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# Network effects, cooperation and entrepreneurial innovation in China

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**Abstract** The rapid rise of an innovative private manufacturing economy in China challenges standard economic explanations of growth, which typically assume the existence of well-defined formal institutions such as property rights and company laws safeguarding investor and creditor interests. We highlight the social structure of cooperation that enables innovative activity in private manufacturing firms when formal property rights protection remains weak. We show how network effects linked to inter-firm cooperation in industrial clusters allowed private entrepreneurs to quickly develop reliable business norms to reduce the inherent risk of malfeasance and contract breach in formal and informal collaborative efforts. Survey data from a sample of 700 manufacturing firms located in China's Yangzi Delta region confirms that both formal and informal types of inter-firm collaboration are effective, though in different areas of innovative activity.
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**Keywords:** network effects; innovation; entrepreneurship; formal R&D agreements; informal cooperation; China



## Introduction

The size and competitiveness of China's private-firm economy is a puzzle that challenges standard economic explanations of entrepreneurial development and economic growth. State-owned enterprises and state-controlled public corporations, many listed on the Shanghai and Shenzhen stock exchanges, have enjoyed most-favored treatment since the start of economic reforms in 1978. Indeed, their dominant position in the economy reinforces the global perception of state capitalism as the form of economy that has evolved in China. Yet despite such perception, and persistent discrimination against private enterprise as an organizational form, the most robust sector of the Chinese economy has been the private sector, which has outperformed the heavily subsidized state-owned and mixed-ownership companies. Our aim is to show how network effects linked to inter-firm cooperation in research and development have contributed to the rise of an innovation-driven private manufacturing economy.

Despite ineffective intellectual property rights protection, placing China 59th globally (comparable to Romania and Liberia; see IPRI, 2013), and limited access to R&D funding from government, private manufacturers are closing the gap with state-owned firms in research and development output (Jefferson *et al*, 2003; Nee *et al*, 2010). In 2012, 29 per cent of patent applications were submitted by private firms and 44 per cent by state-controlled and state-owned companies (China Statistical Yearbook on Science and Technology, 2013, p. 56). Private companies registered 34 per cent of new products brought to market in 2012, whereas state-owned enterprises and state-controlled companies were responsible for 44 per cent.

What explains private-firm R&D productivity closing the innovation gap with larger state-owned firms and public corporations? We argue that the 'bottom-up' construction of economic institutions in geographically concentrated industrial clusters has enabled private companies to circumvent formidable barriers to market entry, weak legal enforcement of contracts, and discriminatory state policies to move up the technological ladder through network effects of cooperative strategies in the diffusion of innovative activity. Our evidence draws on more than 130 qualitative interviews with CEOs of firms, and quantitative firm-level evidence from three waves of the Yangzi Delta Private Entrepreneur and Firm Survey (conducted in 2006, 2009 and 2012) with a random sample of 700 private companies (Nee and Opper, 2012).

First, we discuss the related organizational literature highlighting the role of inter-firm cooperation and alliances in the production of innovation. Then we discuss network effects driving intensification of innovative activity in densely-populated business communities. Our focus is on the development of a diversified portfolio of inter-firm cooperation, informal and formal, which entrepreneurs devise to meet the needs of specific tasks and risks inherent in a broad spectrum of innovative activities. Finally, estimation results quantifying the impact of different forms of inter-firm cooperation on a range of innovative activities confirm a close link between form of collaboration and innovative success.

## Innovation as a Social Process

Insofar as innovation is a social process involving both cooperation and competition, innovations rarely emerge in isolation. Research on innovation confirms that technical change is facilitated through reliance on inter-firm cooperation across a wide spectrum of industries (Hagedoorn and Schakenraad, 1994; Shan *et al*, 1994; Gulati, 1998; Stuart, 1998, 2000; Ahuja, 2000). In advanced industrial economies, it is common practice for firms to enter into cooperative contracts for research and development to share research capabilities and knowledge, in order to take advantage of economies of scale among key players, while limiting market access to rival firms not in the research network (Porter and Fuller, 1986; Pisano *et al*, 1988). A related motive for firms to cooperate stems from interest in minimizing and sharing the uncertainties inherent in R&D, especially in high-technology industries where the technical knowledge required for innovations is at the frontiers of different scientific fields and entails complexities that no firm can afford to internalize in its R&D department (Mowery, 1988; Obleros and MacDonald, 1988). Firms participate in strategic alliances in R&D in order to gain access to other firms' technologies, exercise control over market entry, open new market niches through joint product development, and reduce the time-span required for innovations and their market entry (Porter and Fuller, 1986; Mowery, 1988; Pisano *et al*, 1988; Hagedoorn, 1993).

