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Academia-Industry Linkages and the Role of Active Innovation Policies – Firm-level Evidence in Hong Kong

Wan-Hsin LIU

Abstract:
This paper analyses academia-industry linkages of the Hong Kong (HK) electronics small- and medium-sized enterprises (SMEs) and investigates the role of active innovation policies in this regard. It uses data collected from a questionnaire survey in HK, focusing on three main academia-industry linkages: academic institutions as training bases, as innovation sources and as innovation partners for companies. Our analysis results show that HK companies tend to rely on hiring highly-qualified labour trained by academic institutions to gain access to advanced academic knowledge. In contrast, they do not yet perceive academic institutions as important sources or partners for their innovation activities; however, their willingness to do so seems to be positively affected by the active innovation policies on site.

Keywords: academia-industry linkage, innovation policy, Hong Kong, China

JEL classification: L60, O31, O38, R10

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1 Introduction

Intensive interactions between companies and academic institutions, including universities and research institutes, bring together different expertises from different innovators and are often argued to be advantageous for innovation performance and for sustaining economic growth (e.g. Jaffe, 1989 and Anselin et al., 1997). Among all potential interactive linkages, companies can directly cooperate with or acquire research results from academic institutions, financially support academic research, and hire students, graduates, and researchers etc. to enrich their innovation capabilities. The potential positive effects of academia-industry linkages for innovation and for economic growth motivate governments in many countries to actively promote such linkages.

Earlier studies in this research area suggest that academia-industry linkages utilised by companies for their innovation activities may differ across industries, organisational characteristics of companies, and the business and legal environments in which companies operate (Bekkers and Bodas Freitas, 2008). However, these studies were predominantly carried out in the context of Western countries. In the Asian context, only a limited number of studies were carried out and, to the best of our knowledge, no comparable study was carried out in Hong Kong (HK). Thus, this paper aims to analyse academia-industry linkages of HK companies operating in the Pearl River Delta (PRD) in China to fill this research gap and to provide new insights into factors that determine companies' decisions to engage in certain types of academia-industry linkages.

Economic growth in HK has been claimed to be strongly attributable to the fact that HK companies have relocated their production activities to the nearby low-cost PRD, rather than catching up in technologies (e.g. Chiu and Wong, 2001). However, since 1997 the HK government has markedly changed its role from being a mere institution provider to being an active innovation promoter by implementing a broad spectrum of innovation policies. These policies are expected to enhance companies' incentives to innovate, as suggested in earlier innovation studies in the other newly industrialised economies in Asia such as Korea and Taiwan (e.g. Eriksson, 2005). Moreover, HK innovation policies do not just promote innovation activities in general. They focus especially on promoting innovation-related academia-industry linkages. The second and much stronger wave of promotion of innovation cooperation between academic institutions and companies has taken place in HK since 2005. Against this background, the current paper does not only aim to analyse academia-industry

linkages utilised by HK companies in general. Instead it provides new insights into academia-industry linkages utilised by HK companies, when they are motivated to start to innovate intensively. In addition, it provides new insights into the role of innovation policies as such in HK for affecting companies' willingness to engage in academia-industry linkages. In order to do so, this paper focuses on three such linkages: academic institutions as innovation sources, innovation partners and training bases of highly-qualified labour for companies. We base our analysis on a data set collected from our own questionnaire survey that was addressed to HK electronics small- and medium-sized enterprises (SMEs) operating in the PRD.[1]

This paper is organised as follows. Section 2 discusses earlier studies on academia-industry linkages. Section 3 summarises relevant innovation policies in HK. Because the HK SMEs of interest also operate in the PRD, innovation policies in the PRD are also taken into account. In Section 4, survey and estimation methods are described, taking potential selection bias problems into account. In Section 5, survey data are analysed to explore the relevance of different academia-industry linkages for HK SMEs' innovation activities. In addition, probit models are estimated to investigate the role of innovation policies for HK SMEs' decisions to engage in certain types of academia-industry linkages. Section 6 concludes.

2 Literature background

Academic institutions differ from companies with respect to their innovation goals and how they innovate (Dasgupta and David, 1994). They focus predominantly on basic research to extend and deepen the existing stock of basic knowledge and technologies and they are, in general, willing to share their findings with the public by, for example, publishing them in scientific journals (Trajtenberg et al., 1997). In contrast, the ultimate goal of profit maximisation forces companies to focus more on applied R&D to introduce innovative products into markets, using the basic knowledge and technologies which they either have explored on their own or have obtained from external sources such as academic institutions.

Companies may obtain innovation-related knowledge and technologies from academic institutions through engaging in the following three types of academia-industry linkages (Bozeman, 2000; Feldman et al., 2002; D'Este and Patel, 2007). First, companies can take

[1] This survey "HK Company Survey 2007" aimed at gaining more insights into HK companies' operational practices to find out the potential edges of HK companies over their competitors in global markets. Above all, it focused on investigating how HK companies flexibly react to the global market challenges. This paper only makes use of a subset of survey data collected.

academic institutions as their innovation sources to acquire patents and licenses developed by academic institutions, to search for academic consultancy or to acquire academic publications for their own knowledge exploration. Second, they can take academic institutions as their innovation partners. In this case, they financially support academic research or directly undertake joint research projects with academic institutions. Third, they take academic institutions only as training bases. It means that they directly hire students or graduates and attract researchers to join their research teams to enrich their innovation capabilities.

