the BGT increased its reporting coverage (we test the sensitivity of the results to this difference). The mean number of affiliates per group increased slightly over time. The number of patent applications grew substantially during the last two periods of the study.
Buyer-supplier tie density dropped substantially during the study period, which reflects the increase in the mean number of affiliates. Director sparseness (1 minus director centralization) remained stable during the period; sparseness was high overall (mean=0.96) but exhibited sufficient variation to provide meaningful differences across groups (within a range from 0.87 to 1.0, as Table 2 later reports).

********** Table 1 about here **********

*Market development* used four factors, based on our earlier discussions, measuring each of the items in each period of the study. In contrast with studies that have used linear time trends to measure increased market development (e.g., Khanna and Palepu 2000a), we measured the market development of the institutional environment in Taiwan more directly. *Stock market trading volume* assessed capital market development. The *number of for-profit organizations* operating in the country assessed the availability of commercial intermediaries. The *number of graduates of universities* in Taiwan indicated the extent of the external labor market. Finally, the *number of points* that the *World Competitiveness Report* awarded Taiwan assessed the strength of its legal protection. To create the market development measure, we took the mean value of the growth multipliers for each item after the first time period.

Each of the four elements of the institutional environment grew substantially during the period, resulting in a non-linear increase in the market development measure. Because stock market trading volume exhibited the most explosive growth, we conducted sensitivity analysis with a market development variable that deflated the impact of stock market trading volume, finding robust results. We also found that several other possible measures of external capital market development cited in the *World Competitiveness Report* correlated highly with stock market trading volume, including venture capital availability (r=0.98), cost of capital (r=0.97), credit flow (r=0.92), and local capital market access (r=0.85). The market development measure provides a useful indicator of institutional changes in Taiwan.

One issue is the degree to which strategic scope, market development, or buyer-supplier density might arise endogenously from a group’s innovative activities or from other factors that might be the actual cause of the innovative activities. The stability of director sparseness over time, despite increasing patent activity, suggests that endogeneity between strategic scope and innovative activity is not a substantial issue. Market development undoubtedly reflects the maturation of group activities, but growth
in labor markets, intermediaries, capital markets, and legal protection is beyond the control of any one group. For buyer-supplier ties, meanwhile, lower density associates with greater diversification, so that a question is whether any innovative impact of buyer-supplier ties actually reflects benefits that arise from greater variety of resources of diversified firms or disadvantages that arise from greater coordination costs. The analysis will assess the comparative effects of diversification and buyer-supplier density. Our focus on the interaction of buyer-supplier density with strategic scope and market development, rather than on the direct effects of the variables, also helps assuage endogeneity concerns, because the joint effects are less likely to arise from other causes.

We created two interaction variables to test the hypotheses. \( BSD \times SS \) is buyer-supplier density times strategic scope. \( BSD \times Mkt \) is buyer-supplier density times market development.

**Control variables**

We created time-varying control variables, recorded in the same years as the focal covariates. Two variables recorded other elements of intra-group structure: the density of equity cross-shareholding (\textit{Group equity density}: Proportion of affiliates with cross-shareholdings) and director interlocks (\textit{Group director density}: Mean affiliates per director). Including director density also ensures that any effects of strategic scope (director sparseness) do not arise from underlying effects of density (although strategic scope has low correlation with director density; \( r = -0.15 \)). Other variables recorded internal resource availability (\textit{Group assets}, in billions of New Taiwanese Dollars), competitiveness (\textit{Group industry concentration}: Industry-weighted mean of the five-firm concentration ratio), R&D intensity (\textit{Group industry R&D}: Weighted average of industry-mean R&D of a group’s affiliates), founding family control (\textit{Family share of directors}: Proportion of affiliates whose top executives are founding family members), and links that might substitute for internal ties as sources of resources (\textit{International linkages}: International joint ventures, licenses, acquisitions, foreign direct investments). \textit{Group pre-sample patents} (number of patents that a group received prior to 1981) addressed prior innovative capability. Sensitivity analysis also used the number of affiliates in each group (correlation with assets: \( r=0.49 \)) and the period that groups entered the data (correlation with market development: \( r=0.60 \)).
We recorded group diversification based on an entropy calculation (Palepu 1985) using 2- and 4-digit Taiwan SIC codes. Simply adding diversification as a control variable would raise issues of endogeneity with buyer-supplier density, however, both because buyer-supplier ties can inhibit diversification and because extensive diversification can lead to fewer buyer-supplier ties, as reflected in a correlation between buyer-supplier density and entropy-based diversification ($r = -0.34$). Therefore, we normalized the diversification variable by dividing the entropy measure by the number of ties within the group; *Group diversification (normalized)* has low correlation with buyer-supplier density ($r = -0.10$).