Research on the American biotechnology industry, for example, underscores the dynamics of cooperation as a learning process endogenous to the industry, in which technological development fosters network effects. Such effects involve mechanisms of network externalities, social learning, and normative influence, which stem from the increasing utility of cooperation for firms participating in collaborative R&D projects. 'Once a firm begins collaborating, it develops experience at cooperation and a reputation as a partner. Over time, firms develop capabilities for interacting with other firms … Firms with access to a more diverse set of activities and those with more experience at collaborating are better able to locate themselves in information-rich positions … Put colloquially, a firm grows by being a player; it does not become a player by growing' (Powell *et al*, 1996, pp. 120–121). In biotechnology, formal contractual agreements to cooperate in research and development is the tip of the iceberg in an even larger and more dispersed informal network of cooperative arrangements between firms. 'Beneath most formal ties, then, lies a sea of informal relations' (Powell *et al*, 1996, p. 120) that accumulate over time as firms move from one formal R&D collaboration to another, resulting in informal network connections that offer a continuing source of benefits beyond any particular exchange. Because the locus of innovative activity is embedded in inter-firm networks, the boundaries between firms and research universities become blurred, which in turn promotes timely and effective diffusion of new technologies in the biotechnology industry.

In sum, the organizational literature suggests that to understand where innovations come from, it is important to move beyond the study of the individual entrepreneur and firm to specify network effects in innovation activity. The importance of arrangements such as non-price exchanges and network effects (social learning, normative influence and network externalities) in facilitating firm-based research and development is beyond doubt.

## Collocation and Network Effects

Much organizational analysis of cooperation strategies in research and development draws on research activities in advanced industrial economies. Because cooperation in R&D involves specific risks, well-specified property rights (including intellectual property rights, contract law, corporate law, and arbitration institutions guiding and safeguarding economic transactions) are assumed as implicit background conditions, not part of the actual analysis. But how do innovation networks operate in the absence of the institutional conditions present in high-income economies such as the United States, Japan and Sweden? What happens when innovation partners have an interest in securing key technologies without contributing equal effort or sharing gains from commercialization, but cannot rely on sophisticated contractual agreements enforced by unbiased local courts? How can entrepreneurs gain assurance that the risks of opportunism and expropriation of intellectual property are outweighed by the gains from cooperation? As one entrepreneur we interviewed reasoned: 'If we were in the USA, we would not need to work so hard to protect ourselves, because you can rely on intellectual property rights. Here, if you have a very good idea, before you start business, you must worry about someone copying from you. The legal system is just not good enough to protect intellectual property rights'.

Clearly, weak enforcement of contract law and intellectual property rights pose severe challenges in China, and justify the question as to what extent inter-firm cooperation can offer a viable option to produce similar cooperation gains to those observed in developed economies? In inter-firm R&D collaboration, what are the mechanisms that safeguard joint investments in intellectual property from the risks of opportunism and expropriation, and thus enable increasing utility from inter-firm collaboration? We identify mutually reinforcing mechanisms contributing to increases in utility of inter-firm cooperation in research and development. These mechanisms help to reduce the costs of research and development assumed by a single firm, and also lower the risks of malfeasance and expropriation.

First, collocation of firms in industrial clusters where overlapping networks of firms are geographically concentrated enables firms to benefit from network effects that build up to higher levels of innovative activity. Network effects are evident when the likelihood that people will adopt a novel practice is an increasing function of the number or proportion of others in the social network who have already adopted the practice (DiMaggio and Garip, 2012). Such effects are generated through increases in the utility of inter-firm collaboration for advances in research and development. In industrial clusters, owing to the close spatial proximity of economic actors, network effects have a direct impact. The greater the percentage of firms involved in innovative activity, the higher a firm's probability of social learning and experience in collaborative R&D.

Spatial concentration leads to higher frequency of multiplex relationships and stronger network effects in the diffusion of good ideas and innovative practices.

Three mechanisms – local network externalities, social learning, normative influence – drive network effects (DiMaggio and Garip, 2012). All have more immediate and direct effects through spatial concentration in industrial clusters.

(1) Local network externalities are apparent when the utility of cooperation strategies in innovative activity increases as more entrepreneurs adopt this practice. As innovative activity becomes commonplace, more and more entrepreneurs in the private manufacturing economy adopt the practice of inter-firm cooperation as a strategic choice.
(2) Social learning occurs when members of entrepreneurial networks share information on the utility of cooperation strategies in innovation.
(3) Lastly, normative influence works through side incentives of bestowing social rewards on adopters of cooperative R&D arrangements and social sanctions on opportunism and malfeasance in collaborative research and development.

*Collocation and clustering* are central facilitators of economic cooperation. In the Yangzi Delta region, a self-reinforcing dynamic of industrial cluster formation is at the root of a cumulative growth process. In the three provinces of the Yangzi Delta region – Zhejiang, Jiangsu and Shanghai – extensive multilateral clusters of private firms self-organized in industrial niches provide the institutional matrix of competitive advantage. The industrial cluster is defined as a sectoral and spatial concentration of firms connected through vertical or horizontal relations (Marshall, 1920; Porter, 1990; Krugman, 1991). A defining feature of industrial clusters is that firms in a niche are interconnected entities that compete and cooperate in spatially proximate locations. Industrial clusters not only improve information flows, but social processes embedded in networks lock in business norms sustaining trust and cooperation within close-knit communities of manufacturers.