Empirical studies suggest that companies' decisions to engage in certain types of academia-industry linkages may differ across industries, company characteristics, and the business and legal environments in which companies operate (Bozeman and Coker, 1992; Bozeman, 2000 and Bekkers and Bodas Freitas, 2008).[2] Regarding industries, academic institutions as innovation partners are found to be especially important for R&D intensive industries and for industries whose technological development is rapid. (Cohen et al., 2002 and Schartinger et al., 2002). Moreover, academic institutions as training bases for providing highly-qualified labour for companies' innovation activities are found to be especially important for the electronics industry (Balconi and Laboranti, 2006). In contrast, academic institutions as innovation sources seem to be of similar importance for companies across different industries.

Regarding company characteristics, the following three characteristics are often examined: age, technological capabilities and size. With respect to company age, empirical studies find that academic research seems to be more important for start-ups' R&D activities, seemingly suggesting a generally higher importance across different types of academia-industry linkages for younger companies (Cohen et al., 2002). With respect to technological capabilities, empirical studies argue that companies are required to have certain technological capabilities to be able to establish efficient and effective academia-industry linkages. This further suggests a probably higher relevance across different types of academia-industry linkages for companies' with higher technological capabilities (Ham and Mowery, 1998 and Fontana et al., 2006). Unlike these two company characteristics, however, empirical studies find that the role of company size for companies' decisions for different types of academia-industry linkages is less clear. Bekkers and Bodas Freitas (2008) suggest that large companies with abundant resources may prefer to cooperate with academic institutions or to financially support academic research than small companies. They argue that small companies may, instead,

[2] In addition, characteristics of academic institutions and characteristics of researchers may also matter for companies' decisions on academia-industry linkages (e.g. Bozeman and Coker, 1992 and Bozeman, 2000)

prefer to rely on academic institutions as training bases that provide sufficient highly-qualified labour for their innovation activities. In contrast, Santoro and Chakrabarti (2002) find that small companies may rely more strongly on innovation cooperation with academic institutions to gain access to the costly but highly-qualified research capacities and facilities in such institutions.[3] They also find that large companies may have higher incentives to work on joint education programs with academic institutions.

Regarding the business and legal environments in which companies operate, Hall et. al (2001) find that the quality of intellectual property rights and the appropriability of corporate innovation results matter for determining companies' incentives for cooperating with academic institutions. In addition, Revilla Diez and Mildahn (2007) emphasise the substantial importance of an entrepreneurship-friendly environment for promoting the foundation of spin-off companies. In this way, academic institutions act as training bases that provide highly-qualified researchers capable of transforming academic knowledge into commercialised industrial innovations. Moreover, empirical studies find that, in addition to the overall legal framework, innovation policies may matter. For example, after the initiation of Bayh-Dole Act in the U.S. and the establishment of public R&D labs to promote innovation activities and to encourage interactions between academic institutions and companies in different countries since the late 1970s, a strong increase in the interactions between academic institutions and companies has been identified over time (Rothwell and Dodgson, 1992; Arundel and Geuna, 2004; Cohen et al., 2002; Link, 1996; Link and Scott, 2005). However, findings on whether such an increase in interactions is indeed attributable to innovation policies are inconclusive (Bozeman, 2000; Jensen and Thursby, 2001; Kash and Rycroft, 1994; Yusuf et. al., 2003). However, empirical studies especially those conducted in the Asian context find that policies that aim to influence companies' innovation willingness instead of just to provide innovation-friendly infrastructure tend to be positively relevant for companies' innovation activities (e.g. Eriksson, 2005).

3 Overview of innovation policies in HK and in the PRD

3.1 Innovation policies in HK

It is often argued that there was effectively no industrial and innovation policy in HK before 1997 (Kwong, 1997). The HK government's adherence to market principles was translated into its laissez-faire attitude and its non-intervention industrial policies. It was just a mere

[3] Acs et al. (1994) argued that especially small companies' innovation activities may have comparative advantages in learning from and utilising academic research.

institution provider for the economic development in HK (Tuan and Ng, 1995). To support industrial innovation in such a passive way, new universities in the scientific areas were founded to provide highly-qualified labour for companies' innovation activities.

To promote a healthier and more balanced economy after the Asian financial crisis in 1997, the Commission on Innovation and Technology (CIT) was set up to clarify the role of innovation activities for HK's future and to identify which measures the HK government should undertake to encourage innovation activities (HKSAR, 1998; Baark and Sharif, 2006). Since then, the HK government has continuously increased its direct involvement in promoting industrial and economic development in HK and has changed its role from being a mere institution provider to being an active innovation promoter. Above all, it has placed a special focus on promoting academia-industry linkages for innovation. The University-Industry Collaboration Programme (UICP) has explicitly been added to the newly founded Innovation and Technology Fund (ITF) with an initial injection of 5 billion HKD in 1999.[4] Private companies registered in HK applying for funding under UICP are asked to search for adequate local universities in HK as innovation cooperation partners in advance (HKCSD, 2003a). In 2000 the Innovation and Technology Commission (ITC) was set up as the successor of CIT (ITC, 2007) and the Hong Kong Applied Science and Technology Research Institute (ASTRI) was established. ASTRI is assigned to conduct applied R&D based on the research results of the universities and then to transfer their findings to companies. ASTRI acts like a bridge to facilitate knowledge flows between universities and companies.[5]

In addition, the HK government intends to increase indigenous innovation activities so that the strong reliance of HK companies on the high-tech machines and technologies imported from external suppliers may be gradually reduced and the innovators in HK may obtain higher returns on their innovation investments.[6] To do so, the ITC has announced the "new strategy" in 2005 as the second wave of innovation promotion, which consisted of two key initiatives. The first key initiative was to identify the technology focus areas where innovation should be especially heavily promoted, considering following criteria: (i) existing research capabilities of academic institutions, (ii) HK companies' competitive advantages, (iii) industrial needs and

[4] Since 1983, the exchange rate (HKD/USD) has been fixed at 7.8, HKCSD (2008).
[5] The Industrial Technology Research Institute in Taiwan, the Korean Advanced Institute of Science and Technology in Korea and thirteen industry-specific research institutes and centres in Singapore were used as reference models for the construction of the ASTRI (e.g. HKSAR, 1998).
[6] We obtained this information through background interview with the former Commissioner Wong of the ITC in September 2007.