Table 2 reports descriptive statistics. Family share of directors correlates with group director density ($r = 0.63$), while negative correlations arise for market development with industry concentration ($r = -0.48$) and buyer-supplier density ($r = -0.31$); buyer-supplier density and industry concentration also correlate with time period. Sensitivity analyses assess robustness to the correlations.

**Method**

The count nature of our dependent variable (number of patents), together with over-dispersion of values of the variable, suggests using negative binomial regression for the analysis (Hausman, Hall, and Griliches 1984; Gurmu and Trivedi 1994). Because the dependent variable includes many zeros (only 26% of business groups patented during the period), we adopted Zero-Inflated Negative Binomial (ZINB) regression (Mullahy 1986; Lambert 1992). ZINB regression separates two regimes that may generate zero outcomes. In regime 1 (the “inflation” regime), the patent outcome is always zero, reflecting the fact that some firms never patent. In regime 2 (the “count” regime), the usual negative binomial process applies, including the fact that some firms generate no patents in some years and positive counts in other years (an alternative approach of examining only groups that patented would risk sample selection bias). Greene (2003: 779-780) demonstrates that ZINB outperforms standard negative binomial when regime-splitting is needed, which a significant Vuong statistic indicates arises with our data.

**RESULTS**

Table 3 reports the results. Model 1 contains the control variables, while subsequent models add interaction variables to test the hypotheses and explore the results. The $LLR$ (log-likelihood ratio) $chi$-
**square** statistic indicates that the models provide statistically significant explanatory power, while the **LLR change** statistic demonstrates improved explanatory power versus nested models.

************ Table 3 about here **********

Panel B of the models estimates influences on whether a group will undertake patent applications during the study period. ZINB models typically include a moderate number of variables in the inflation panel (Long 1997). We included the three primary conceptual variables (buyer-supplier density, strategic scope, market development) to ensure that any “count” effects associated with our focal concepts did not arise from tendencies to be a patenter (“inflation” effects). We also included inflation covariates that reflect the technological emphasis of a group’s businesses (Group industry R&D, Group pre-sample patents), competitive conditions (Group industry concentration), and group characteristics that might affect the likelihood that a firm would have resources needed for patenting (Group assets, International linkages, Family share of directors). Panel B in model 1 shows that the likelihood that a group would be a patenter increased with group assets, the R&D intensity of the industries in which the group operated, international linkages, and pre-sample patents; subsequent models report similar results.

Panel A then reports influences on how many patents a group files in a given two-year window, conditioned on the fact that it filed at least one application during the study period. In addition to the main effects of the three focal variables, Panel A includes variables for director and equity density, assets, international linkages, industry concentration, diversification, and pre-sample patents. We later report sensitivity analyses that find robust results with other control variables.

Model 1 shows that greater buyer-supplier density leads to lower patent applications (p<0.01), suggesting that local search constrains the innovative activity of groups with extensive operating ties. Neither strategic scope nor market development has a significant main effect on patenting. Among the other variables, industry concentration and group diversification reduce group innovativeness, while equity density and pre-sample patents contribute to group innovativeness. The positive effect of equity density is consistent with Belenzon and Berkovitz’s (2008) study of business groups in Europe.

Models 2a, 2b, and 3 test hypotheses 1 and 2 by adding interactions of buyer-supplier density with strategic scope (BSD x SS) and with market development (BSD x Mkt). Models 2a and 2b add the
interactions separately, while model 3 includes both interaction terms. Each of the models provided increased statistical fit (p<0.01 or p<0.05), based on the change in the LLR chi-square v. nested models.

The results in Table 3 support both hypotheses. Consistent with hypothesis 1, greater strategic scope increases the marginal benefit of buyer-supplier density (BSD x SS; p<0.10 in model 2a, p<0.05 in model 3). The result suggests that strategic scope helps groups escape from local search traps that internal operating ties can create. In turn, consistent with hypothesis 2, market development reduces the marginal benefit of buyer-supplier density (BSD x Mkt; p<0.10 in model 2b, p<0.01 in model 3). The pattern suggests that the opportunity costs of local search become particularly pronounced as the institutional environment increasingly supports market-based innovative efforts.

