Innovation activities, sources of innovation and R&D cooperation: evidence from firms in Hong Kong and Guangdong Province, China

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Abstract: In a globalised and knowledge-based economy, companies must innovate continuously. Recent studies suggest that companies create multiple types of innovation and should expand the boundaries of their knowledge-production processes to cooperate with external organisations for innovation. Extant empirical studies of relationships between internal and external innovation activities, R&D cooperation, and types of innovation in developed countries have yielded mixed results. As a prominent Asian newly industrialising economy (NIE), Hong Kong's innovation and technology management has rarely been studied. This study explores the innovation activities and performance of Hong Kong companies with operations in Guangdong. Using a survey – based on the community innovation survey 4 (CIS4) – of 492 companies, we have found that intramural and extramural R&D, acquisition of machinery, and R&D cooperation are important for product, process, organisational, or marketing innovation. A notable result is that market-related efforts play a key role in most innovation undertaken by firms under study.

Keywords: Guangdong; Hong Kong; R&D cooperation; types of innovation; innovation management; market-related innovation; technology management.

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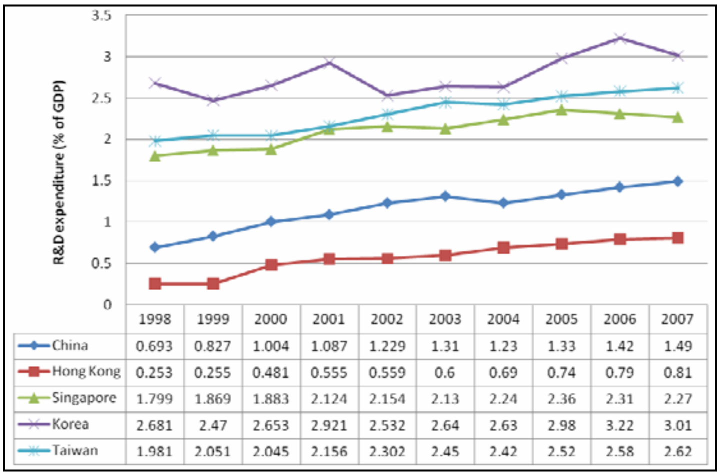
1 Introduction

Innovating and generating new technology are essential to long-term economic development (Verspagen, 2005; Kim and Nelson, 2000; Freeman and Soete, 1997; Grossman and Helpman, 1994), so much so that they play a critical role in predicting the long-term survival of organisations (Ancona and Caldwell, 1987), driving an organisation's success (Higgins, 1995) and sustaining the competitive advantages of nations (Porter, 1990). Policy-related and scholarly literature have both linked innovation with competitive and economic outcomes at the national (OECD, 2010; Schmoch et al., 2006; Lundvall, 1992), regional (Cooke, 2001; Cooke et. al., 1997) and individual firm levels (Vega-Jurado et al., 2009; Amara and Landry, 2005).

Newly industrialised economies (NIEs) in Asia have also followed this path in creating policy frameworks to enhance innovation capabilities (Rowley and Warner, 2005; Kim and Nelson, 2000; Lall and Urata, 2003; Haque et al., 1995; Lall, 1992) and innovation studies scholars have been keen to understand how the NIEs have caught up with advanced industrialised economies (cf. Brahmbhatt and Hu, 2009; Hobday, 2007; Fagerberg and Godinho, 2005). The Asian NIEs have all spent around 2% of GDP on R&D during the last decade [Figure 1(a)] – with Hong Kong being the only exception. While empirical studies were conducted on innovation patterns in NIEs in the early 1990s (Lall, 1992; Hobday, 1995), and scholars have re-examined the relationship between innovation activities and performance in Korea, Singapore, and Taiwan recently (Bogliacino et al., 2009; Brahmbhatt and Hu, 2009; Eom and Lee, 2010; Zhao et al., 2005), similar empirical studies on Hong Kong are conspicuous by their absence.

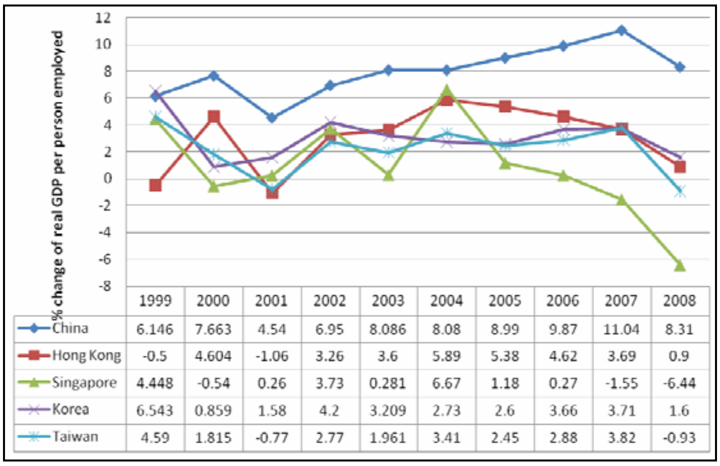
Hong Kong's R&D expenditures are consistently lower than are those in the other NIEs [Figure 1(a)], but its overall productivity growth remains impressive and technology cooperation has been moderately strong over the past ten years [Figures 1(a) and 1(b)]. Since many Hong Kong firms have transformed themselves into service providers, transitioning from manufacturing to trading, we believe that it is important to examine the extent to which Hong Kong firms are innovating and in what ways are they doing so. In this paper, we focus on Hong Kong-owned manufacturing firms in Guangdong because they have hitherto not been studied, and because unless they innovate and move up the value chain they will find it difficult to survive in Guangdong, dramatically undermining Hong Kong's manufacturing-related service-based economy. Survival of these firms is necessary for the millions of workers employed in Guangdong, but even more importantly, to ensure the sustainability of Hong Kong's service-based economy, which functions in tandem with the considerable manufacturing that Hong Kong firms undertake in Guangdong (Sharif and Huang, 2012).

Figure 1 (a) R&D expenditure as a percentage of GDP by country (b) overall productctivity growth by country (see online version for colours)



	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
China	0.693	0.827	1.004	1.087	1.229	1.31	1.23	1.33	1.42	1.49
Hong Kong	0.253	0.255	0.481	0.555	0.559	0.6	0.69	0.74	0.79	0.81
Singapore	1.799	1.869	1.883	2.124	2.154	2.13	2.24	2.36	2.31	2.27
Korea	2.681	2.47	2.653	2.921	2.532	2.64	2.63	2.98	3.22	3.01
Taiwan	1.981	2.051	2.045	2.156	2.302	2.45	2.42	2.52	2.58	2.62

(a)



	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
China	6.146	7.663	4.54	6.95	8.086	8.08	8.99	9.87	11.04	8.31
Hong Kong	-0.5	4.604	-1.06	3.26	3.6	5.89	5.38	4.62	3.69	0.9
Singapore	4.448	-0.54	0.26	3.73	0.281	6.67	1.18	0.27	-1.55	-6.44
Korea	6.543	0.859	1.58	4.2	3.209	2.73	2.6	3.66	3.71	1.6
Taiwan	4.59	1.815	-0.77	2.77	1.961	3.41	2.45	2.88	3.82	-0.93

(b)

Source: IMD World Competitiveness Yearbooks 2000–2009

By examining the innovation practices of Hong Kong companies, focusing on their innovation activities, types of innovation, and R&D cooperation, we contribute to innovation scholarship in two ways. First, we provide an empirical study of innovation activities undertaken by Hong Kong firms with operations in Guangdong province. In particular, we analyse data on external and internal innovation activities, R&D cooperation, types of innovation, and sources of innovation. We thereby provide for the first time a comprehensive assessment of innovation in Hong Kong companies. Second, the paper identifies specific innovation activities that have, when applied to specific types of innovation, proven particularly effective for Hong Kong companies. Although the relationship between innovation capabilities and performance in advanced industrialised countries has been tested (Freeman, 2002), few studies have tested this relationship with data from newly industrialising economies such as Hong Kong, and likewise few studies have tested the full range of innovation activities. As one of the most competitive economies in Asia, Hong Kong should be able to provide important innovation-related cases for academic analysis (Baark and Sharif, 2006; Yu, 2005; Hobday, 1995), the results of which should apply to similarly sized, outward-oriented economies such as Singapore, Taiwan, Malaysia, Finland, Norway, and Denmark. We therefore extend the focus on product and process innovation in the existing literature (Li et al., 2010), playing off an updated definition of innovation from the OECD (2005), to consider the full range of product, process, marketing, and organisational innovation.

The remainder of the paper consists of a review of the relevant literature that yields our research questions in Section 2, a description of our methodology and statistical approach in Section 3, presentation and discussion of the results in Section 4, and concluding remarks with caveats about the study's limitations in Section 5.