(iv) market potentials. Among nine technology focus areas identified, the following four are especially strongly related to the electronics industry: communications technologies, consumer electronics, integrated circuit design and opto-electronics.[7] The second key initiative was to set up R&D centres to facilitate the information and technology transfer between universities and companies (ITC, 2005).[8] In total, six R&D centres were founded till 2006. Because ASTRI's research is strongly related to the four abovementioned electronics-related focus areas, the R&D centre of information and communications technologies is subsumed under ASTRI. In addition, the new strategy introduced a new three-tier funding structure for the ITF. Under this three-tier funding structure, R&D centres are taken as the first-tier receivers of funding.[9] In other words, HK companies searching for governmental financial support for innovation are encouraged to seek more intensive cooperation relationships with these R&D centres (ITC, 2005).

3.2 Innovation policies in the PRD in Guangdong

For HK companies operating in the PRD, innovation policies in HK may not be the only political elements that may influence their incentives to innovate and to engage in academia-industry linkages. Innovation policies in the PRD may also be relevant in this regard. The Guangdong government determined the innovation policies in the PRD and its decisions, compared to the decisions of the HK government, have been more intensively influenced by the policies of the Chinese central government. In other words, innovation policies in the PRD in Guangdong have been shaped by the innovation-related decisions of the Chinese central government. These crucial decisions are the "Decision on the Reform of the Science and Technology System in 1985", the "Decision on Accelerating Scientific and Technological Progress in 1995", the "Decision on Strengthening Technological Innovation and Developing High Technology and Realising Its Industrialisation in 1999" and the "Decision on Implementing the Medium-and Long-term Strategic Plan for the Development of Science and Technology and Improving the Indigenous Innovation Capability in 2006" (OECD, 2008).

[7] The other five identified focus areas are "automotive parts and accessory systems", "Chinese medicine", "logistics/ supply chain management enabling technologies", "nanotechnology and advanced materials" and "textile and clothing".

[8] These universities are Chinese University of HK, City University of HK, HK Baptist University, HK Polytechnic University, HK University of Science and Technology and University of HK.

[9] Individual innovation projects belonging to the other areas identified in the ITC's consultation paper (ITC, 2004) but were not chosen as one of the nine focus areas under the "new strategy" would be promoted by the ITF as the second-tier receivers. The third-tier receivers cover the projects whose innovation outcomes cannot be applied commercially immediately.

Through these four crucial decisions, the Chinese central government tried to bring more market elements into the centrally-planned innovation system in China, which was characterised by a clear separation of the research activities of academic institutions from the production activities of companies (Gu and Lundvall, 2006). Over time, it has increasingly emphasised the importance of innovation for sustaining Chinese economic development and the crucial role of intensive academia-industry linkages in this regard. However, unlike in HK, related innovation policies in China strongly emphasised the commercialisation of academic research results initiated directly by academic institutions. The essential role of private companies in actively engaging in academia-industry linkages for innovation was firstly emphasised in 2006.

To encourage academic institutions to engage in more academia-industry linkages, a "push-and-pull" strategy has been applied in China. On the one hand, the central and local governments gradually reduced their funding for academic research to force academic institutions to finance their research projects by cooperating with companies. On the other hand, technology markets were set up to provide academic institutions more commercialisation opportunities. In addition, university science parks were established to support academic start-ups and, later, many research institutes were encouraged to merge with especially state-owned enterprises or to transform themselves into production entities to reduce the academia-industry gap. The effects of these academia-biased policies on encouraging academia-industry linkages were found to be rather limited in Guangdong due to its inherent shortage of highly-qualified labour and research-intensive academic institutions (GDSTC, 2004). Moreover, Guangdong's advantage as regards economic development lies in the fact that it has numerous private companies, rather than state-owned enterprises. Against this background, to more effectively promote academia-industry linkages in Guangdong, companies in Guangdong have been encouraged to search for academic support for their innovation activities from the academic institutions in nearby HK. They have been also encouraged to found new enterprises in HK to apply for financial supports from the ITF for their innovation activities (GDSTC, 2004). We expect that these policies may enhance again the relevance of the focus and structure of the HK innovation policies for companies in Guangdong. In 2006, the Guangdong government, together with Ministry of Education, started a new wave of promotion of academia-industry linkages. It went beyond the regional boundary and started to encourage academic institutions from all over China to cooperate with companies in Guangdong to facilitate the industrial upgrading of Guangdong.

In summary, innovation policies in HK and Guangdong promote academia-industry linkages and they are relevant for HK companies operating in the PRD. However, the comparative advantages of providing highly-qualified labour and research-intensive academic institutions in HK and the stronger policy focus in HK on company innovation initiatives may result in a relatively higher relevance of innovation policies in HK than policies in Guangdong for encouraging HK companies to innovate and to engage in academia-industry linkages.