In the Yangzi Delta region, it was the rapid entry of new private start-up firms and bottom-up formation of integrated ‘industrial clusters’ (*chanye jiqun*) and ‘production chains’ (*chanyelian*) of specialty suppliers which allowed private producers to cooperate and accept risks not fully covered by contractual agreements. Through mutual cooperation and joint problem solving, private producers reduced environmental uncertainties and enhanced strategic capability development.

Collocation in industrial clusters allows entrepreneurs to internalize the costs of research and development through joint participation and cost sharing in innovative activities. The cluster becomes a geographically concentrated production market for the industrial niche, with upstream suppliers and downstream distributors within close reach and the economy of scale to compete in global and domestic markets. The diffusion of innovation in these clusters depends on social interaction and geographic proximity of market participants. Learning how others detect and realize market opportunities is an essential lesson that is greatly affected by ongoing social interactions of market players. Entrepreneurs carefully analyze the factors for success and failure for innovative activities by talking about the experience of other market players in their industry. Similarly, entrepreneurs learn through direct observation and face-to-face consultation with others on how to create new ideas.

Geographic proximity facilitates mutual monitoring, information sharing and the rise of *social norms* that limit the risk of malfeasance and contract breach. As self-reproducing social structures of firms arrayed in a network, production markets are more close-knit than White's (2002) accounts of the geographically dispersed production markets of North America. In industrial clusters, economic transactions are guided informally by mechanisms regulated by ongoing social relationships. Malfeasance and contract breach within dense business networks are quickly made public through gossip and other forms of community sanction. Entrepreneurs aiming to establish sustainable businesses in their local community are thus naturally tied to a certain code of conduct, which limits the moral hazard problem involved in inter-firm collaborations. Only 5 per cent of respondents in our 2012 survey reported business conflicts with suppliers or customers. Moreover, every second respondent was certain that she would learn about any conflicts between her suppliers or customers with any other company in the region. Lastly, cross-cutting multiplex relationships of spatially concentrated entrepreneurs, suppliers and distributors encourage the endogenous emergence of social norms and conventions that enable cooperation and trust (Granovetter, 1985; Coleman, 1988; Ellickson, 1991; Portes and Sensenbrenner, 1993; Uzzi, 1996; Nee and Ingram, 1998; Watts, 1999; Burt, 2004).

In sum, collocation and network effects jointly reduce the costs of innovation and increase the utility of cooperation in innovative activity by facilitating local network externalities, social learning of innovative activity, and normative influence. These social mechanisms lead to an alleviation of resource constraints in private manufacturing firms that lack the legitimacy to gain access to government-sponsored funds for research and development. Local role models provide the scripts, myths and norms that highlight cooperation and mutual learning as an essential feature of innovative activity. These mechanisms embedded in the emergent private production markets have shaped incentives and opportunity, which jointly enabled the rapid development of innovative activities outside the state-controlled mainstream economy.

## Where Good Ideas Come From

Following the folk wisdom of entrepreneurs in the region that even small innovations can make a difference, it has become commonplace for firms to introduce new products, product upgrades, production processes and organizational innovations to improve their profit margin (see Table 1). The sheer frequency of innovative activities suggests that private entrepreneurs in the Yangzi Delta region have successfully developed a culture of innovation. Though patentable innovations

**Table 1:** Firm innovation between 2003 and 2011, in per cent

| *Type of Innovation performed* | *In 2003–2005* | *In 2006–2008* | *In 2009–2011* |
|---|---|---|---|
| Process innovation | 62 | 66 | 60 |
| Introduce new product | 58 | 52 | 58 |
| New management technique | 65 | 64 | 48 |
| New quality control | 61 | 41 | 34 |
| Upgrade existing product line | 50 | 41 | 32 |
| Discontinue at least one product line | 22 | 15 | 11 |
| New patent approved | NA | 5 | 0.8 |
| New joint venture with foreign partner | 20 | 7 | 0.5 |
| Outsource major production activity | 24 | 5 | 0.2 |

*Source:* Yangzi Delta Private Entrepreneur and Firm Survey 2006, 2009, 2012. Seventy five per cent of the firms participating in the final survey wave also responded in Wave 1 or 2.



are still rare, around 60 per cent of firms reported that they had introduced new production processes and more than 50 per cent had introduced new products in each of the three surveys. While most manufacturers make only marginal improvements and modifications to existing products and product lines, some continuously expanded or modified their main line of business, and developed new product lines as a strategy to move into less crowded niches offering higher profit margins. In these cases, the firm made bold technological shifts that requiring substantial investments in research and development.