2 Literature review and research questions

2.1 Hong Kong's innovation system: growing interdependence with Guangdong

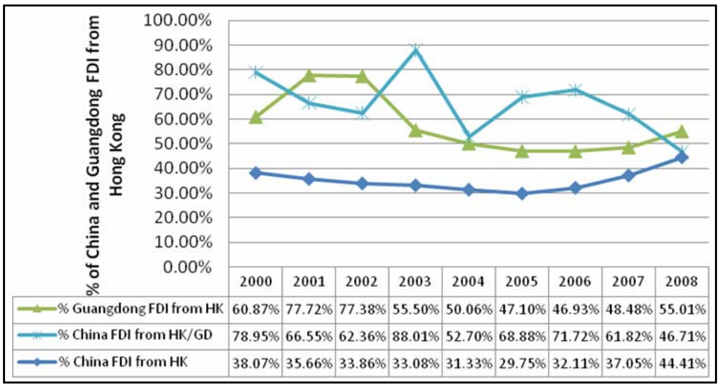
Hong Kong companies are closely integrated with the Pearl River Delta (PRD) – among the most highly efficient regions for technology adoption in China (Guan and Chen, 2010). In the 1980s and 1990s, many Hong Kong firms transformed themselves into service providers, transitioning from manufacturing to trading, thereby maintaining the former British colony's global competitive advantage (Sharif, 2006). Many entrepreneurs in Hong Kong operate as traders in Hong Kong and as proprietors of or partners in plant facilities in the Mainland. The import/export firms operated by these entrepreneurs import goods from their factories in China, especially Guangdong, and subsequently re-export them to the rest of the world. Following this business model, Hong Kong entrepreneurs have successfully reduced their manufacturing costs and achieved high rates of growth by leveraging their access to the abundant, and relatively cheaper, labour and land resources in Guangdong (Nelson and Pack, 1999).

The Hong Kong Census and Statistics Department (2007) recorded 12,535 manufacturing firms registered in Hong Kong in 2007, but 15,798 import/export firms there engaged in manufacturing-related activities using subcontractors in the Mainland. According to the Federation of Hong Kong Industries (2003), the number of companies in China owned and controlled by Hong Kong businesses was estimated at between 50,000 and 60,000 in 2002, employing approximately 447,000 and 11 million workers in

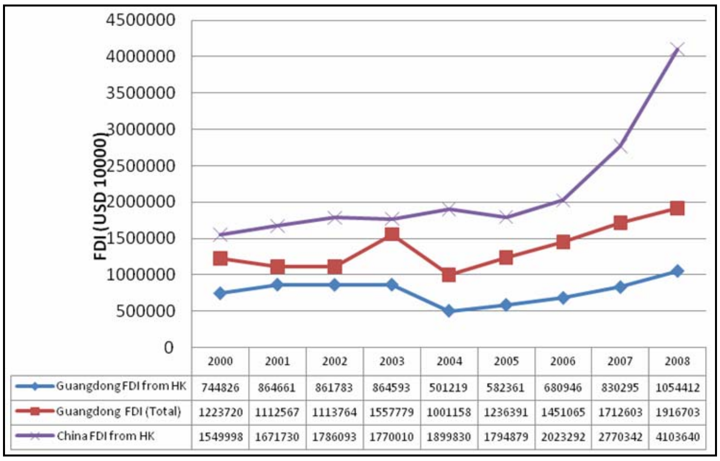
Hong Kong and China, respectively. According to Tsang (2008), the National Bureau of Statistics of China recorded in 2007 some 70,000 export-processing plants in Guangdong, of which 57,500 – employing 9.6 million workers – were Hong Kong-owned (Huang and Sharif, 2009).

As shown in Figure 2, Hong Kong has recently been a major source of FDI for Guangdong and even other parts of China. In 2008, 44.41% of China FDI (US$ 41 billion) was sourced from Hong Kong, of which 46.71% went to Guangdong. This investment constituted 55% of total FDI in Guangdong. By accounting for the close relationship between Guangdong and Hong Kong – we offer an empirical study of Hong Kong-owned companies with manufacturing operations in Guangdong – we avoid confusion that can arise in studies of Hong Kong companies that ignore their manufacturing operations in Guangdong and the PRD (Sit, 2005, 2006).

Figure 2 (a) The percentage of actual foreign investment in China and Guangdong from Hong Kong (b) actual foreign investment in China and Guangdong from Hong Kong (see online version for colours)



(a)



(b)

Source: China Statistical Yearbooks 2000–2009 and Guangdong Statistical Yearbooks 2000–2009

Since the opening of China, Hong Kong-owned manufacturing firms have demonstrated strong marketing capabilities and managerial skills, and have made good use of these capabilities in collaboration with export-oriented sectors in China. Hong Kong companies have practiced adaptive entrepreneurship, competing with firms from developed economies by producing similar or incrementally improved products at lower cost (Yu, 2005; Sit, 1998). Concentrating on skilful exploitation of available technology, they rarely perform R&D aimed at creating proprietary technology or upgrade their technology (Davies, 1999). Hong Kong companies have worked well with other companies externally to gain cost and efficiency advantages, but they have depended on their intermediary firms to maintain a considerable share of business in the global market (Meyer, 2000). As shown in Figure 1, Hong Kong ranks very low in R&D expenditures as a percentage of GDP.

2.2 Key concepts: innovation activities, sources of innovation, and R&D cooperation

2.2.1 Innovation activities

Innovation occurs across a range of activities that can affect firm-level innovation performance. There is considerable empirical evidence that intramural and extramural R&D indicate a firm's level of innovativeness and boost innovation activity (Dosi, 1988; Freeman and Soete, 1997; Baldwin and Hanel, 2003; Strokey, 1995; Griliches, 1995; Hall, 1996; Hall and van Reenen, 2000; Frenkel et al., 2001). Notwithstanding the growth in recent years of R&D outsourcing and R&D-focused strategic alliances, intramural R&D has been shown to be positively correlated with product innovation, defined as "the market introduction of a new good or service or a significantly improved good or service with respect to its capabilities" (Romijn and Albaladejo, 2002). The acquisition of machinery, equipment, and software also contributes to developing new processes for innovation. Process innovation involves incremental improvements through suppliers of new machinery and equipment (Pavitt, 1984). Firms often prefer to invest in new equipment and machinery offered by other companies, instead of developing process innovations themselves. Marketing strategies such as advertising (Koeller, 1996) and managing pairs of products/markets (Baldwin and Johnson, 1996) have also been shown to benefit innovation. In general, a good marketing strategy contributes to commercial success and to the exporting of new products/processes, thereby encouraging firms to innovate (Baldwin and Johnson, 1996).

Innovating firms need highly educated, technically qualified, and experienced personnel with diverse backgrounds (Freel, 2005; Guangzhou Hu, 2003; Koeller, 1996; Koschatzky et al., 2001; Romijn and Albaladejo, 2002; Shefer and Frenkel, 1998; Souitaris, 2002); in some studies training has been positively correlated with innovation (Baldwin and Johnson, 1996; Kam et al., 2003; Koschatzky et al., 2001; Souitaris, 2002). The qualifications and cumulative experience of managers are likewise important keys (Baldwin and Johnson, 1996; Romijn and Albaladejo, 2002; Souitaris, 2002).

2.2.2 Sources of innovation

Innovation depends not only on factors internal to firms, but also on interactive processes involving relationships between firms and external actors (Tidd, 2006; Kline and

Rosenberg, 1986). To stimulate innovation, firms may seek information from customers, suppliers, universities, research institutions, government/public authorities, consultants, the press, or trade fairs (e.g., OECD, 2010; Santamaria et al., 2009; von Hippel, 1988).

External sources of innovation thus complement an organisation's in-house knowledge-creation capabilities (Grant, 1996) through formal or informal networks that facilitate learning processes, including learning-by-using, learning-by-doing, and learning-by-sharing (Lengrand and Chartrie, 1999; Foray, 2000). Interactions with external sources of innovation often provide missing external inputs into the learning process that many firms cannot provide for themselves (Romijn and Albaladejo, 2002), which then improve innovation performance (Caloghirou et al., 2004). Hence, technological innovation can be conceptualised as a learning and evolutionary process (Cohen and Levinthal, 1989; Dodgson, 1993).

According to learning theory, a firm's innovation performance is also an outcome of expanding its knowledge base (Henderson and Cockburn, 1996). Firms can acquire knowledge by tapping into external knowledge bases (Cohen and Levinthal, 1989; Huber, 1991). They can reinforce their technological capabilities by importing technologies, and then diffusing, assimilating, communicating, and absorbing new knowledge from a variety of innovation sources (Prahalad and Hamel, 1990). A firm's ability to acquire, utilise, and develop valuable resources and capabilities often depends on acquiring and absorbing external knowledge (Teece et al., 1997).