4 Method

4.1 Survey method

This paper aims to investigate how HK SMEs engage in academia-industry linkages and the role of HK innovation policies in this regard. It focuses on the following three linkages: academic institutions as innovation partners, innovation sources, and training bases of highly-qualified labour for companies. Linkages as such differ from each other in the degree of direct involvement of companies in related activities. We suppose that companies are more directly and actively involved when they have academic institutions as their innovation partners than as their innovation sources and further than as their training bases. This paper analyses a subset of data collected by our own questionnaire survey in HK in 2007.[10]

We addressed the standardised questionnaire survey to HK SMEs, instead of large companies, because of the prevalence of SMEs among all the companies registered in HK (98%, HKSCC, 2008). We decided to focus on electronics SMEs due to, firstly, the fact that the electronics industry is one of the focus areas of the innovation policies in HK. Secondly, the electronics industry is very important for the economy in HK and for the economy in the PRD, which has become the main production base of many HK electronics companies since the open-door policy in China in the late 70s.[11] In 2006, the gross output value of the electronics industry amounted to 41% of all industries above a designated size in Guangdong as a whole (GPBS, 2007).[12] Note that more than 80% of the gross domestic product in Guangdong in 2006 was generated in the PRD. In addition, about 45% of exports of electronics products (in value) from China as a whole in 2006 were from Guangdong, which reflects the prominent position

[10] The full questionnaire can be obtained from the author upon request.
[11] HK electronics companies were among the first-movers which moved their production to the PRD since the Chinese government opened the first four Special Economic Zones for foreign investment in the late 70s. Three of the four Special Economic Zones were set up in the PRD (e.g. Berger and Lester, 1997; Enright et al.,2005.
[12] The gross output value of industry above a designated size consists of the output value of "all state-owned enterprises" and that of "non-state-owned enterprises with annual business revenue of over 5 million RMB". In 2006, the gross output value of industry above a designated size accounted for about 87% of the gross output value of industry with all enterprises in Guangdong (GPBS, 2007).

of Guangdong or more specifically the PRD, compared to other regions in China with respect to the development of the electronics industry (GPBS, 2007; NBSC, 2007).[13]

We obtained basic information on the electronics SMEs for this survey from the company data bank of the HK Trade Development Council (TDC)[14], in which 4,572 HK companies were registered as electronics SMEs operating in the PRD in September 2007. Our local cooperation partner, Social Science Research Centre (SSRC) at the University of Hong Kong, sent interview invitations to 3,000 companies randomly selected from the TDC data bank. In total, senior executives of 104 companies agreed to give personal interviews to complete the questionnaires. [15] Additionally, the SSRC carried out follow-up work to clarify misunderstandings in responses. We were aware that this survey method would be time- and cost-consuming, but this was the only way to ensure a high quality of data obtained.

4.2 Estimation issue

In order to investigate the role of innovation policies for companies' decisions to engage in certain types of academia-industry linkages, two groups of binary probit models are estimated:

$$\Pr(Y = 1 \mid X) = \Phi(X'\beta) \qquad (1)$$ [16]

where Y is "evaluating academic institutions as at least a little important innovation sources or not ($source_i$)" in the first group and is "having academic institutions as innovation partners or not ($partner_i$)" in the second group.[17] X is a vector of explanatory variables and β is a vector of parameters reflecting the effects of X on the probability.[18] Φ(.) denotes a standard normal distribution. The probit models are estimated with robust standard errors.[19]

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[13] In 2006, HK's gross domestic product reached 1,476 billion HKD ($189 billion), while 2,620 billion RMB ($328 billion) were produced domestically in Guangdong (GPBS, 2007; HKCSD, 2007a).

[14] The TDC is an industrial association with a strong linkage to the HK government. It offers a wide range of services to facilitate the creation of opportunities in international trade for the HK-based companies, especially HK SMEs. URL: http://www.hktdc.com/.

[15] Each personal interview took on average 60 minutes. The content of the interviews was strictly based on the standardised survey questionnaires. We decided to go through the questionnaires with the senior executives instead of conducting post surveys in order to ensure a higher quality of the data obtained.

[16] The observation subscript "i" is omitted here. See Greene (2003) p665-666 for more information.

[17] Academic institutions mentioned in the corresponding questions for these two variables were literally not restricted to the academic institutions in HK and in the PRD. However, given empirical findings (e.g. Jaffe, 1989 and Anselin et al., 1997) that proximity matters for spill-over of academic knowledge to industrial innovation, we assumed that when HK companies consider to source from or cooperate with academic institutions, they may tend to consider academic institutions in HK or in the PRD instead of those locating far away. In addition, as mentioned in section 3, HK companies may consider academic institutions in HK rather than those in the PRD due to the higher quality of academic research in HK.

[18] Because probit models are non-linear models, estimated coefficients (β) are not exactly equal to the marginal effects of the explanatory variables but they principally provide sufficient information on the directions of the effects of X on the outcome probability.

[19] More concretely, the Stata module "probit" with variance type "robust" is used for estimation. See Stata Press (2005b) p468-482 and Stata Press (2005c) p493-496 for more information.

For both groups of probit models, four different model constructions are considered. As described in Section 2, empirical literature finds companies' decisions on certain types of academia-industry linkages may differ across industries and company characteristics. This study focuses on HK companies from the electronics industry; thus, the heterogeneity across industries in this regard is expected to be mitigated in advance. Therefore, in the first model construction, only three company characteristics are considered as explanatory variables: company size measured in number of total employees in 2006 in log ($size_i$), age measured in difference between 2007 and the start year of business in HK (age_i), and innovation capability measured in the share of sales realised in the ODM (Original Design Manufacturing) and OBM (Original Brand Manufacturing) way ($capability_i$).