Model 4 reports exploratory analysis that added the three-way interaction of buyer-supplier density and the two conditioning factors (BSD x SS x Mkt), along with the two-way interaction of strategic scope with market development (SS x Mkt). The most intriguing result in model 4 is the significant positive coefficient on the BSD x SS x Mkt variable (p<0.01), in contrast with the negative coefficients for BSD x SS (n.s.) and BSD x Mkt (p<0.01). The positive three-way interaction suggests that greater strategic scope helps groups with extensive buyer-supplier ties overcome local search constraints when opportunity costs arise as market development occurs.

Model 4 also reports a negative effect for SS x Mkt (p<0.01), showing that the benefits of strategic scope decline as external institutions become more developed (a model that added only the SS x Mkt two-way interaction to model 3 produced a similar result). This result may seem counter-intuitive, because one might expect strategic scope to offer greater innovative benefit as the market environment expands, but the negative coefficient suggests that internal coordination involving multiple leaders may become more difficult as the external environment becomes more complex.

Models with multiple interactions can be difficult to interpret. Therefore, we plotted the joint effects of buyer-supplier density, strategic scope, and market development from model 4 to examine how they work together to influence group innovativeness. Figures 1a to 1c depict the results. The most intriguing region of these figures lies at the rear-right, which combines high buyer-supplier density with low strategic scope. High buyer-supplier density combined with low strategic scope moves from being at
least on par with other combinations when market development is low (Figure 1a) to a strong
disadvantage as development of market-oriented institutions occurs (Figure 1c). The pattern helps
demonstrate how local search and its moderators affect innovative activity.

********** Figures 1a, 1b, and 1c about here **********

Sensitivity analyses

Several sensitivity analyses demonstrated robustness. First, models 5a and 5b test sensitivity to the measurement of the market development variable. Model 4 reflected a non-linear measure of market development trends. Model 5a finds similar results with a less dramatic non-linear market development measure that uses only 50% of the capital market growth element of the four items in the measure (other non-linear market development growth estimates, such as a measure based on the square of time, produced similar results). Model 5b uses linear time as the market development measure, again with similar results. We also tested model 3 with the two alternative market development variables, finding similar results to those reported, including statistically significant support for both H1 and H2 (p<0.01).

Second, we investigated whether the benefits of group equity density (ED) declined as the market became more developed (ED x Mkt), either in addition to the effects of BSD x Mkt and BSD x SS or in place of them. Although it would be straightforward to predict that the benefits of internal equity ties will decline as market institutions emerge, such a hypothesis lies outside our conceptual focus on buyer-supplier ties and local search. Therefore, we explore the effect as an empirical issue to determine whether any such influences substitute for the observed moderations of BSD. Estimates that added ED x Mkt to model 1 found a significant negative effect (p<0.05), which remained moderately significant when we added ED x Mkt to model 3 (p<0.10). At the same time, BSD x SS (p<0.01) and BSD x Mkt (p<0.05) remained significant when model 3 added ED x Mkt, so that any conditioning effect of market development on equity density does not substitute for the focal effects of BSD.

Third, we varied the control variables in model 3. The predicted results were robust when we dropped any or all of the control variables. Similarly, the predicted results were robust to adding Group industry R&D (positive, p<0.10), Family share of directors (n.s.), Number of affiliates (n.s.), and Period of first group entry (positive, p<0.01). We also tested for non-monotonic effects of buyer-supplier density,
following Uzzi and Spiro (2005), finding a negative impact of both density and density squared.

Fourth, we tested H1 and H2 using one-, three-, and four-year patent windows, rather than two-year windows. We found similar support for both hypotheses for the alternative patent windows.

Fifth, we tested H1 and H2 using only the top 100 groups based on sales in all years, to test sensitivity to the larger number of groups in the later years. The results supported both hypotheses.

Sixth, it is possible that the combined impact of high operating density and high strategic scope on innovation arises from financial autonomy. High financial autonomy might reflect high strategic autonomy, high operating density (if groups use buyer-supplier ties to stabilize performance in the absence of a highly central holding company that stabilizes performance by moving funds among affiliates), and high innovativeness (if tight financial control constricts innovative activity). Nonetheless, the results are equivalent when we control for financial autonomy (1 minus equity centralization).