2.2.3 R&D cooperation

Several innovation scholars, particularly those who apply the innovation systems approach, argue that firms do not operate or innovate in isolation, but through enduring inter-relations with other firms and institutions (von Hippel, 1988; Lundvall 1988; Freeman, 1991; Harland, 1996; Gulati et al., 2000; Coombs et al., 2003). Individual companies that cannot keep pace with these multiple technologies often rely on other technology sources, forming alliances with other companies rather than exploring conventional arms-length markets.

Interaction with suppliers, customers, public research agencies, industry associations, or foundations may also provide missing external inputs that firms cannot easily develop. Such interaction might be undertaken to gather information about technologies and markets or to obtain other inputs to complement the internal learning process (Rothwell and Dogson, 1991; Dodgson, 1993; Lundvall, 1988, 1992; Edquist, 1997; Freeman, 1991, 1995; Panda and Ramanathan, 1996). Firm interdependence for innovation has been spreading in recent years (Chesbrough, 2003), as suggested by growth in innovation-related strategic alliances (Hagedoorn, 2002).

2.2.4 Research questions

The innovation system that has emerged in Hong Kong during recent decades is shaped both by government policies and the characteristics of innovation patterns pursued by the majority of Hong Kong firms. Since Hong Kong firms have generally been reluctant to spend much money on R&D investment, they have instead depended on strong marketing capabilities and managerial skills to maintain their global competitive advantage (Nelson and Pack, 1999). The small entrepreneurial HK firms need to rapidly exploit market opportunities and then flexibly modify their production lines to introduce new products with short lead-times (Yu, 2005; Sit, 1998). To enhance their technological capabilities, the firms skilfully exploit technology available on the international market (Davies, 1999) and keep acquiring effective production and design engineering capabilities externally, e.g., overseas customers (Enright et al., 2005). Firms in the innovation system therefore tend to use family networks to coordinate the production functions with lower transaction costs. Small firms in Hong Kong therefore often depend on foreign customers or overseas parent companies as sources of innovation, while some large to medium-sized firms develop their own technologies (Leung and Wu, 1995). The companies tend to adopt more R&D cooperation to learn external technological knowledge from developed countries and on this basis progressively augment their R&D capabilities (Cheng and Zheng, 2001). In other words, firms in Hong Kong's innovation system rely principally on their own innovation efforts that require little R&D investment, plus targeted external sources which may include cooperation. Government policies and services also appear to have reinforced this pattern in the innovation system, although lately university-industry relations have been strongly promoted (Sharif and Baark, 2008).

In a sense, Hong Kong's innovation system is thus shaped by the particular features of firms in a highly competitive, internationalised economy and by the limited resources that exist for R&D and access to key innovation sources and partners for R&D cooperation (Sharif, 2006). However, such characteristics have hardly been identified beyond the anecdotal level, and the shift of manufacturing units to Guangdong province appears to have reinforced these characteristics. In this paper, we therefore need to further explore the variety of innovation activities and sources of knowledge that contribute to innovation in Hong Kong firms with manufacturing in Guangdong, and study the impact of R&D cooperation on innovation activities. The theoretical literature does not provide sufficiently specific axioms about the causal relationships between the innovation system and the features of innovation in firms of NIEs like Hong Kong, and therefore, our analysis will be based on the following research questions:

Research Question 1 How do innovation activities and sources of innovation affect types of innovation pursued by Hong Kong-owned manufacturing firms in Guangdong?

Research Question 2 How does R&D cooperation affect types of innovation, innovation expenditure, and turnover among Hong Kong-owned manufacturing firms in Guangdong?

3 Methodology

3.1 Measures

In this study we employed survey instruments based on the questionnaire included in the Fourth Community Innovation Survey (CIS4), adding questions reflecting issues unique to Hong Kong. The authors conducted the survey in March 2008. CIS4 offers a comprehensive instrument for measuring firm-level innovation performance and activities and has been used to measure innovation performance in Europe and other regions (Frenz and Letto-Gillies, 2009; Heidenreich, 2009; Castellacci, 2008). Thus, the constructs derived from CIS4 selected for this study (see Appendix) have been verified through extensive data collection practice and innovation research.

3.1.1 Independent variables

To examine the role of innovation patterns exhibited by Hong Kong enterprises with manufacturing activities in Guangdong, the survey gathered data on independent variables related to innovation activities, sources and expenditures. Space does not allow us to discuss each variable in detail here, but it suffices to say that they have been found significant as inputs to innovation processes in research based on data from several rounds of Community Innovation Surveys (for more detailed descriptions, please see Appendix). The corresponding variables took the value 1 to indicate that a firm engaged in a specific innovation activity or received innovation-related public financial support and 0 if it did not. Sources of innovation were measured using a four-point Likert scale to indicate the relative importance of innovation-related information sources, while similar Likert scales were used to gauge a firm's motivation to engage in innovation-related R&D cooperation. Innovation expenditure was measured as a continuous variable based on the firm's estimate of Hong Kong dollars allocated to various components of expenditure, or the total expenditure.

3.1.2 Dependent variables

The dependent variables of our study focus on output from innovation processes. Although we do not imply a simple, unidirectional causality between innovation inputs and outputs, we believe that a close correlation suggests strong interdependence. Thus a close association of certain sources of innovation with a marketing innovation can be seen, we argue, as indicating that such sources are particularly helpful for this type of innovation. Our first model therefore includes a dichotomous variable indicating whether the enterprise had undertaken product, process, marketing, or organisational innovation in 2006–2007. This variable took the value 1 when a firm declared that it had undertaken a given type of innovation as described in the Appendix and 0 if it had not. Our second model employs a dependent variable that relied upon a continuous, percentage-type measurement of a firm's turnover derived from innovation. This represents the goods and services innovations introduced during 2006–2007 that were new to the market as a percentage of a firm's total turnover. This variable was used to test whether greater innovation expenditure generated a better innovation outcome when mediated by R&D cooperation.

3.1.3 Control variables

Following the CIS4 methodological recommendations, we included three control variables in all the logistic regression models. The first two variables were company size in 2006 and 2007, measured by number of employees after a log transformation. By controlling for size, we accounted for potential economies and diseconomies of scale (Swan and Allred, 2003; Hitt et al., 1997) and addressed performance measurement bias due to company size (Devaraj et al., 2004). We also included type of industry using seven dummies in the regression. The dummy variables covered agriculture and fishing; manufacturing; electricity, gas and water; construction; wholesale, retail and import/export trades, restaurants and hotels; transport, storage and communication; finance, insurance, real estate and business; and community, social and personal services.

3.2 Sampling

The CIS4 methodological recommendations suggest that the sampling unit should be the single enterprise among the total population of enterprises in the industry surveyed. Enterprises in this survey were selected based on the Hong Kong Standard Industrial Classification (HSIC) four-digit code. To ensure data quality, surveys were conducted by phone and face-to face interviews to collect the data. This approach reduced respondent bias due to misunderstanding of the questionnaires.

Reflecting our focus on the innovation activities of Hong Kong enterprises with Guangdong manufacturing operations, the sample was drawn mainly from companies listed in the Chinese Manufacturing Association (CMA) 2008 Directory of Members. To broaden the sampling frame, we also identified 870 Hong Kong enterprises with manufacturing activities in Guangdong using our personal networks. The final sampling frame comprised 3,170 Hong Kong manufacturers with Guangdong manufacturing activities. To further verify the appropriateness of the samples, respondents provided the addresses of their offices in Hong Kong and manufacturing facilities in Guangdong. We randomly contacted 10% of the respondents to verify that they had operations in both locations, and confirmed that all had manufacturing activities in Guangdong and businesses in Hong Kong, which supported our sampling selection. T-tests were also conducted to verify that there were no significant differences between the samples obtained from the CMA directory and the ones obtained from our personal networks in terms of company profile, types of innovation, and innovation activities and turnover.

The targeted respondents included the president, general manager, or another senior manager of each firm. Of the selected 3,170 firms, 493 responded to the survey. After data cleaning, one incomplete response was deleted. Finally, 492 effective questionnaires were analysed in this study for a response rate of 15.5%.

3.3 Non-response bias

To detect non-response bias, a test was conducted to determine if significant differences existed between late respondents and early respondents in terms of variables relevant to the research questions (Armstrong and Overton, 1977). The average values of demographic items from the first 10% of respondents were compared with those of the last 10% using t-tests. We found no statistically significant difference between the means for the items across the two groups, indicating little or no non-response bias.

We controlled for common method variance in the procedural stage (Podsakoff et al., 2003). In order to minimise respondent bias, the cover letter described the survey only as an innovation study survey so respondents did not know what would be measured. Questions measuring the dependent and independent variables in the questionnaire were split up to achieve psychological and methodological separation. Respondents were granted anonymity to mitigate respondent evaluation apprehension. This study adapted existing measurement items from the CIS to carefully verify the scale items, to reduce item ambiguity, and to keep questions precise.