In addition to industries and company characteristics, Section 2 also mentioned that the business and legal environments in which companies operate may also matter for companies' decisions on academia-industry linkages. Our survey samples are HK companies operating in the PRD, implying that they actually operate in the same business and legal environment, at least in the objective term. However, they may perceive same innovation policies differently, and differently perceived innovation policies may matter for their decisions on academia-industry linkages to different extent. To deal with this issue, in the second model construction, two policy-related variables are considered as independent variables in addition to the abovementioned three company characteristics. The first policy-related variable refers to companies' attitudes towards innovation policies. Because companies were not directly asked to assess the importance of innovation policies for their decisions on academia-industry linkages, a policy proxy is used. This policy proxy is derived from a survey question asking companies to assess the importance of tax exemptions and other local governmental preferential treatments for companies' decisions on innovation locations ($policy_i$). This proxy is reclassified into 2 dummy variables for the estimation models due to its ordinal characteristics: $policy\_md_i$ and $policy\_st_i$. The former (latter) variable has a value "1" when the corresponding company assesses governmental policies as at least a little or normally important (important or very important) for its decision on innovation location. Companies with $policy\_md_i$ ($policy\_st_i$) equal to "1" are further suggested to have a moderately (strongly) positive attitude towards governmental policies. The second policy-related variable refers to companies' predictability of policy changes in the past 5 years, with "1" indicating that policy changes are predictable or very predictable ($predict\_dm_i$).

The third and fourth model constructions are used to cope with two potential selection bias problems in our survey. Each of these two constructions includes a binary selection model corresponding to the selection bias considered, in addition to the outcome probit model introduced above as in the second model construction. These two models are jointly estimated by using full information maximum likelihood estimation method.[20] A potential "self-selection bias" is considered first. More precisely, companies producing different products may be differently open to public enquiry, because they may have different amounts of sensible data to be protected. Thus, companies producing different products may differ from each other in their willingness to respond to our interview invitation.[21] To take this self-selection bias into consideration, a new binary variable called "$responding_j$" is created, with value "1" indicating companies' participation in our survey. The subscript *j* refers to j^{th} SME in the TDC data bank.[22] As explanatory variables for companies' responses to our interview invitation, 7 different product types are considered: laboratory and scientific equipments ($labequip_j$), audio-visual products ($avprod_j$), computer and peripherals ($pcperi_j$), electrical appliances ($elecappli_j$), telecom products ($teleprod_j$), electronic/electrical components and accessories ($eleccompo_j$) and cameras and photographic equipments ($photoequip_j$).

Secondly, a potential "sample selection bias" which is determined by a survey question which classified companies interviewed into innovative or non-innovative companies is considered. In the survey, innovative companies refer to companies which introduce new or significantly improved products into markets or/and implement new or significantly improved processes, organisational modes and market strategies (OECD, 2005). In other words, both companies which did not make any innovation efforts and companies which made efforts but did not yet

[20] More concretely, we apply the Stata module "heckprob" to estimate the third and fourth model constructions, where the two selection models are taken into account. The module "heckprob" fits the maximum-likelihood probit models with sample selection. See Stata Press (2005a) p468-475 for more information.

[21] It is also possible that companies' different willingness in responding to interview invitations is determined by their prior experiences with academic institutions if they think from the beginning that the survey aims to clarify the academia-industry linkages. However, we expect that such self-selection bias is less relevant for this study due to our neutral survey design. This survey was called "HK Company Survey 2007" and we neutrally formulated our motives why we would like to invite companies to participate in this survey, namely we would like to know more about HK companies' operational practices to find out the potential edges of HK companies over their competitors in global markets. We did not mention directly that we would study their relationships with academic institutions for innovation.

[22] As mentioned in section 4.1, we sent the survey questionnaires to 3000 companies which were randomly selected from the TDC data bank. We are aware that to consider the first type of potential selection bias problem, information of the 3000 companies should be used. However, the selection of companies was carried out by our local cooperation partner; thus, the list of 3000 selected companies was not available to us. But for all that, because these 3000 companies were randomly selected from the TDC data bank, we decided to use the information of all HK electronics SME in the data bank to enable the estimation of the corresponding selection model. Moreover, taking HK's definition of SME into consideration (no more than 100 employees, see HKCSD (2007b)), not all 4572 companies but only 4481 companies in the TDC data bank are SMEs. Thus, the subscript j may have a maximal value of 4481. The subscript i is equal to j for the SMEs interviewed in the survey.

come out with innovative outcomes would be identified as non-innovative companies in the survey. Based on our survey design, only innovative companies were asked to answer questions which provide information for the two outcome variables regarding academia-industry linkages. However, it is possible that the second type of non-innovative companies may engage in academia-industry linkages but information as such was not available. To cope with this sample selection bias, a binary variable called "$inno_i$" is used in the selection model, with value "1" indicating innovative companies and "0" non-innovative companies. Company characteristics which are available among all interviewed companies and are suggested by literature to affect whether companies carry out innovative outcomes are used as innovation determinants in the second selection model (e.g. Acs and Audretsch, 1990; Aghion et al., 2005; Scott, 2009). In total, three innovation determinants are considered: company size measured in number of employees in total in log ($size_i$, as in the outcome models above), being manufacturer or not ($manuf_i$, available from the TDC data bank), and the competition intensity faced by companies ($compet_i$). The last variable is further classified, due to its ordinal characteristics, into 2 dummy variables: facing moderately (strongly) increasing competition pressure or not ($compet\_md_i$ & $compet\_st_i$).

5 Results

As mentioned in Section 4, 104 HK companies completed the survey questionnaires. However, two of them do not satisfy the official SME definition in HK. Thus, these two companies are not included in the following analysis.