In industrial clusters, innovators and new market entrants benefit from local network externalities stemming from imitation and learning. The visible and frequent entry of newcomers into open markets serves as a motivational force to innovate. Entrepreneurs who successfully bring new products to the market serve as role models, attracting more entrepreneurial talent into emergent production markets. In periods of explosive founding of private firms, local business culture even generates a social movement dynamic to join in entrepreneurial endeavors and to innovate. Some of our interviewees confirmed that social pressure and general expectations to come up with new ideas to compete successfully in the market are a widely-held norm of entrepreneurial action. In our 2012 survey, entrepreneurs who regularly develop new products or product upgrades self-assessed their own status higher than entrepreneurs without novel products (based on statistical mean comparison test).

A distinctive trait of innovative activity in private manufacturing is its strong market orientation focusing on applied solutions serving the specific needs and wishes of customers. Customer orientation is not just an important component in developing distribution networks and building a loyal customer base, it also helps to steer innovative activities toward marketable solutions with robust demand. Long-term customers constantly request quality improvements and cost reductions. This often requires adjustments and modifications to the production process and

**Table 2:** Top external sources for new ideas (in per cent)

| *Listed among top three sources for ideas of innovation* | *2006–2008* | *2009–2011* |
|---|---|---|
| Customers | 82 | 87 |
| Other businesses in own industry | 50 | 51 |
| Suppliers | 30 | 33 |
| Conferences or trade fairs | 29 | 23 |
| Technical or industry standards | 31 | 22 |
| Universities, research institutes, research services | 8 | 10 |
| Industry association | 7 | 7 |
| Businesses in other industries | 8 | 5 |
| Books and scientific journals | 8 | 5 |
| Overseas/international companies | 5 | 5 |
| Government assistance | 3 | 2 |

*Source:* Yangzi Delta Private Entrepreneur and Firm Survey, 2009 and 2012.



improvements of quality management to guarantee certain product standards. Customer-driven innovation goes beyond mere quality concerns. Through observational research, entrepreneurs develop new ideas for product improvements.

Clearly, not all of these ideas lead to innovation. Some never go beyond imitation. Nonetheless, customer-oriented R&D often leads to real innovation. In our 2012 survey, 87 per cent of the interviewed managers ranked customer ideas among the three most important sources for new ideas (see Table 2). About 51 per cent of managers looked to companies in their own industry for new ideas. Notwithstanding, there is an important dissimilarity between mimicking or imitating the innovations of competitors, and the customer orientation of innovative activity. Customer orientation usually entails a proactive effort to anticipate the demand for novelty, although entrepreneurs who mimic or imitate their competitors' innovations naturally position themselves as technology followers. Ideas for proactive changes also come from the network of suppliers, who provide additional sources for new ideas. About 33 per cent of the surveyed managers in 2012 indicated that their suppliers serve as one of the most important sources for ideas.

Conferences and trade fairs, showcasing new domestic and global developments in specific industries and niche markets, provide a complementary institutionalized platform that allows producers to test their ideas and receive immediate customer responses. Trade fairs also facilitate inter-firm comparisons and help identify future market trends. New technical and industry standards provide additional incentives and ideas to bring new products and production processes in line with national regulation. Particularly, environmental standards play an important role in guiding developmental trends within particular market segments. Various automobile-parts producers pointed to the important role of environmental standards when it comes to innovation. In total, 22 per cent of all interviewees regarded technical and industry standards as one of the three most important sources for new ideas in 2012.

## Forms of R&D Cooperation

The crucial role of inter-firm collaborations in R&D is well-understood in developed knowledge-based economies (Powell *et al*, 1996). But in the context of China's emerging-market economy, entrepreneurs not only are challenged by relational risks associated with long-term collaborative efforts across organizational boundaries (Ring and Van de Ven, 1992), but they also confront uncertainties stemming from weak contract enforcement, high litigation costs and inconsistent enforcement of court rulings. In response to institutional uncertainties, entrepreneurs have devised a differentiated portfolio of cooperative arrangements, both informal and formal, that encompass a broad spectrum of organizational contexts.

### Informal collaboration

Industrial clusters provide fertile grounds for the development of informal technology collaborations. A manifestation of network effects in industrial clusters is the rapid exchange of ideas, the frequency of joint search for technical solutions, and the sharing of equipment needed to engage in innovation as a natural outgrowth of long-standing and geographically proximate business relationships. In close-knit networks of entrepreneurs, actors expect mutual help and support. This contributes to sharing of information about new technologies during the course of casual business talks. Informal exchange of ideas in networks is often the starting point for joint search for new technology, novel products and innovative ways to manufacture new products. Often, network effects contribute to rapid diffusion of novel ideas and techniques that in turn motivate joint interest in novelty, the collaborative search for novel technical solutions, and the joint use of equipment for innovative activities. In this sense, network effects arise as natural outputs of ongoing social relationships, where expectation of mutual help and support in close-knit networks of entrepreneurs contributes to social learning. Understanding of the utility of inter-firm cooperation in innovation often follows informal discussion in business relationships on the cost-effectiveness and utility of joint development and acquisition of new technologies.