4 Results and discussion

4.1 Company profiles

Table 1 shows the top three categories of respondents to be manufacturing (73.4%), wholesale, retail and import/export trades, restaurants and hotels (10.8%), and finance, insurance, real estate and business (6.5%). The sample is highly appropriate for our study because most of the respondents operate in local/regional markets within Hong Kong and Guangdong (65.4%), regional markets in Hong Kong plus Mainland China (61.4%), or global markets (70.7%). On average, respondents employed 1,716 staff in 2006 and 1,862 in 2007. About 72% of the individuals who responded to our survey were managers or occupied a more senior position, supporting the credibility of the data.

Table 1 Company profile

	Frequency	*Percent*
Types of industry		
Agriculture and fishing	1	0.2%
Manufacturing	361	73.4%
Electricity, gas and water	8	1.6%
Construction	12	2.4%
Wholesale, retail and import/export trades, restaurants and hotels	53	10.8%
Transport, storage and communication	14	2.8%
Finance, insurance, real estate and business	32	6.5%
Community, social and personal services	3	0.6%
Nil	8	1.6%
Geographic markets in 2006–2007		
Local/regional within Hong Kong and Guangdong	332	65.4%
Hong Kong plus Mainland China	302	61.4%
All other countries	348	70.7%
	Mean (SD)	*Maximum – minimum*
Company size		
No. of employees in 2006	1,716 (6,432)	90,000 – 0
No. of employees in 2007	1,862 (6,787)	91,000 – 0
Respondent's position in the company		
Director, president or general manager	256	52%
Departmental manager	98	20%
Engineer	33	7%
Administrative officer	95	19%
Others	10	2%

Table 2 Company innovation profile

	Frequency	*Percent*
Intellectual property rights used in 2006–2007 (Yes/No)		
Apply for a patent	110	22.4
Register an industrial design	74	15.0
Register a trademark	167	33.9
Claim copyright	87	17.7
Having innovation outputs in 2006–2007 (Yes/No)		
Product innovation	269	54.7
Process innovation	286	58.1
Marketing innovation	244	49.6
Organisational innovation	318	64.6
	Mean (SD)	*Maximum – minimum*
The percentage of total turnover in 2006–2007 (%)		
Turnover % due to product innovations introduced that were new to the market	21.32% (19.71)	100.00% – 0.00%
Turnover % due to product innovations introduced that were new to the firm	25.89% (21.17)	100.00%– 0.00%
Turnover % due to products sold that were unchanged or only marginally modified	58.63% (26.91)	100.00% – 0.00%
Innovation expenditure in 2007 (HKD)		
Intramural (in-house) R&D	$10,262,531 ($42,843,388)	$500,000,000 – $10,000
Acquisition of R&D (extramural R&D)	$6,591,661 ($38,044,397)	$400,000,000 – $5,000
Acquisition of machinery, equipment, and software (exclude expenditures on equipment for R&D)	$16,431,472 ($136,387,727)	$2,000,000,000 – $1,000
Acquisition of other external knowledge	$995,058 ($3,648,790)	$34,495,000 – $1,000
Total *(combining the above 4 expenditures)*	$23,968,940 ($164,946,285)	$2,500,000,000 – $10,000

Table 2 shows the innovation performance of respondents in 2006–2007. Across the sample, in 2006–2007, 54.7% of the enterprises undertook product innovation; 58.1% engaged in process innovation; 49.6% were involved in marketing innovation; and 64.6% carried out some form of organisational innovation. Of these, 22.4% had applied for patents in 2006–2007, while 33.9% had registered trademarks during that period. 15% and 17.7% of the enterprises, respectively, had registered an industrial design or claimed copyright. On average, the turnover due to products that were new to the market (innovation turnover) constituted over 20% of total turnover during 2006–2007, while surveyed enterprises had spent on average over 20 million Hong Kong dollars in innovation expenditure. These data suggest that Hong Kong manufacturers resemble those of European countries, where more than half of firms are innovators (Eurostat, 2010), but with a relatively larger share of turnover due to new-to-market innovations, which constituted only 10% of turnover among European firms (Eurostat, 2009).

4.2 Analytical findings: Research Question 1

In order to examine the first research question, we developed several models using binary logistic regression analysis. The simplified regression equations are as follows:

$$\text{Model 1}: \text{ProdI} = a_1 + b_1\text{IA} + c_1\text{CV} + e_1$$

$$\text{Model 2}: \text{ProcI} = a_2 + b_2\text{IA} + c_2\text{CV} + e_2$$

$$\text{Model 3}: \text{MarkI} = a_3 + b_3\text{IA} + c_3\text{CV} + e_3$$

$$\text{Model 4}: \text{OrgaI} = a_4 + b_4\text{IA} + c_4\text{CV} + e_4$$

where a_x, b_x, and c_x are estimates of the respective parameters, e_x refers to error terms, CV refers to control variables (number of employees in 2006 and 2007; type of industry), IA refers to types of innovation activities, ProdI refers to product innovation, ProcI refers to process innovation, MarkI refers to marketing innovation, and OrgaI refers to organisational innovation. Table 3 records the estimates of the impact of innovative activities on types of innovation outputs. The results show that the models were significant at p-value less than 0.01 (Chi-square = 36.534 to 42.654), with Cox and Snell R-square and Nagelkerke R-square values ranging from 0.114 to 0.196. VIF and tolerance tests were also used to test for possible multicollinearity of innovation activities (independent variables) with innovation types (dependent variables). The results show a range of tolerance for the constructs of 0.86 to 0.99, with the VIF ranging from 1.01 to 1.25, indicating that multicollinearity is unlikely to be a serious problem (Field, 2009).

The results of the analysis indicate six important impacts of various innovative activities on the four main types of innovation. First, our findings indicate that intramural R&D conducted by Hong Kong-owned manufacturers in Guangdong is positively correlated with product and marketing innovations. Such investments in intramural R&D provide firms with a competitive edge over firms that do not invest in intramural R&D, at least during the early stages of the innovation process. These findings agree with what we find in the literature, namely, that investment in R&D is an important indicator of a firm's level of innovativeness (Dosi, 1988; Freeman and Soete, 1997; Baldwin and Hanel, 2003).

Second, our study finds that acquiring machinery, equipment, and software is positively correlated with process and organisational innovation. This confirms that purchasing machinery and equipment remains the most important strategy in developing new processes, especially for relatively unsophisticated enterprises. For such firms, process innovation frequently relies on incremental improvements that are made feasible by suppliers of new machinery and equipment (Vega-Jurado et al., 2009; Pavitt, 1984). This accords with Porter's (2009) finding that ICT technologies and specialised machinery were purchased by many companies engaged in low-tech industrial sectors, as well as Wang's (2006) finding that enterprises view the purchase and implementation of an enterprise resource planning (ERP) software system as a major innovation activity.

Third, our results indicate that training is positively associated with marketing and organisational innovations, reflecting the outward-looking, market-oriented nature of Hong Kong-owned manufacturers in Guangdong, to whom close connections with customers is of paramount importance. Staffing firms with better educated, technically qualified, and experienced personnel remains an important innovation-related strategy among these firms – in terms of improving the marketability of their products to international markets as well as in terms of developing new management strategies. A further explanation of these findings is that Hong Kong-owned manufacturing firms in Guangdong leverage training to acquire externally developed technologies (Hoffman et al., 1998; Romijn and Albaladejo, 2002).