5.1 Descriptive analysis

5.1.1 Cost reduction versus innovation

Engaging in academia-industry linkages for innovation may only matter for HK companies to some extent, if they indeed intend to innovate. In the past, HK companies relied strongly on cost reduction strategy through, for example, relocating production processes into low-cost PRD instead of relying on innovation to maintain their competitiveness.[23] However, the HK innovation policies and the increasing global market competition may encourage HK companies to innovate more intensively than before. The survey addressed this by asking companies to evaluate the importance of cost reduction strategy and the importance of innovation strategy, respectively. A five-level scale was applied in this question, with "1" indicating very important and "5" not important. About 75% of the 102 responding companies

[23] HK companies relied strongly on relocating to developing countries, e.g. the PRD in China, to deploy cheaper production factors to maintain their price competitiveness (e.g. Chiu and Wong, 2001; Lau and Green, 2001).

evaluate "cost reduction" as a very important or important strategy, while 72% evaluate "innovation strategy" as very important or important. Two-tailed Wilcoxon signed rank test (WSRT) is applied to examine the distribution of the variables according to the differences between the pair of answers given by every responding company. The hypothesis of the same distribution cannot be rejected ($p = 0.362$), suggesting a similar importance of innovation and cost reduction for HK electronics SMEs.[24] Taking earlier studies which found that HK companies had a much higher preference for cost reduction than for innovation into account, this finding implies that HK electronics SMEs nowadays may have increasing willingness for innovation than before. To better sketch the innovation activities undertaken by the HK electronics SMEs, non-innovative companies were filtered out by a survey question which asked companies to indicate whether they carry out innovation activities or not.[25] 88 of 102 companies (86.3%) responded that they carry out innovation activities. The share of innovative companies in our sample is much larger than that in all HK companies (42.3%) based on the official statistics (HKCSD, 2006). This seems to suggest that HK electronics SMEs are more willing or capable to innovate than HK companies in general.

5.1.2 Academia-industry linkages for innovation

Academic institutions as innovation sources

To carry out innovation outcomes, innovative companies either need to create innovation-related knowledge and technologies by themselves or they need to acquire such knowledge or technologies from external sources. To better investigate the importance of academic institutions as innovation sources for HK electronics SMEs, innovative companies were asked to assess the importance of eight alternative sources in total.[26] These alternatives can be roughly separated into 2 groups: internal and external sources. Internal sources consist of own R&D department (OwnRDD), own production-related department (OwnPDD), own marketing-related department (OwnMKD) and the hiring of highly-qualified workers (HQWorkers). Externally, companies can acquire innovation-related knowledge and technologies from academic institutions (Academia), other companies or individuals (OtherCom) or by directly acquiring innovation products from other innovators (DirectAcq). As presented in Table 1, all four internal sources are assessed by more than 50% of the 88 innovative electronics SMEs as being very important or important innovation sources. The

[24] WSRTs are also applied to clarify the other issues in the following sections. Results of WSRTs are not shown in Tables (available upon request) but are directly interpreted.
[25] As mentioned above, innovation definition from the OSLO Manual (OECD, 2005) is applied in our study.
[26] The last sourcing alternative is "others". Only 5 companies ever used other sources. Thus, this source alternative is not further considered in the analysis.

shares of companies evaluating own R&D department and own marketing department as very important or important sources even amount to about 70%. In contrast, academic institutions as innovation sources seem to be the least important for the HK electronics SMEs. Only 15% of the 88 responding companies consider academic institutions as very important or important sources and about 35% evaluate them as not important at all.[27]

Results of two-tailed pair-wise WSRTs also suggest a strictly lower importance of academic institutions as innovation sources than other sources considered (at a significance level of 1% for each case). Nevertheless, it is worth noting that the company share regarding academic institutions as important innovation sources in the survey is still much larger than the share from the official statistics. According to the official statistics, only about 0.3% of HK companies in general assessed academic institutions as highly important sources for their technological innovation, while 98% of HK companies even did not make use of such institutions for their technological innovation in 2006 (HKCSD, 2006). Such a difference between HK electronics SMEs and HK companies may suggest that HK electronics SMEs seem to be more willing to source innovation-related knowledge from academic institutions than HK companies in general, although HK electronics SMEs, taking other possible innovation sources into account, still prefer other innovation sources, especially the internal ones than academic institutions.

Table 1 Company shares by importance[a] of different innovation sources in % (n=88)

	OwnRDD	OwnPDD	OwnMKD	HQWorkers	Academia	OtherCom	DirectAcq
1	40	17	30	24	5	13	11
2	30	34	39	34	10	33	19
3	15	23	19	25	28	35	36
4	2	11	1	7	22	7	9
5	14	15	11	10	35	13	24

Note:[a]A 5-level importance scale was applied: 1 - very important, 2- important, 3 - of normal importance, 4- of little importance, 5 - not important. Source: Own HK Company Survey 2007

Academic institutions as innovation partners

In addition to simply absorbing research results from academic institutions, companies may actively cooperate with academic institutions for innovation to benefit from their expertise. To clarify whether HK electronics SMEs do cooperate with academic institutions for innovation, the survey, thus, concentrated at first on exploring the modes of innovation organisation applied by HK electronics SMEs innovating in the nearby PRD. According to the survey results, 70 of 88 HK innovative electronics SMEs (79.5%) carry out innovation activities in

[27] Among the other 2 external sources, other companies or individuals are taken by more HK innovative electronics SMEs as very important or important than the direct acquisition of innovation products.

the PRD. These 70 companies were asked to evaluate the importance of four different innovation organisational modes, if they apply them – "own R&D", "cooperation with partners"[28], "acquisition of licenses and innovations" and "reverse engineering". "Acquisition of licenses and innovations" is the least frequently (53%) applied innovation organisational mode for the HK electronics SMEs. In contrast, over 90% of the 70 companies innovate on their own and about 76% (73%) engage in reverse engineering (cooperate with innovation partners, Table 2). In addition, regarding the importance of different organisational modes, a slightly smaller share of companies considers cooperation (42%) as a very important or important innovation organisational mode compared to the reverse engineering (47%) or own R&D activities (48%).