Another manifestation of network effects is the increasing utility of pooling resources and skills to jointly develop and advance technical capabilities as a means to circumvent the high cost of standalone R&D departments. Nearly 80 per cent of entrepreneurs in the Yangzi region surveyed in 2012 reported that they were engaged in informal technical collaborations with at least one member firm in their industrial cluster.

Informal collaborations often focus on marginal product upgrades, process developments, and the sharing of new insights on management and quality control, as well as the initial stage of product developments – typically at an early exploratory stage, when the specific tasks, resource needs and potential market value of the endeavor cannot even be estimated. They often involve minor improvements in products and production processes that clearly are far from the Schumpeterian view of 'new combinations'. These early-stage collaborative activities are important in that they allow both partners to assess the quality of their relationship without committing themselves to a long-term strategic alliance to engage in collaborative development of new technology or products.

## Formal collaboration

Because informal technical cooperation does not provide sufficient protection from the risks of opportunism and expropriation of intellectual property, it is a form of inter-firm cooperation with significant limits and downsides. Entrepreneurs seeking patentable innovations therefore turn to formal technology agreements backed by contracts that specify *ex ante* a rational plan of the scope of collaboration and the type of innovation sought. Such contracts anticipate future contingencies with respect to assignment of duties, and the rights of the collaborating parties and the distribution of profits. Formal contracts are typically reached after both parties have been engaged in an initial exploratory phase, often based on non-contractual agreement.

Formal contractual agreements, like non-contractual agreements in collaborative technology development, rest on the foundation of ongoing social relationships where both parties know the partner's reputation and capabilities for joint technology development. What legal contracts do is reinforce the trust and cooperation that is often already in place, and which are the outgrowth of an ongoing business relationship between cooperating partners. Because intellectual property rights are weak and easily expropriated, in the Yangzi Delta region entrepreneurs prefer to find their R&D collaborators from within their close business networks. They often rely on personal introductions and the fine-grained information on reputation for trustworthiness and technical capabilities of prospective partners gained from their networks. If a broker is involved in introducing innovation partners, it is in the interest of the broker to make good recommendations rather than risk losing reputation and brokerage opportunities. In the Yangzi Delta region, larger firms have gradually extended their search for technical and research partnerships beyond their local business networks.

Entrepreneurs learn to form strategic alliances built on strong intrinsic interest in contract compliance to provide an additional safeguard against opportunism and expropriation of intellectual property. A variety of strategic alliances has evolved for asset-specific investments in technology and technical capabilities involving partners who share specialized technology needs. Another form of inter-firm cooperation involves partners whose firms sub-contract for larger firms, and whose production capacity is too small to use jointly-developed technology for parallel lines of production that could be sold to benefit the sub-contractor's individual firm. Other entrepreneurs only enter into joint technology development with another firm if the expected time needed to copy the entirety of the innovation would be long enough to allow the innovators to still capture substantive profits.

In the Yangzi Delta region, entrepreneurs choose from a repertoire of contractual agreements depending on the technical capability of their firm and the resource constraints of contracting parties in joint development of technology:

(1) Larger firms with weak technical capabilities but strong financial resources prefer to buy patented technologies, often from state-owned enterprises or university-based research institutes. Frequently, the firm agrees to pay a certain amount for a specified technology design by a contracting firm or research institute that specializes in providing R&D services.
(2) Manufacturers looking for technical innovations they need in components used in their main product line turn to suppliers of specialized products. In such cases, the manufacturer makes an *ex ante* contractual commitment to purchase a minimum volume from the supplier commissioned to develop the component part, who in turn guarantees not to sell the innovation to a third party. In this type of technology contract, suppliers often offer to develop the technical specifications of the component *pro bono* for the manufacturer.
(3) In long-term technology agreements, entrepreneurs share financial costs of research and development by establishing joint ventures solely to engage in R&D. These arrangements generally involve private firms with in-house R&D departments with the technical capability to form strategic alliances to share the financial and technical costs of R&D with a domestic or international company to gain access to state-of-the-art technologies. The *quid pro quo* for the more advanced technology firm is to gain market access in product niches difficult to penetrate and future profits. The increasing utility of this form of inter-firm cooperation has led to the diffusion of this practice. Many of the larger manufacturing firms in the Yangzi Delta region have formed strategic alliances in technology development and transfers with international companies.

Network effects driven by the increasing utility of formal forms of joint technology development have led firms without in-house R&D units to enter into contractual agreements for cooperative technology development. Twelve per cent of firms lacking R&D departments interviewed in the 2012 survey wave reported that they have formal technology agreements with another firm. Twenty per cent of the companies with R&D departments entered into technology agreements. Overall, the 700 private manufacturing firms in our sample reported a broad portfolio of R&D strategies (see Table 3). Thirty two per cent of the private manufacturers surveyed in 2012 have neither in-house R&D facility nor any R&D agreements, but 32 per cent relied exclusively on in-house R&D, and the remaining 36 per cent used a combination of in-house research and various forms of inter-firm alliances. (Figure 1)

**Table 3:** Portfolio of R&D strategies ($n = 700$)

| | *Yes* | *No* |
|---|---|---|
| Informal technology collaboration with key network node | 164 | 536 |
| Formal R&D contracts (with universities, research institutes, or firms) | 111 | 589 |
| In-house R&D department/R&D activities | 352 | 348 |

*Source:* Yangzi Delta Private Entrepreneur and Firm Survey, 2012.