Table 3 Relationships between types of innovation and innovation activities

	Product innovation	*Process innovation*	*Marketing innovation*	*Organisational innovation*
	Coefficient (S.E.)			
	Model 1	*Model 2*	*Model 3*	*Model 4*
Control variables				
No. of employees in 2006 (log)	–0.008 (0.500)	0.125 (0.088)	–0.497 (0.465)	0.392 (0.497)
No. of employees in 2007 (log)	–0.054 (0.502)	0.176 (0.534)	0.454 (0.465)	0.116 (0.078)
Ind_1#	0.144 (44923.258)	0.318 (44789.887)	20.049 (40192.686)	20.605 (40192.841)
Ind_2	–19.328 (20066.216)	20.426 (8715.466)	0.452 (1.327)	0.229 (1.342)
Ind_3	–19.148 (20066.216)	–0.139 (23753.070)	–0.316 (1.360)	–0.416 (1.381)
Ind_4	20.427 (20066.216)	19.676 (8715.466)	–0.722 (1.218)	–0.163 (1.236)
Ind_5	20.086 (20066.216)	18.595 (8715.466)	–0.089 (1.423)	0.877 (1.591)
Ind_6	20.910 (20066.216)	–0.435 (26636.938)	–2.300* (1.182)	19.854 (17820.835)
Ind_7	20.173 (20066.216)	19.433 (8715.466)	–0.604* (0.309)	–0.116 (0.078)

Notes: Binary logistic regression analysis with a stepwise backward-likelihood ratio was used. As this study was exploratory in nature, a stepwise method was used and the backward-likelihood ratio method was selected to minimise Type II errors and this type of method usually results in the most parsimonious model (Field, 2009).
#The dummy variables for the eight industries were specified as follows:
Ind_1 = 1: community, social and personal services; Ind_2 = 1: finance, insurance, real estate and business; Ind_3 = 1: transport, storage and communication;
Ind_4 = 1: wholesale, retail and import/export trades, restaurants and hotels;
Ind_5 = 1: construction; Ind_6 = 1: electricity, gas and water;
Ind_7 = 1: manufacturing; Ind_1-7 = 0: agriculture and fishing.
*$p < 0.10$; **$p < 0.05$; ***$p < 0.01$

Table 3 Relationships between types of innovation and innovation activities (continued)

	Product innovation	*Process innovation*	*Marketing innovation*	*Organisational innovation*
	Coefficient (S.E.)			
	Model 1	*Model 2*	*Model 3*	*Model 4*
Innovation activities				
Intramural R&D	*0.899**** *(0.300)*	0.039 (0.365)	*0.611*** *(0.296)*	0.082 (0.324)
Extramural R&D	0.131 (0.347)	–0.206 (0.385)	–0.107 (0.295)	0.497 (0.352)
Acquisition of machinery, equipment and software	–0.533 (0.382)	*0.825*** *(0.357)*	–0.156 (0.328)	0.743** (0.336)
Acquisition of other external knowledge	0.085 (0.315)	0.074 (0.356)	–0.160 (0.274)	0.241 (0.310)
Training	0.162 (0.332)	0.419 (0.349)	*0.533** *(0.286)*	*0.795**** *(0.299)*
Market introduction of innovations	*0.592*** *(0.296)*	*0.657*** *(0.319)*	*0.889**** *(0.252)*	*0.801**** *(0.294)*
Other preparations	*0.847**** *(0.321)*	0.056 (0.352)	0.319 (0.272)	0.573* (0.315)
R&D cooperation on any of your innovation activities with other enterprises or institutions	*0.584** *(0.338)*	*1.401**** *(0.440)*	0.289 (0.292)	0.585 (0.338)
Constant	2.631*** (0.361)	56.428 (26146.398)	1.390 (1.189)	1.509*** (0.546)
No. of observation	303	303	303	303
–2 log likelihood	302.323	262.331	376.805	311.179
Cox and Snell R-square	0.121	0.129	0.114	0.131
Nagelkerke R-square	0.179	0.204	0.153	0.191
Chi-square (sig.)	39.000 (0.000)	42.018 (0.000)	36.534 (0.000)	42.654 (0.000)

Notes: Binary logistic regression analysis with a stepwise backward-likelihood ratio was used. As this study was exploratory in nature, a stepwise method was used and the backward-likelihood ratio method was selected to minimise Type II errors and this type of method usually results in the most parsimonious model (Field, 2009).
[#]The dummy variables for the eight industries were specified as follows:
Ind_1 = 1: community, social and personal services; Ind_2 = 1: finance, insurance, real estate and business; Ind_3 = 1: transport, storage and communication;
Ind_4 = 1: wholesale, retail and import/export trades, restaurants and hotels;
Ind_5 = 1: construction; Ind_6 = 1: electricity, gas and water;
Ind_7 = 1: manufacturing; Ind_1-7 = 0: agriculture and fishing.
*p < 0.10; **p < 0.05; ***p < 0.01

Fourth, market introduction of innovation is strongly correlated with all types of innovation activities, including product innovation, process innovation, marketing innovation, and organisational innovation. Put another way, market-based activity related to innovation is the most important factor affecting innovativeness in Hong Kong-owned manufacturing firms in Guangdong. This finding confirms the market-oriented character of Hong Kong firms, which typically operate in global supply chains in which a producing firm's market is defined by a selected number of customers who lead the way by prescribing the production processes and activities of the manufacturing firms. This finding also underlines the acute market awareness of these manufacturers and is consistent with the broad characterisation of Hong Kong-owned manufacturing firms as embodying innovativeness through:

a high levels of absorptive capacity from global knowledge sources, adaptation of technology, and recombinative capabilities for synthesising knowledge into new productive configurations

b the ability to learn from advanced customers and markets; agile sensitivity to changing demand and imitative speed/creative imitation

c organisational flexibility, orchestrating loosely coupled networks and business processes and employing quality control (Sharif and Baark, 2005).

Fifth, cooperation on innovation activities with other enterprises or institutions is primarily positively correlated with process innovation, followed by product innovation. The nimbleness and flexibility of Hong Kong firms enable them to be deeply integrated into international supply chains in which customers are an overwhelmingly important source of innovative ideas and activity (MacBeth and Ferguson, 1994; Oliver, 1990). Interaction with suppliers and customers often provides otherwise unavailable external inputs into innovation activities for Hong Kong-owned manufacturing firms in Guangdong, enabling firms to gather information about technologies and markets and obtain various other inputs to complement the internal learning process (Rothwell and Dodgson, 1991; Dodgson, 1993; Lundvall, 1992; Edquist, 1997; Panda and Ramanathan, 1996). R&D cooperation is insignificant for organisational and marketing innovation. Both organisational and marketing innovation rely primarily on non-technological inputs, so R&D cooperation makes only small contributions.

Another binary logistic regression analysis was conducted to examine the relationship between various sources of innovation and types of innovation (Table 4). The simplified regression equations in this study are as follows:

$$\text{Model 5}: \text{ProdI} = a_5 + b_5\text{SI} + c_5\text{CV} + e_5$$

$$\text{Model 6}: \text{ProcI} = a_6 + b_6\text{SI} + c_6\text{CV} + e_6$$

$$\text{Model 7}: \text{MarkI} = a_7 + b_7\text{SI} + c_7\text{CV} + e_7$$

$$\text{Model 8}: \text{OrgaI} = a_8 + b_8\text{SI} + c_8\text{CV} + e_8$$

where a_x, b_x, and c_x are estimates of the respective parameters, e_x refers to error terms, CV refers to the control variables, and SI refers to individual sources of innovation. Through principal component analysis, we identified three major categories of sources of innovation: internal or market sources (combining internal R&D, suppliers, clients/customers, and competitors), consultants or institutional sources (combining consultants, universities, and government agencies), and other sources (combining conferences, journals, and associations). Principle component analysis (varimax with Kaiser normalisation), Cronbach's alpha reliability tests, and confirmatory factor analysis using structural equation modelling (with maximum likelihood estimation and several model fit indexes) were conducted to verify sources of innovation (see Appendix).

Table 4 shows that the models were significant at p-value less than 0.01 (chi-square = 14.018 to 38.344), with Cox and Snell R-square and Nagelkerke R-square values ranging from 0.044 to 0.163. VIF and tolerance tests were used to test for possible multi-collinearity of innovation sources (independent variables) with innovation types (dependent variables). The results show that the tolerance range of the constructs was less than 1 and that of the VIF was less than 5, indicating that multi-collinearity was unlikely to be a serious problem (Field, 2009).

Table 4 Relationships between types of innovation and sources of innovation

	Product innovation	*Process Innovation*	*Marketing innovation*	*Organisational innovation*
	Coefficient (S.E.)			
	Model 5	*Model 6*	*Model 7*	*Model 8*
Control variables				
No. of employees in 2006 (log)	–0.035 (0.490)	0.185** (0.081)	0.501 (0.455)	–0.489 (0.494)
No. of employees in 2007 (log)	0.125 (0.492)	–0.150 (0.529)	–0. 525 (0.455)	0.167** (0.073)
Ind_1#	0.210 (44,912.135)	0.369 (44,746.180)	20.101 (40,192.970)	20.623 (40,192.970)
Ind_2	–19.958 (20,040.584)	–20.529 (9,287.876)	–0.015 (1.272)	0.132 (1.304)
Ind_3	–19.256 (20,040.584)	–0.095 (24,076.284)	–0.501 (1.371)	–0.530 (1.394)
Ind_4	–20.359 (20,040.584)	–19.757 (9,287.876)	–0.644 (1.216)	–0.093 (1.235)
Ind_5	–20.087 (20,040.584)	–18.805 (9287.876)	–0.085 (1.422)	0.872 (1.592)
Ind_6	–20.950 (20,040.584)	–0.503 (26,537.309)	–1.911 (1.187)	19.875 (17,818.879)
Ind_7	–20.145 (20,040.584)	–19.528 (9,287.876)	–0.490 (0.301)	–0.110 (1.182)