Finally, we assessed how changes in density and scope from period i to period i+1 affected change in patenting activity from the two years after period i to the two years after period i+1. The analyses controlled for non-normalized group diversification, change in diversification, other controls, and group-specific fixed effects. Using multiple model specifications (available on request), we found that increased buyer-supplier density led to fewer patent applications (p<0.05); conversely, therefore, reduced buyer-supplier density leads to more patent applications. The result is consistent with the idea that reducing the density of operating ties creates an increased emphasis on distant search that helps identify innovative opportunities, reinforcing the local search logic underlying the buyer-supplier mechanism. Thus, the trend to reduced reliance on intra-group buyer supplier ties that occurred during the study period appears to have facilitated groups’ increased innovativeness. By contrast, changes in strategic scope had no significant impact on change in patenting. The lack of impact likely arises because strategic scope was more stable that buyer-supplier density during the study period, as Table 1 showed.

**DISCUSSION**

This study sought to explain variation in business group innovativeness. We find that intra-group buyer-supplier ties are most likely to contribute to innovative activity at early stages of institutional market development. As market institutions emerge, density of intra-group buyer-supplier ties can then
constrain innovative activity, particularly when a group’s senior leadership is highly concentrated. Such limits on strategic scope appear to inhibit a group’s ability to recognize external opportunities. Thus, the factors shaping group innovativeness change substantially as markets evolve.

The results have implications for business group strategy in dynamic environments. The work shows that characteristics that contribute to innovation under one set of conditions may become millstones as conditions change. In pre-market environments, groups can benefit from intra-group buyer-supplier ties because few external options are available or, even if available, may not be trustworthy. A dense set of internal buyer-supplier ties initially provides access to reliable goods and services in environments that lack market intermediaries without strongly constraining a group’s innovativeness relative to other groups. As the environment becomes more market-oriented, however, internal linkages become less necessary as sourcing options and may impose constraints on innovation. Groups that do not shift from an internal sourcing strategy and/or centralized leadership structure as external sources become available and as market conditions will support external activities will suffer as innovators and, in turn, face competitive disadvantages in an environment that favors technological advance. The economic experience in Japan during the 1990s provides an obvious example of these problems, as groups that once were drivers of national expansion found it difficult to adapt as they increasingly competed in open markets; indeed, the country as a whole suffered because of the widespread corporate rigidity. Similarly, Morck and Yeung (2004) and Fogel, Morck, and Yeung (2008) argue that over-emphasis on group structures can inhibit innovation in advanced economies.

The work contributes to evolutionary theory by identifying factors that shape the constraints of local search. Recent research suggests that firms can overcome local search constraints via managerial mobility and intra-firm alliances (Rosenkopf and Nerkar 2001; Rosenkopf and Almeida 2003). This study identifies an additional mechanism for overcoming local search traps, highlighting the scope of attention that senior management can provide in assessing strategic opportunities. Moreover, the study shows that the opportunity costs of local search become stronger as a country’s innovation infrastructure becomes established. Even as market institutions emerge, though, greater strategic scope can help relieve opportunity costs that would otherwise penalize firms with extensive operating ties.
The work has limitations that point to additional research. We focus on one country that has undergone only a partial transition to market-orientation. We examine only a limited measure of innovative activity, based on patent applications. We lack data on group R&D activity and intra-group R&D ties (although industry-level R&D and prior patenting activity provide meaningful controls). It would also be useful to incorporate informal linkages of intra-group structure.

An additional intriguing issue in our context is that group structure might affect incentives to use patents as opposed to other forms of protecting new technology. For example, a group with more linkages will have greater transactional complexity and so may rely more contracts and/or relationships with its affiliates rather than patents. Although such an explanation would apply to the negative main effect of buyer-supplier density, however, it would not explain the positive main effect of equity density. Moreover, it is not clear that this explanation would affect the interactions of buyer-supplier density with strategic scope and market development, which we focus on. This is an intriguing point for continuing research.

Other extensions would be useful. One could examine how groups achieve lower buyer-supplier density over time, where mechanisms include cutting existing ties, adding new affiliates that do not have ties, or via the entry of new groups with lower operating density. It would also be helpful to investigate more general implications for multi-business firm innovation.