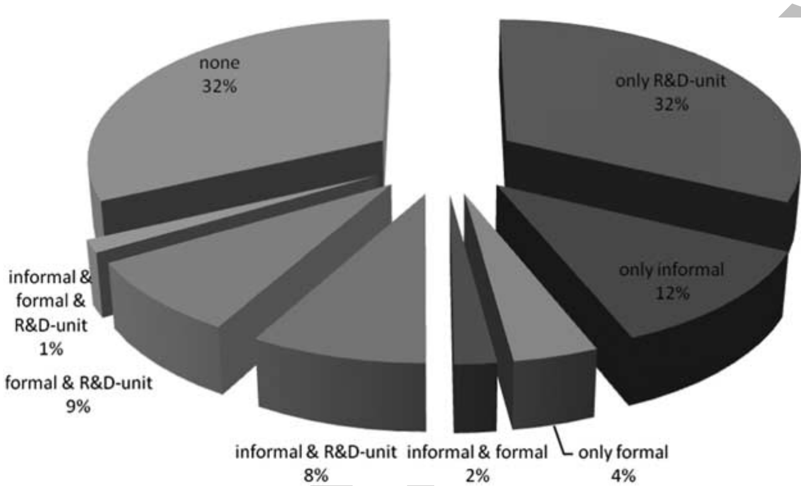


**Figure 1:** Distribution of innovation portfolio.
*Source:* Yangzi delta private entrepreneur and firm survey, 2012.

We compared the innovation strategies reported by CEOs of the 700 firms in our sample to provide evidence for the range of informal and formal technology cooperation used by private manufacturers in the Yangzi Delta region. Companies that rely on more than one innovation strategy tend to introduce more innovation than those who only rely on in-house R&D, as evidenced in our innovation index (ranging from 0 to 4), which combines the number of distinct innovation types (new patent, new product, product upgrade, new production process) developed between 2009 and 2011 (Figure 2). Significantly, companies without in-house R&D introduce more innovations than companies with in-house R&D facilities, through cooperative arrangements involving both informal and formal research collaborations. The highest innovation score is achieved by manufacturing firms that rely on a mix of in-house R&D and formal and informal collaborations with other firms. This finding underscores the importance of an innovation strategy that can flexibly adapt to the

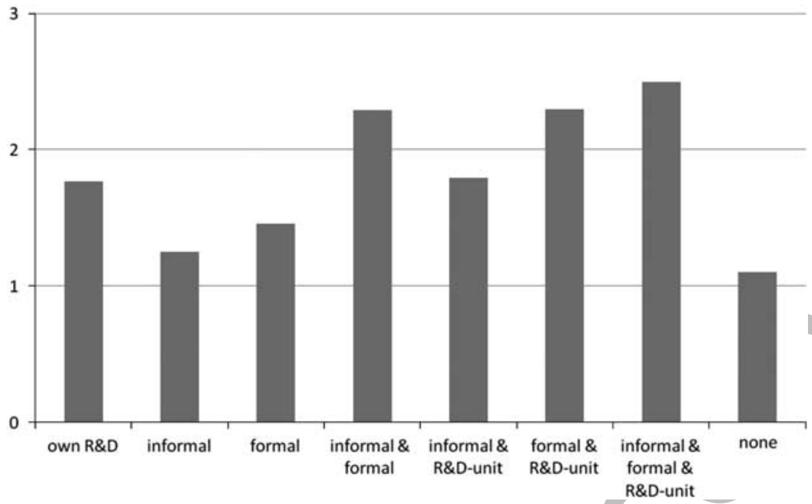


**Figure 2:** Number of innovation types (1–4).
*Source:* Yangzi delta private entrepreneur and firm survey, 2012.

uncertainties and risks of a complex institutional environment undergoing transformative change.

## The Effect of Innovation Strategies on Firm Innovativeness

For a more thorough confirmation of the suggested link between a diversified portfolio of formal and informal collaborative strategies and distinct innovation outcomes in China's transformative private enterprise economy, we rely on the Yangzi Delta Private Entrepreneur and Firm Survey conducted three times since 2006 (see Nee and Opper, 2012). Seven hundred randomly sampled companies located in seven cities (Shanghai, Nanjing, Nantong, Changzhou, Hangzhou, Wenzhou and Ningbo) and operating in five manufacturing sectors, representing the region's key economic activities ranging from labor-intensive to technology-intensive production (textile, automobile and parts, ordinary machinery, pharmaceutical, and electronics and communication devices), participated in each survey wave (75 per cent of the companies participated multiple times).[1] For the purpose of this analysis we focused on the most recent survey conducted in 2012, as it presents the most fine-grained information on collaborative R&D activities. A sample breakdown by city and sector for the participating firms is provided in Appendix A.