Notes: Binary logistic regression analysis with a stepwise backward-likelihood ratio was used. As this study was exploratory in nature, a stepwise method was used and the backward-likelihood ratio method was selected to minimise Type II errors and this approach usually results in the most parsimonious model (Field, 2009).
#The dummy variables for the eight industries were specified as follows:
Ind_1 = 1: community, social and personal services; Ind_2 = 1: finance, insurance, real estate and business; Ind_3 = 1: transport, storage and communication;
Ind_4 = 1: wholesale, retail and import/export trades, restaurants and hotels;
Ind_5 = 1: construction; Ind_6 = 1: electricity, gas and water;
Ind_7 = 1: manufacturing; Ind_1-7 = 0: agriculture and fishing.
The transformed uncorrelated variable from PCA analysis (Anderson-Rubin method) was used (Field, 2009).
*p < 0.10; **p < 0.05; ***p < 0.01

Table 4 Relationships between types of innovation and sources of innovation (continued)

	Product innovation	*Process Innovation*	*Marketing innovation*	*Organisational innovation*
	Coefficient (S.E.)			
	Model 5	*Model 6*	*Model 7*	*Model 8*
Sources of innovation##				
Internal and market sources	*0.485*** (0.132)*	*0.560*** (0.147)*	*0.487*** (0.127)*	*0.445*** (0.134)*
Consultant and institutional sources	0.044 (0.136)	0.172 (0.161)	0.233* (0.127)	*0.408*** (0.144)*
Other sources	0.153 (0.134)	0.171 (0.153)	*0.470*** (0.127)*	0.260* (0.136)
Constant	1.157*** (0.137)	20.000 (9287.876)	0.751*** (0.266)	0.170 (0.434)
No. of observations	312	312	312	312
–2 log likelihood	336.879	277.313	386.766	329.717
Cox and Snell R-square	0.044	0.103	0.116	0.097
Nagelkerke R-square	0.065	0.163	0.155	0.141
Chi-square (sig.)	14.018 (0.000)	33.826 (0.000)	38.344 (0.000)	31.745 (0.000)

Notes: Binary logistic regression analysis with a stepwise backward-likelihood ratio was used. As this study was exploratory in nature, a stepwise method was used and the backward-likelihood ratio method was selected to minimise Type II errors and this approach usually results in the most parsimonious model (Field, 2009).
#The dummy variables for the eight industries were specified as follows:
Ind_1 = 1: community, social and personal services; Ind_2 = 1: finance, insurance, real estate and business; Ind_3 = 1: transport, storage and communication;
Ind_4 = 1: wholesale, retail and import/export trades, restaurants and hotels;
Ind_5 = 1: construction; Ind_6 = 1: electricity, gas and water;
Ind_7 = 1: manufacturing; Ind_1-7 = 0: agriculture and fishing.
The transformed uncorrelated variable from PCA analysis (Anderson-Rubin method) was used (Field, 2009).
*p < 0.10; **p < 0.05; ***p < 0.01

The data indicate a sixth important impact of innovative activities on types of innovation, namely that internal or market sources remain the pre-eminent sources of knowledge for all types of innovation. This finding agrees with previous findings, which underscores that, in addition to internal R&D, firms depend mainly on customers or suppliers to input new product information and technologies (Enright et al., 1997; Hyland et al., 2006; von Hippel, 1988). These patterns of knowledge inputs are particularly common in developing countries (Lall, 1992) and small and medium-sized enterprises (Varis and Littunen, 2010). But as the data collected for European firms by CIS4 also indicated, "enterprises engaged in innovation tend to use internal sources and market sources more often than institutional sources" [Eurostat, (2007), p.3].

It is worth noting that consultants and institutional sources are positively correlated with marketing and organisational innovations, while showing no significant impact on product or process innovations. This finding may suggest that there are competent managerial consultants that could help Hong Kong firms undertake marketing and organisational innovations. It may be equally noteworthy that innovations developed in universities and public research institutes have no effect on any type of product or process innovation. It is possible that these sources are generic and derive primarily from basic science, which makes it difficult for firms to see immediate returns (Mowery and Sampat, 2005). However, Eom and Lee (2010) found that university-industry collaboration in Korea also had no significant effect on the success of technological innovation, but nevertheless affected innovation direction by making it easier for firms to generate patents. Similar findings apply to Japanese small businesses (Okamuro, 2007). Furthermore, knowledge generated by universities and public research institutes may differ markedly from knowledge issuing from applied research conducted by firms. University researchers may create technological or non-technological information with greater scientific than market value (Dasgupta and David, 1994). This problem is particularly challenging given the weak R&D investment record of Hong Kong firms, whose technological know-how is remote from the scientific knowledge created by universities and public institutes. This explanation aligns with our finding of an insignificant relationship between journal publications and various types of innovation as shown in Table 4. Firms may be reluctant to cooperate with universities because their weak internal R&D investment leaves them unable to absorb technological knowledge from universities (Laursen and Salter, 2004; Schmidt, 2005).

4.3 Analytical findings: Research Question 2

To address the second research question, we conducted OLS linear regression analyses to test the impact of R&D cooperation on the relationship between innovation expenditure and innovation-related turnover (which is a measure of the extent of successful innovation output). The linear regression equations employed for this test are as follows:

Model 9a-e: $InnoTurn = a_9 + b_9 InnoExp + c_9 CV + e_9$; where CO is equal to 1

Model 10a-e: $InnoTurn = a_6 + b_6 InnoExp + c_6 CV + e_6$; where CO is equal to 0

where a_x, b_x, and c_x are estimates of the respective parameters, e_x refers to error terms, CV refers to the control variables, InnoExp refers to innovation expenditures, InnoTurn refers to innovation-related turnover in 2007, and CO is a dummy variable for R&D cooperation.

We have adopted a straightforward OLS linear regression analysis to examine this question because the limitations of available data (only 160 valid responses) would not support a more simple and intuitive approach using an interactive term of R&D cooperation and innovation expenditure in the regression analysis. Table 5 shows that our regression models, while they are statistically significant, have low R^2, referring to a small effect size. A small effect size in a regression model is quite common in social science studies (Cohen et al., 2003). To detect the effect of an interactive term in a model with small effect size, at least 392 sample responses are required for a reasonable power of 0.80 (Aiken and West, 1991). We therefore report the results of our OLS regression here as a preliminary finding because we believe that they illustrate key aspects of the role of R&D cooperation for Hong Kong firms.

Table 5 Impact of R&D cooperation on the relationship between innovation expenditure and innovation turnover

	Innovation turnover (turnover due to products new to the market)										
	Standardized coefficients (S.E.)										
		Companies have R&D cooperation					*Companies have no R&D cooperation*				
	Baseline[##]	*With in-house R&D expenditure*	*With acquisition of R&D expenditure*	*With acquisition of machinery, equipment, and software expenditure*	*With acquisition of other external knowledge expenditure*	*With total innovation expenditure*	*With in-house R&D expenditure*	*With acquisition of R&D expenditure*	*With acquisition of machinery, equipment, and software expenditure*	*With acquisition of other external knowledge expenditure*	*With total innovation expenditure*
		Model 9a	*Model 9b*	*Model 9c*	*Model 9d*[##]	*Model 9e*	*Model 10a*	*Model 10b*	*Model 10c*	*Model 10d*	*Model 10e*
Control variables											
No. of employees in 2006 (log)	–0.647 (4.782)	–0.232 (7.983)	0.032 (9.239)	–0.687 (8.631)	–1.134 (12.887)	–0.339 (7.896)	–0.734 (7.720)	1.292 (6.817)	–0.082 (11.687)	0.144 (12.960)	–0.687 (7.346)
No. of employees in 2007 (log)	0.652 (4.821)	0.368 (8.142)	0.243 (9.447)	0.804 (8.780)	1.274 (13.162)	0.466 (8.039)	0.628 (7.591)	–1.230 (6.809)	0.032 (11.373)	–0.114 (13.736)	0.687 (7.292)
Ind_1[#]	–0.055 (22.041)	###	###	###	###	###	###	###	–0.016 (25.724)	–0.011 (21.837)	###
Ind_2	–0.073 (10.468)	–0.471 (14.862)	–0.543 (18.659)	–0.489 (14.529)	0.132 (14.938)	–0.500** (14.308)	0.281** (13.462)	–0.096 (15.630)	–0.034 (22.463)	0.013 (20.729)	–0.069 (18.602)
Ind_3	–0.008 (12.162)	–0.470 (16.223)	–0.519 (17.115)	–0.439 (16.359)	–0.192 (15.143)	–0.461 (16.125)	0.068 (27.462)	###	0.153 (25.563)	0.223 (21.207)	0.120 (24.556)
Ind_4	–0.070 (10.097)	–0.527 (14.953)	–0.517 (16.387)	–0.502 (15.682)	–0.053 (21.431)	–0.526 (14.859)	–0.060 (20.952)	###	0.017 (16.339)	0.242 (16.075)	0.013 (15.524)
Ind_5	0.022 (12.840)	–0.367 (17.872)	–0.333 (22.867)	–0.370 (17.975)	–0.168 (20.641)	–0.359 (17.726)	0.198 (25.559)	0.247 (15.236)	0.337*** (19.976)	###	0.242** (14.030)
Ind_6	–0.101 (16.796)	###	###	###	###	###	###	###	###	###	###
Ind_7	–0.111 (9.123)	–0.677 (12.973)	–0.655 (13.735)	–0.632 (13.086)	###	–0.657 (12.873)	0.015 (19.450)	–1.230 (6.809)	0.144 (14.806)	0.163 (12.295)	0.140 (14.213)