Business groups have been key actors in many emerging market economies, including Germany and England in the 19th century, the U.S. and Scandinavia in the early 20th century, Japan in the mid-20th century, South and East Asian countries such as India, Korea, and Taiwan in the late 20th century, and Southeast Asian economies such as Malaysia and Thailand in the 21st century. Understanding differences in groups’ roles as innovators, both across groups and over time, is central to understanding trajectories of technological development.
REFERENCES


Table 1. Business groups in Taiwan, 1981-1998: Affiliates, patent applications, buyer-supplier density, strategic scope, and market development

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of groups</th>
<th>Number of affiliates (mean per group)</th>
<th>Patent applications by business groups: Two-year period after base year (mean applications per group)</th>
<th>Mean intra-group buyer-supplier density</th>
<th>Strategic scope: Mean intra-group director sparseness</th>
<th>Market development of the institutional environment: Relative magnitude *</th>
<th>Capital markets: Stock market trading volume ($US million)</th>
<th>Commercial intermediaries: No. of for-profit organizations</th>
<th>External labor market: Number of university graduates</th>
<th>Legal protection: No. of points in world competitiveness report **</th>
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<td>1981</td>
<td>100</td>
<td>716 (7.2)</td>
<td>162 (1.6)</td>
<td>0.22</td>
<td>0.967</td>
<td>1.0</td>
<td>13.2 (1.0)</td>
<td>608,658 (1.0)</td>
<td>32,102 (1.0)</td>
<td>3.3 (1.0)</td>
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<td>1986</td>
<td>97</td>
<td>749 (7.7)</td>
<td>143 (1.5)</td>
<td>0.17</td>
<td>0.965</td>
<td>1.7</td>
<td>39.0 (3.0)</td>
<td>741,887 (1.2)</td>
<td>39,065 (1.2)</td>
<td>4.3 (1.3)</td>
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<td>1990</td>
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<td>819 (8.1)</td>
<td>118 (1.2)</td>
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<td>0.960</td>
<td>5.5</td>
<td>232.3 (17.6)</td>
<td>863,664 (1.4)</td>
<td>49,399 (1.5)</td>
<td>5.3 (1.6)</td>
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<td>1994</td>
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<td>1,116 (9.7)</td>
<td>780 (6.8)</td>
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<td>8.1</td>
<td>351.2 (26.6)</td>
<td>975,549 (1.6)</td>
<td>68,274 (2.1)</td>
<td>6.4 (1.9)</td>
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<td>1,938 (10.8)</td>
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<td>612.0 (46.4)</td>
<td>1,034,328 (1.7)</td>
<td>87,421 (2.7)</td>
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<td>5,339 (9.0)</td>
<td>2,562 (4.3)</td>
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<td>6.96</td>
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* Market development is the mean value of the multipliers of each of the four dimensions, using 1981 as the base year (the multipliers are in parentheses); the results are robust to other combinations of the four dimensions.

** The 1981 and 1986 values of the legal protection score are estimates (the market development measure is robust to alternative estimates).

Table 2. Correlations and summary statistics (n=582 to 591; 576 cases used in analysis)

<table>
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<td>BSD: Buyer-supplier density</td>
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<td>Mkt: Market development</td>
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<td>Time period</td>
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<td>Group director density</td>
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<td>6.96</td>
<td>3.30</td>
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<td>0.21</td>
<td>4.81</td>
<td>0.69</td>
<td>0.15</td>
<td>0.31</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>40.8</td>
<td>0.23</td>
<td>0.03</td>
<td>4.78</td>
<td>1.47</td>
<td>0.30</td>
<td>0.20</td>
<td>90.9</td>
<td>1.70</td>
<td>0.15</td>
<td>17.68</td>
<td>0.26</td>
<td>0.24</td>
<td>1.95</td>
</tr>
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<td>Minimum</td>
<td>0</td>
<td>0</td>
<td>0.87</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0.24</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Maximum</td>
<td>850</td>
<td>1</td>
<td>1</td>
<td>13.2</td>
<td>5</td>
<td>1</td>
<td>1</td>
<td>1,008</td>
<td>6.94</td>
<td>0.83</td>
<td>341.4</td>
<td>1</td>
<td>1.67</td>
<td>19.8</td>
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Table 3. ZINB estimates of influences on business group innovativeness (n=576, 105 non-zero patent application observations; robust standard errors)