The private manufacturers in our sample had all been in business for more than 3 years, and employed at least 10 salaried workers. The average firm age in 2012 was

12 years. On average, companies employed 133 workers with the largest firm employing 2150. Only CEOs (professional CEOs or owner CEOs) were invited to participate, an important feature that guarantees comparable and reliable information across the entire sample. All interviews were conducted by professional interviewers in face-to-face interviews on the company premises. The survey questionnaire covered a broad range of questions ranging from governance to ownership and performance measures. An entire section was devoted to a firm's innovation activities and strategies.

To test our claim that entrepreneurs have developed a diversified portfolio of collaborative strategies for specific innovation projects, we explored four distinct dependent variables, each captured as a binary measure of the occurrence of a distinct innovation type over the preceding 3-year period (2009–2011).

First, we asked about a firm's patenting activities. Because new patents were reported by only 8 per cent of the firms in the sample, we did not further differentiate the type of patents received. We note that the majority of these patents were awarded for design and utility models, suggesting an early stage in innovative activity for private firms in the Yangzi Delta region. Further, we include self-reported measures of whether companies have introduced new products, upgraded new production lines/products, or introduced new production processes or technical process innovations.

Our model examines inter-firm cooperation in innovation strategies. We capture with a binary variable the existence of in-house R&D facilities and existence of formal R&D agreements between the firm and research institutes, universities or other companies. Although we have fine-grained information on collaboration partners, we decided not to differentiate between different types of partners. The focal point of our analysis is on the effectiveness of partnership agreements, rather than the comparative value of different strategic alliances. Finally, we use a binary measure to capture whether the CEO maintained an informal technology exchange/collaboration with the most highly valued business contact. Since most companies reported informal technology contacts (with at least one partner in their extended network), we chose to focus on the most highly valued informal partnership. Control variables include the total number of employees, number of in-house R&D staff, existence of any formal agreements to license in patents or trademarks, firm age, firm size measured by total assets, industrial sector and city location (for descriptive statistics, see Appendix B).

Table 4 summarizes results from probit estimations with robust standard errors clustered on city. A few observations stand out, and consistently underscore our narrative of the importance of collaborative research in China's Yangzi Delta region. We find that both formal and informal R&D collaboration matter. For larger innovation projects, such as new patents and the introduction of entirely new products, the probability of successful project completion increases for companies with formal R&D agreements. In tacit improvements, such as upgrades of products or

**Table 4:** Formal R&D contract, informal collaboration and in-house R&D

| | *Patent approved* | *New product introduced* | *Product line upgraded* | *New technology processes introduced* |
|---|---|---|---|---|
| *R&D strategy* | | | | |
| Informal R&D collaboration | −0.321 (0.216) | −0.020 (0.149) | 0.243** (0.109) | 0.312*** (0.108) |
| Formal R&D contract | 0.985*** (0.252) | 0.456* (0.264) | 0.108 (0.127) | −0.040 (0.211) |
| Own R&D department | 0.781*** (0.288) | 0.801*** (0.082) | -0.138 (0.176) | −0.057 (0.174) |
| *Controls* | | | | |
| Total employees (log) | 0.053 (0.161) | 0.115 (0.074) | 0.084 (0.128) | 0.125 (0.087) |
| Number of R&D staff | 0.020 (0.032) | 0.127** (0.050) | 0.102*** (0.030) | 0.058** (0.027) |
| Firm 'licenses in' patents /copyrights/ trademarks | 0.939*** (0.311) | 0.127 (0.410) | 0.650** (0.267) | 0.196 (0.242) |
| Firm age (log) | −0.223* (0.132) | −0.059 (0.154) | 0.249** (0.098) | 0.156 (0.101) |
| Total assets (log) | 0.026 (0.106) | −0.019 (0.073) | −0.029 (0.089) | −0.028 (0.071) |
| Sector | YES** | YES** | YES*** | YES* |
| City | YES*** | YES*** | YES*** | YES*** |
| Constant | −2.737*** (0.631) | −1.122** (0.464) | −1.248** (0.620) | −0.824** (0.408) |
| Observations | 698 | 698 | 698 | 698 |
| Pseudo $R^2$ | 0.310 | 0.219 | 0.088 | 0.052 |

*Source:* Yangzi Delta Private Entrepreneur and Firm Survey, 2012.
*Note*: $*P<0.10$, $**P<0.05$, $***P<0.01$ (two-tailed tests); robust (heteroskedastic-consistent) standard errors clustered on city in parentheses.



production lines, and the introduction of new production processes and production technologies, companies with informal R&D exchange report higher probabilities of success. This confirms the suggested specialization effect in the choice of R&D portfolios. In-house R&D presents an advantage for patenting and product development, but remains an insignificant factor for product upgrades and process innovations. In comparison of effect size, we show that formal R&D contracts have an even stronger impact than in-house R&D facilities when it comes to patenting activities.