Notes: OLS Linear regression (stepwise) analysis with three control variables (i.e., number of employees in 2006 and 2007 and type of industry) was used.
[#]The dummy variables for the eight industries were specified as follows: Ind_1 = 1: community, social and personal services; Ind_2 = 1: finance, insurance, real estate and business; Ind_3 = 1: transport, storage and communication; Ind_4 = 1: wholesale, retail and import/export trades, restaurants and hotels; Ind_5 = 1: construction; Ind_6 = 1: electricity, gas and water; Ind_7 = 1: manufacturing; Ind_1–7 = 0: agriculture and fishing.
[##]In the regression analysis, the model used Entermode because all variables were statistically insignificant.
###The variables are constants in the regression model and automatically deleted from the analysis. No statistical data can be reported.
*$p < 0.10$; **$p < 0.05$; ***$p < 0.01$.

Table 5 Impact of R&D cooperation on the relationship between innovation expenditure and innovation turnover (continued)

	Innovation turnover (turnover due to products new to the market)										
	Standardized coefficients (S.E.)										
		Companies have R&D cooperation					Companies have no R&D cooperation				
	Baseline[##]	*With in-house R&D expenditure*	*With acquisition of R&D expenditure*	*With acquisition of machinery, equipment, and software expenditure*	*With acquisition of other external knowledge expenditure*	*With total innovation expenditure*	*With in-house R&D expenditure*	*With acquisition of R&D expenditure*	*With acquisition of machinery, equipment, and software expenditure*	*With acquisition of other external knowledge expenditure*	*With total innovation expenditure*
		Model 9a	*Model 9b*	*Model 9c*	*Model 9d*[##]	*Model 9e*	*Model 10a*	*Model 10b*	*Model 10c*	*Model 10d*	*Model 10e*
Innovation expenditure											
In-house R&D		*0.263*** (0.000)*					*0.224* (0.000)*				
Acquisition of R&D			*0.261* (0.000)*					*0.514**** (0.000)*			
Acquisition of machinery, equipment and software				*0.335**** (0.000)*					0.073 (0.000)		
Acquisition of other external knowledge					–0.049 (0.000)					*0.364*** (0.000)*	
Total innovation expenditure						*0.279*** (0.000)*					0.114 (0.000)
Constant (un-standardised)	25.101** (9.765)	22.660*** (2.225)	22.816*** (2.660)	22.318*** (9.426, 2.368)	16.425 (12.259)	22.718 (2.195)	17.496*** (2.550)	13.800*** (2.120)	18.145*** (2.276)	17.534*** (2.718)	17.034*** (2.080)
No. of observation	216	68	54	64	36	70	68	31	77	37	91
F-value (sig.)	0.617	*4.886***	*3.809**	*7.828****	0.602	*5.740***	*4.412***	*10.392****	*9.588****	*5.345***	*5.521***
R^2	0.026	0.069	0.068	0.112	0.131	0.078	0.120	0.264	0.113	0.132	0.058
Adjusted R^2	–0.16	0.055	0.050	0.098	–0.087	0.064	0.092	0.238	0.102	0.108	0.048

Notes: OLS Linear regression (stepwise) analysis with three control variables (i.e., number of employees in 2006 and 2007 and type of industry) was used.
[#]The dummy variables for the eight industries were specified as follows: Ind_1 = 1: community, social and personal services; Ind_2 = 1: finance, insurance, real estate and business; Ind_3 = 1: transport, storage and communication; Ind_4 = 1: wholesale, retail and import/export trades, restaurants and hotels; Ind_5 = 1: construction; Ind_6 = 1: electricity, gas and water; Ind_7 = 1: manufacturing; Ind_1–7 = 0: agriculture and fishing.
[##]In the regression analysis, the model used Entermode because all variables were statistically insignificant.
###The variables are constants in the regression model and automatically deleted from the analysis. No statistical data can be reported.
*p < 0.10; **p < 0.05; ***p < 0.01.

Table 5 shows that when enterprises engaged in R&D cooperation with other organisations, any expenditure on machinery, equipment, and software had a positive effect on innovation-related turnover (β = 0.335, t-value = 2.798) and with total innovation expenditure (β = 0.279, t-value = 2.396). In this way, R&D cooperation could provide significant *complementary* assets enhancing investments in equipment and software as well as improving the effects of total investment in innovation. On the other hand, when enterprises engaged in R&D cooperation with other organisations, there were marginally significant effects of innovation turnover from expenditure on acquiring external R&D ($p < 0.10$, β = 0.261, t-value = 1.952) but no significant effects of other external sources of knowledge ($p > 0.10$, β = –0.049, t-value = –0.614). This might suggest that R&D cooperation could also function as a substitute for other external sources of knowledge for innovation.

However, when enterprises did not cooperate in R&D, extramural expenditure for acquisition of R&D became significant, showing a positive effect on innovation-related turnover ($p < 0.01$, β = 0.514, t-value = 3.224). Acquiring other external knowledge was similarly associated with positive effects on innovation output, as indicated by innovation-related turnover (β = 0.364, t-value = 2.312). Thus, the absence of R&D cooperation was associated with a stronger effect of external acquisition of knowledge.

Whether or not firms engaged in R&D cooperation, there is a positive and significant effect of in-house R&D expenditure on innovation-related turnover (for cooperating firms, β = 0.263, t-value = 2.210 and, for non-cooperating firms, β = 0.224, t-value = 1.922). In other words, internal R&D efforts remained the most prominent factor in the generation of sales through innovative products. Such efforts would be enhanced through R&D cooperation. R&D cooperation also had a positive effect on the relationship between expenditure on acquisition of equipment and software and innovation-related turnover. Alternatively, expenditure on outsourcing of R&D and exploitation of external knowledge sources by firms that did not engage in R&D cooperation had the most significant effects on innovation-related turnover.

Table 6 Motivation for R&D cooperation for innovation activities in 2006–2007

	Reason	*N*	*Degree of importance [freq. (%)]*			
			High	*Medium*	*Low*	*Not relevant*
1	Low cost	178	107 (60.1)	51 (28.7)	12 (6.7)	8 (4.5)
2	Close to market and customers	176	61 (34.7)	56 (31.8)	35 (19.9)	24 (13.6)
3	Close to qualified R&D personnel	176	38 (21.6)	78 (44.3)	39 (22.2)	21 (11.9)
4	Favourable government policy	176	30 (17)	50 (28.4)	46 (26.1)	50 (28.4)
5	Close to competitors	176	27 (15.3)	59 (33.5)	54 (30.7)	36 (20.5)
6	Close to local collaborators	176	24 (13.6)	70 (39.8)	49 (27.8)	33 (18.8)
7	Close to knowledge source *(universities and scientific institutions)*	176	19 (10.8)	51 (29)	66 (37.5)	40 (22.7)

In general, firms were motivated to undertake R&D cooperation as a means of reducing the cost of R&D. Cooperation may enable firms to learn more effectively through open-ended learning and knowledge sharing between partners (Grant, 1996), which may be useful for Hong Kong firms with low internal R&D investment. Table 6 shows that Hong Kong firms cooperate in innovation activities with other firms in order to reduce costs

(60.1%) and stay close to market and customers (34.7%), but are usually not motivated by favourable government policies (17%) or by close proximity to universities and scientific institutions (10.8%).

5 Conclusions and limitations

An NIE like Hong Kong depends on effective innovation to maintain the competitiveness of its manufacturing firms. Our study shows that Hong Kong firms with manufacturing activities in Guangdong province respond to such challenges in ways that are similar to those of small and medium-sized firms in industrialised economies, but also follow patterns of innovation that may be slightly different from those of firms in comparable economies.