Companies engaging in cooperative innovation activities (51 in total) were then further asked to specify their cooperation partners. As a result, 67% (53%) of these 51 companies cooperate with their customers (suppliers) for their innovation projects, while only 10% of them indeed have academic institutions as innovation partners.[29] Moreover, survey results show that "partners' good reputation", "partners' expertise" and "good experiences (with partners) in former business" are the three most important criteria considered by companies while deciding on innovation cooperation partners.[30] These two findings together seem to suggest that academic institutions are not perceived by companies as qualified partners due to their deficiency in reputation, expertise or former industrial relationships. However, such perception of companies may be biased due to communication deficit between academic institutions and companies and, thus, companies' unfamiliarity with potential supports which academic institutions may provide. Nevertheless, the share of HK electronics SMEs cooperating with academic institutions (7% of 70 innovative SMEs) is still much larger than that of HK innovative companies as a whole cooperating with universities (0.5%) and research institutes (0.04%) for their technological innovation, respectively (HKCSD, 2006). This seems to suggest a more intensive academia-industry linkage in term of having academic institutions as innovation partners among HK electronics SMEs than among HK companies in general, although HK electronics SMEs also still much strongly prefer their customers or suppliers as their innovation partners.

[28] The difference between innovation source and innovation cooperation with partners was made clear to companies interviewed by especially emphasising the role of mutual interest and trust and the long-term characteristics for the innovation cooperation.
[29] This result of a high relevance of customers or suppliers as innovation partners for HK electronics SMEs is consistent with results from the other surveys (e.g. FHKI, 2003, 2007; HKCSD, 2001, 2003b, 2004, 2005, 2006).
[30] More detailed information regarding partner selection criteria can be found in Table A1 in Appendix.

Table 2 Company shares by importance of different innovation organisational modes in % (n=70)

	Own R&D	Cooperation	Acquisition	Rev. Engineering
1 (very important)	24	16	6	17
2 (important)	24	26	23	30
3 (of normal importance)	30	27	21	16
4 (of little importance)	10	4	0	13
5 (not important)	3	0	3	0
Not applied	9	27	47	24

Source: Own HK Company Survey 2007

Academic institutions as training bases

Results above seem to suggest a relatively lower importance of academic institutions as innovation sources or partners, compared to other potential innovation sources or partners, for the HK electronics SMEs. This may imply that the existence of academic institutions is probably not a substantial criterion for HK electronics SMEs when deciding on concrete innovation locations. In the survey, companies innovating in the PRD were asked to assess the importance of eight criteria considered for deciding their innovation locations in the PRD, with "1" indicating very important and "5" not important: "availability of highly-qualified workers and researchers (AvaiHQ)", "innovation structure, e.g. universities, science parks and venture capital companies etc. (InnoSTR)", "proximity to companies from the same or related industries (Proximity)", "tax exemptions and other governmental preferential treatments (PrefTRM)", "fewer governmental interventions (FGovINT)", "established legal system (EstabLS)", "personal or family ties (PersTIE)" and "others". Because it is possible that SMEs do not make separate decisions on innovation locations but innovate directly close to their production plants, the 70 HK innovative electronics SMEs are classified into two groups: innovating somewhere else than their production locations in the PRD (independent locational decision, 11 companies) and innovating at the production locations in the PRD (dependent locational decision, 59 companies). The assessment results of locational criteria in case of these two company groups and in case of all 70 companies are presented in Table 3, respectively.[31] It shows that the availability of highly-qualified workers or researchers is taken as very important or important by most of the responding companies in all three groups. Among companies with independent locational decisions, the corresponding company share amounts to more than 91%, while that amounts only to 46% among companies with dependent locational decisions. In addition, the following criteria – innovation structure,

[31] Nine of 70 companies specified that there was another locational criterion which was important for deciding their innovation locations ("others"). More concretely, 6 of these 9 companies specified that they chose to innovate just near their production plants. This information again supports our decision to separate companies into two groups according to the difference between their production and innovation locations. Because these two groups of companies are analysed separately for the following part, we omit the company distribution w.r.t. "others" as one of the locational criterion in Table 3.

proximity to companies from the same or related industries, and well-established legal systems, are also assessed with a higher importance by greater shares of companies in the case of independent locational decisions than in the case of dependent locational decisions.[32]

Table 3: Importance of criteria on innovation location (share of total firms in the corresponding group, %)

	Inno≠Pro n=11	Inno=Pro n=59	Total n=70		Inno≠Pro n=11	Inno=Pro n=59	Total n=70
AvaiHQ				InnoSTR			
1	36	22	24	1	0	9	7
2	55	24	29	2	64	12	20
3	9	29	26	3	19	25	24
4	0	14	11	4	9	22	20
5	0	12	10	5	9	32	29
Proximity				PrefTRM			
1	9	12	11	1	0	9	7
2	46	29	31	2	9	12	11
3	27	29	29	3	36	17	20
4	0	10	9	4	36	25	27
5	18	20	20	5	18	37	34
FGovINT				EstabLS			
1	0	17	14	1	27	12	14
2	27	17	19	2	9	10	10
3	46	27	30	3	27	25	26
4	27	19	20	4	27	27	27
5	0	20	17	5	9	25	23
PersTIE							
1	0	3	3				
2	0	7	6				
3	36	20	23				
4	27	14	16				
5	36	56	53				

Note: The same scale of importance was applied (see Table 1). Source: Own HK Company Survey 2007

Considering the existence of innovation structure in more detail, although no company with independent locational decisions considers this criterion as being very important, 64% of them consider it as important, relative to 9% (very important) and 12% (important) in the case of dependent locational decisions. Although innovation structure referred to not only academic institutions but also science parks and venture capital companies etc. in the survey, the relatively high importance of innovation structure in case of independent locational decisions may still give a positive reference for a potentially high relevance of the existence of academic institutions for companies' independent decisions on innovation locations.