Turning attention to the set of control variables, a few observations are worth noting. First, as may be expected, the size of in-house R&D departments appears to affect innovation outcomes, although not in the case of patenting activities. Further, companies with licensing agreements seem to be more successful in patenting activities and product upgrades. This may suggest the presence of modest spillover effects, although similar effects are not statistically significant for new product developments or process innovations. Lastly, firm size (measured by total number of employees and total assets) is generally not associated with a firm's likelihood to successfully complete innovation projects. This suggests a highly competitive private manufacturing economy in which no firm has secured sufficient market position to dominate the innovation process in their manufacturing niche.

A general concern in cross-sectional estimation strategies is the risk of reverse causality. On the basis of the rich pool of qualitative interviews, however, we are relatively certain that cooperative agreements are available to companies independent of their proven track record in terms of R&D. This is also in line with the observation that many companies maintain formal or informal inter-firm collaborations, but are not able to maintain their own in-house R&D facilities. Finally, reporting errors are likely to plague any self-reported measures to some extent. In our case, however, comparison with earlier survey waves gives some confidence in the validity of results, as use of earlier survey data generates findings similar to those presented here (Nee and Opper, 2012).

## Conclusion

Organizational research has long emphasized the importance of inter-firm collaborations in innovation activities. Little research, however, has explored inter-firm alliances in R&D activities when the institutional environment lacks the intellectual property rights protection of advanced economies. Our study underscores that successful inter-firm cooperation is possible even if the context is characterized by tight financial constraints and weak enforcement of intellectual property rights. Collaborative research within dense industrial clusters has enabled China's private companies to gradually climb up the technology ladder, in spite of formidable institutional barriers set up by policymakers to safeguard the economic dominance of state-owned and state-controlled industrial enterprise. Through bottom-up entrepreneurial activities and the gradual development of norms of cooperation, private firms have been able to enter the top echelon of China's economy, gradually acquiring market shares from national giant corporations.

Our study of private firms in the Yangzi Delta region provides insights into mechanisms enabling the rise of innovation-driven capitalism when formal protection of property rights is either weak or even absent. It was the development and use of bottom-up institutional arrangements within close-knit groups of like-minded actors which provided the necessary funding and reliable business norms to venture into highly risky research activities. In geographically concentrated industrial districts, network effects from the increasing utility of innovative activities for competitive advantage spurred bottom-up institutional innovations, while enabling cooperation in R&D allowed entrepreneurs to build an autonomous capability in innovation.

Importantly, the emerging portfolio of cooperative activities allowed entrepreneurs to participate in innovation activities independent of their resource conditions, size, and distinct technological needs. Embedded in close-knit social structures of industrial clusters, China's start-up entrepreneurs have been able to develop a broad portfolio of cooperative tools and corresponding inter-firm agreements, both formal and informal, that reflects the different technological needs and capabilities at different stages of firm development. In this way, innovation, broadly defined as the introduction of new processes and products, early became part of the general entrepreneurial culture, which in turn fostered and facilitated the emergence of globally competitive clusters of industrial production.

Our account has implications going beyond the immediate application presented here, and offers a broader theoretical lesson for understanding the relationship between network effects and economic development.



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## Note

1 For a more detailed account of the longitudinal survey effort, sampling strategy and questionnaire design, refer to www.capitalism-from-below.com.

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## Appendix A

**Table A1:** The sample by sector and city

| *City* | *Textile* | *Pharma* | *Machinery* | *Transport* | *Electronics* | *Total* |
|---|---|---|---|---|---|---|
| Shanghai | 19 | 18 | 9 | 7 | 46 | 99 |
| Nanjing | 12 | 30 | 15 | 6 | 37 | 100 |
| Nantong | 30 | 29 | 13 | 12 | 16 | 100 |
| Changzhou | 19 | 28 | 23 | 20 | 10 | 100 |
| Hangzhou | 36 | 24 | 13 | 20 | 8 | 101 |
| Wenzhou | 26 | 32 | 18 | 2 | 22 | 100 |
| Ningbo | 30 | 27 | 11 | 10 | 22 | 100 |
| Total | 172 | 188 | 102 | 77 | 161 | 700 |

## Appendix B

**Table B1:** Descriptive statistics of explanatory variables

| | *N* | *Mean* | *Standard Deviation* | *Minimum* | *Maximum* |
|---|---|---|---|---|---|
| Informal technology collaboration | 698 | 0.235 | 0.424 | 0 | 1 |
| Formal R&D contract | 698 | 0.159 | 0.366 | 0 | 1 |
| In-house R&D facilities | 698 | 0.504 | 0.500 | 0 | 1 |
| Number of R&D staff | 698 | 2.507 | 2.804 | 0 | 30 |
| Total employees (log) | 698 | 4.335 | 0.963 | 1.792 | 7.673 |
| Firm age (log) | 698 | 2.391 | 0.436 | 0 | 3.401 |
| Total Assets (log) | 698 | 6.830 | 1.203 | 2.996 | 11.608 |