We found generally that Hong Kong firms do innovate – with 50% of the sampled firms reporting significant innovation outputs (Table 2). Fundamentally, intramural R&D is employed by these firms to enhance performance in product and marketing innovation. On the other hand, acquisition of machinery, equipment, and software is the preferred approach to enhancing process and organisational innovation. Training is utilised to enhance marketing and organisational innovations, while R&D cooperation with other organisations has a positive effect on product and process innovation. Characteristically (for Hong Kong firms), efforts to enhance market introduction of innovations remains a significant backbone for any type of innovation.

The key sources of knowledge for all types of innovation remain the innovative inputs generated by internal R&D and inputs received from the market – predominantly from customers and suppliers. In addition, consultants and institutions such as universities contribute to organisational innovation, while sources such as conferences, journals, and so on contribute primarily to marketing innovations. These patterns reflect the strongly market-oriented character of innovation among Hong Kong firms, and indicate the extent to which firms consider inputs from internal or value-chain networks essential to their innovative output. Given that the Hong Kong government's policies on promoting innovation are oriented towards supporting university-industry links (Sharif and Baark, 2008), the conspicuous absence of reliance on universities and public research organisations for product and process innovation is particularly worrisome. Perhaps additional incentives to make full use of available innovative knowledge would pay off in this area.

Our data also reveal that R&D cooperation can provide important effects on the impact of particular types of innovation expenditures on innovation-related output, measured as turnover related to new products. R&D cooperation can thus enhance the effects of in-house R&D and expenditure on acquisition of equipment and software. Firms also carry out R&D cooperation to overcome excessive risk and financial constraints in innovative expenditure (Abramovsky et al., 2005). In contrast, firms that did not engage in R&D cooperation experienced the most significant effects on expenditure in acquiring external R&D and knowledge. It would appear that governments could enhance innovation spillovers by promoting R&D cooperation, allowing firms to share the costs and risks of R&D cooperation.

In terms of organisational research, our study suggests that firms could enhance their innovation performance by differentiating their efforts related to types of innovation. This result coheres with those of other studies that have shown how various types of R&D cooperation and innovation activities are associated with specific types of innovation in certain industries (Vega-Jurado et al., 2009; Freel, 2003). In the particular situation of Hong Kong-owned manufacturing firms, it is evident that marketing activities, including market research and advertising, are essential to all types of innovation. Intramural R&D is primarily pursued for product and marketing innovation. Training enhances marketing and organisational innovation. Finally, process innovation is largely driven by the acquisition of machinery, equipment, and software and by R&D cooperation, but is not significantly related to extramural R&D or the acquisition of other external knowledge.

Like other survey-based studies, ours is subject to limitations associated with using a single key informant for data collection. The underlying assumption behind this method is that a senior manager, by virtue of his or her position within a company, is capable of providing opinions and perceptions that reflect that company's behaviour (Philips, 1981). Nevertheless, this approach simultaneously limits our research to testing content validity based purely on quantitative data. Similarly, the cross-sectional data used in the present study may obscure fundamental changes in relationships that hold among the variables. Our cross-sectional data do not allow us establish a causal relationship between the innovation activities and sources and the types of innovation, since we cannot establish the time lag between inputs and outputs. We cannot reject the idea that a firm's intention to pursue certain types of innovation will lead to particular types of innovation sources and activities. But, as the types of innovation are measured as the firm's innovation outputs in this study, we suggest that various innovation sources and activities and R&D cooperation (inputs) may be particularly helpful for certain types of innovation (outputs). In future research, we intend to develop a longitudinal multiple-informant approach. However, the complications of conducting research using multiple informants and the practical difficulties of using information from such research should not be underestimated (Philips, 1981). Finally, we have a limited amount of data, which has prevented us from conducting statistical approaches using interactive terms for regression or structural equation analysis.

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Appendix

Survey instrument measures

Control variables	*Measures*
Log company size in 2006/2007	What was your enterprise's total number of employees in 2006 and 2007?
	Type of answer: Actual figures
Type of industry	What is the main activity according to Hong Kong Standard Industrial Classification (HSIC) four-digit code?
Independent variables	
Innovation activities	During the two years 2006–2007, did your enterprise engage in the following innovation activities?
	Type of answer: Yes (1) or No (0)
Intramural (in-house) R&D	Creative work undertaken within your enterprise to increase the stock of knowledge and its use to devise new and improved products and processes (including software development)
Extramural R&D	Same activities as above, but performed by other companies (including other enterprises within your group) or by public or private research organisations and purchased by your enterprise
Acquisition of machinery, equipment, and software	Acquisition of advanced machinery, equipment, and computer hardware or software to produce new or significantly improved products and processes
Acquisition of other external knowledge	Purchase or licensing of patents and non-patented inventions, know-how, and other types of knowledge from other enterprises or organisations
Training	Internal or external training for your personnel specifically for the development and/or introduction of new or significantly improved products and processes
Market introduction of innovations	Activities for the market introduction of your new or significantly improved goods and services, including market research and launch advertising
Other preparations	Procedures and technical preparations to implement new or significantly improved products and processes that are not covered elsewhere.

Survey instrument measures (continued)

Control variables	*Measures*		
Independent variables			
Cooperation on any of the innovation activities with other enterprises or institutions	During the two years 2006–2007, did your enterprise cooperate on any of your innovation activities with other enterprises or institutions? Innovation cooperation is active participation with other enterprises or non-commercial institutions on innovation activities. Both partners do not need to commercially benefit. Exclude pure contracting out of work with no active cooperation.		
Sources of innovation	During the two years 2006–2007, how important to your enterprise's innovation activities were each of the following information sources? *Type of answer: High (3), Medium (2), Low (1), Not used (0)*	PCA factor loading	CFA standardised factor loading (X^2/df: 2.58; CFI: 0.938; IFI: 0.940; RMSEA: 0.057)
Internal and market sources	*Total variance explained (TVE): 20.58%, Cronbach's alpha: 0.62*		
Internal R&D	Within your enterprise or enterprise group	0.52	0.36
Suppliers	Suppliers of equipment, materials, components, or software	0.64	0.49
Customers	Clients or customers	0.75	0.60
Competitors	Competitors or other enterprises in your sector	0.71	0.68
Consultant and institutional sources	*TVE: 20.18%, Cronbach's alpha: 0.76*		
Consultants	Consultants, commercial labs, or private R&D institutes	0.61	0.58
Universities	Universities or other higher education institutions	0.87	0.81
Governments	Government or public research institutes	0.83	0.81
Other sources	*TVE: 19.62%, Cronbach's alpha: 0.73*		
Conferences	Conferences, trade fairs, and exhibitions	0.82	0.80
Journals	Scientific journals and trade/technical publications	0.78	0.74
Associations	Professional and industry associations	0.71	0.55
Innovation expenditures	Please estimate the amount of expenditure for each of the following four innovation activities in 2007 only. *(Type of answer: Hong Kong dollars)*		

Survey instrument measures (continued)

Control variables	*Measures*
Dependent variables	
Intramural (in-house) R&D	Intramural (in-house) R&D (include capital expenditures on buildings and equipment specifically for R&D)
Acquisition of R&D	Acquisition of R&D (extramural R&D)
Acquisition of machinery, equipment, and software	Acquisition of machinery, equipment, and software (exclude expenditures on equipment for R&D)
Acquisition of other external knowledge	Acquisition of other external knowledge
Total innovation expenditure	Total of these four innovation expenditure categories
Product innovation	During the two years 2006–2007, did your enterprise introduce new or significantly improved goods (exclude the simple resale of new goods purchased from other enterprises and changes of a solely aesthetic nature), and/or new or significantly improved services? *Type of answer: Yes (1) or No (0)*
Process innovation	During the two years 2006–2007, did your enterprise introduce: • New or significantly improved methods of manufacturing or producing goods or services? • New or significantly improved logistics, delivery or distribution methods for your inputs, goods or services; and/or new or significantly improved supporting activities for your processes, such as maintenance systems or operations for purchasing, accounting, or computing? *Type of answer: Yes (1) or No (0)*
Marketing innovation	During the two years 2006–2007, did your enterprise introduce significant changes to the design or packaging of a good or service (exclude routine/seasonal changes such as clothing fashions); and/or new or significantly changed sales or distribution methods, such as internet sales, franchising, direct sales or distribution licenses? *Type of answer: Yes (1) or No (0)*
Organisational innovation	During the two years 2006–2007, did your enterprise introduce new or significantly improved knowledge management systems to better use or exchange information, knowledge, and skills within your enterprise; a major change to the organisation of work within your enterprise, such as changes in the management structure or integrating different departments or activities; and/or new or significant changes in your relations with other firms or public institutions, such as through alliances, partnerships, outsourcing, or sub-contracting? *Type of answer: Yes (1) or No (0)*
Innovation turnover	Please give the percentage of your total turnover in 2007 from goods and service innovations introduced during the two years 2006–2007 that were new to your market: *Type of answer: percentages*