<table>
<thead>
<tr>
<th></th>
<th>1 s.e.</th>
<th>2a s.e.</th>
<th>2b s.e.</th>
<th>3 s.e.</th>
<th>4a s.e.</th>
<th>5a (a) s.e.</th>
<th>5b (a) s.e.</th>
<th>s.e.</th>
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<tbody>
<tr>
<td>BSD: Buyer-supplier density</td>
<td>-4.85</td>
<td>1.86</td>
<td>***</td>
<td>-89.43</td>
<td>53.48</td>
<td>**</td>
<td>48.89</td>
<td>78.73</td>
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<tr>
<td>SS: Strategic scope</td>
<td>4.32</td>
<td>9.39</td>
<td>-10.29</td>
<td>15.85</td>
<td>8.63</td>
<td>**</td>
<td>9.91</td>
<td>75.55</td>
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<tr>
<td>Mkt: Market development</td>
<td>0.01</td>
<td>0.11</td>
<td>-0.04</td>
<td>0.11</td>
<td>0.14</td>
<td>0.13</td>
<td>0.15</td>
<td>0.12</td>
</tr>
<tr>
<td>BSD x SS (H1: +)</td>
<td>86.53</td>
<td>54.51</td>
<td>*</td>
<td></td>
<td>116.03</td>
<td>51.72</td>
<td>**</td>
<td>-81.00</td>
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<tr>
<td>BSD x Mkt (H2: -)</td>
<td>-0.58</td>
<td>0.40</td>
<td>*</td>
<td>-0.84</td>
<td>0.36</td>
<td>***</td>
<td>-18.99</td>
<td>7.68</td>
</tr>
<tr>
<td>BSD x SS x Mkt</td>
<td>18.92</td>
<td>8.05</td>
<td>***</td>
<td>35.05</td>
<td>14.84</td>
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<tr>
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<td>2.26</td>
<td>***</td>
<td>-11.74</td>
<td>4.17</td>
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<td>Group director density</td>
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<td>-0.95</td>
<td>0.78</td>
<td>-0.44</td>
<td>0.79</td>
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<td>0.71</td>
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<td>Group equity density</td>
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<td>1.38</td>
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<td>2.67</td>
<td>1.46</td>
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<td>3.13</td>
<td>1.41</td>
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<td>Group assets</td>
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<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
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<tr>
<td>International linkages</td>
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<td>0.69</td>
<td>-0.06</td>
<td>0.76</td>
<td>-0.24</td>
<td>0.68</td>
<td>-0.33</td>
<td>0.61</td>
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<td>Group industry concentration</td>
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<td>1.77</td>
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<td>-5.50</td>
<td>2.00</td>
<td>***</td>
<td>-4.74</td>
<td>1.58</td>
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<tr>
<td>Group div. (normalized)</td>
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<td>1.47</td>
<td>***</td>
<td>-4.99</td>
<td>1.29</td>
<td>***</td>
<td>-5.40</td>
<td>1.51</td>
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<td>Group pre-sample patents</td>
<td>0.15</td>
<td>0.07</td>
<td>**</td>
<td>0.11</td>
<td>0.06</td>
<td>**</td>
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<td>0.06</td>
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<tr>
<td>Ln(α) dispersion</td>
<td>1.78</td>
<td>0.18</td>
<td>***</td>
<td>1.72</td>
<td>0.16</td>
<td>***</td>
<td>1.74</td>
<td>0.18</td>
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<td>LLR chi-square (df)</td>
<td>44.8 (10)</td>
<td>56.0 (11)</td>
<td>50.7 (11)</td>
<td>78.6 (12)</td>
<td>71.95 (14)</td>
<td>72.21 (14)</td>
<td>73.07 (14)</td>
<td>7.86 **</td>
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<td>LLR change (df)</td>
<td>11.3 (1) **</td>
<td>5.9 (1) **</td>
<td>33.9 (2) **</td>
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</tbody>
</table>

Note 1: ZINB estimates with simple s.e. had highly significant Vuong statistics (ZINB with robust standard errors does not calculate a Vuong statistic), suggesting that standard negative binomial analysis is not appropriate.

Note 2: The H1 and H2 results in model 3 were robust to multiple sensitivity analyses: Dropping any or all of the control variables in Panel A; adding Group industry R&D, Family share of directors, Number of affiliates, Period of first group entry, Buyer-supplier density squared, and Financial autonomy (1 – equity centralization), alone or in combination; adding the interaction of group equity density and market development (ED x Mkt); using 1-, 3-, and 4-year patent windows; and restricting the sample to 100 groups (by sales) per period.
Figure 1a. Joint impact of buyer-supplier density and strategic scope on innovative activity (Table 3, model 4): Low market development period (Mkt=1)

Interpretation: Most combinations are similar

Figure 1b. Joint impact of buyer-supplier density and strategic scope on innovative activity (Table 3, model 4): Moderate market development period (Mkt=5.5)

Interpretation: High buyer-supplier density combined with low strategic scope (right rear) creates some constraints as the market develops.

Figure 1c. Joint impact of buyer-supplier density and strategic scope on innovative activity (Table 3, model 4): High market development period (Mkt=13.2)

Interpretation: High buyer-supplier density combined with low strategic scope (right rear) now becomes highly negative relative to lower market development period.