Taking the finding on the substantial importance of the availability of highly-qualified workers for innovation into account, a high relevance of academic institutions for decisions on innovation locations compared to a relatively low relevance of academic institutions as innovation sources and innovation partners seems to suggest that some other functions of

[32] This suggests that the importance of these locational criteria would be strongly underestimated, if companies with dependent locational decisions are not separately analysed.

academic institutions such as teaching and training students and researchers, but not directly their research results, probably matter more for HK electronics SMEs' innovation activities.

5.2 Estimation results: the role of active innovation policies

Although innovation policies in HK explicitly promote academia-industry linkages, the analysis above only finds that academic institutions as innovation sources or as innovation partners are of low importance for the HK electronics SMEs. In this section, two groups of probit models with four different constructions for each are estimated to better clarify whether there actually exists a positive relationship between innovation policies in HK and companies' engagement in sourcing from and partnering with academic institutions.[33] Descriptions of the variables used and some descriptive statistics for the variables are summarised in Table A2 in the Appendix, and the results of the estimated coefficients are presented in Table 4 below. The first four columns present results of the four model constructions for the case of academic institutions as innovation sources and the last four columns for the case of academic institutions as innovation partners. Columns (1) and (5) refer to the first construction considering only company characteristics as independent variables in the outcome models. Columns (2) and (6) report estimation results after adding policy-related variables into the models. The other four columns report results after considering the two selection models in addition to the outcome probit models. More precisely, columns (3) and (7) report estimation results after considering the self-selection bias problem (responding or not), while columns (4) and (8) report estimation results after considering the selection bias problem (innovating or not). [34] Because probit models are non-linear models, the estimated coefficients are different from the marginal effects of the explanatory variables. Based on the last model construction in both groups, Table 5 reports marginal effects measured at a fixed reference point.[35]

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[33] See Section 4.3 for more information about the estimation models. In addition, it is worth noting that the limited sample size may make it difficult to establish the best-specified model for our study. Thus, the estimation exercises here should rather be taken as first econometric attempts to analytically clarify the relationships between HK innovation policies and companies' decisions regarding academia-industry linkages.

[34] As additional model constructions, we tried different policy-related variables as proxy variables (e.g. how important are governmental preferential treatments as locational criterion for companies while choosing their production location). Using alternative policy-related variables as such helps cope with potential causality problems between the two outcome variables and policy-related variables used in Table 4, because in general cases HK companies made decisions on production locations in the PRD much earlier than their decision on starting to innovate. In addition, size information were added (staff range in HK and staff range in China; partially available from the TDC data bank) into the first selection model. Excluding cases in which no results come out due to convergence problem resulted by data limitation, basic findings as presented in Table 4 are hardly affected.

[35] To fix the reference point for measuring the corresponding marginal effects, dummy variables in the outcome models are set to be zero, the other independent variables are set to be at their mean levels. To check the robustness of marginal effects, marginal effects are also measured at different points with different combination of independent variables. In case of setting all dummy variables including those in selection models equal to 0

Table 4 Estimation results (coefficients)

	Source				Partner			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Policy_md		0.736**	0.628*	0.640***		-0.328	-0.132	-0.285
		(0.364)	(0.421)	(0.239)		(0.563)	(0.429)	(0.548)
Policy_st		0.826**	0.687*	0.697***		0.926*	0.529	0.908*
		(0.463)	(0.529)	(0.281)		(0.620)	(0.527)	(0.597)
Predict_dm		0.388	0.295	0.301**		0.599	0.109	0.545
		(0.401)	(0.400)	(0.129)		(0.523)	(0.418)	(0.491)
Size	-0.047	-0.022	-0.026	0.015	0.055	0.033	-0.030	0.033
	(0.083)	(0.096)	(0.085)	(0.063)	(0.148)	(0.147)	(0.143)	(0.145)
Age	0.020	0.016	0.012	0.007	-0.022	-0.026	-0.013	-0.025
	(0.017)	(0.019)	(0.018)	(0.013)	(0.028)	(0.026)	(0.021)	(0.024)
Capability	-0.001	0.003	0.002	0.003	-0.001	-0.001	0.002	-0.001
	(0.004)	(0.005)	(0.004)	(0.004)	(0.005)	(0.007)	(0.006)	(0.006)
_Cons	0.369	-0.364	-1.515	-0.616	-1.411***	-1.561***	-2.946***	-1.689***
	(0.414)	(0.588)	(1.732)	(0.474)	(0.494)	(0.541)	(0.362)	(0.505)
Selec. model 1: Responding								
Labequip			0.191				0.222	
			(0.438)				(0.428)	
Avprod			0.076				0.095	
			(0.132)				(0.117)	
Pcperi			0.314**				0.314***	
			(0.123)				(0.121)	
Elecappli			-0.055				-0.004	
			(0.131)				(0.127)	
Teleprod			0.013				-0.025	
			(0.149)				(0.141)	
Eleccompo			-0.313**				-0.369***	
			(0.126)				(0.122)	
Photoequip			-0.239				-0.184	
			(0.236)				(0.232)	
_cons			-2.059***				-2.050***	
			(0.118)				(0.118)	
Selec. model 2: Inno								
Size				0.021				0.025
				(0.041)				(0.041)
Compet_md				0.471***				0.811**
				(0.095)				(0.390)
Compet_st				0.358**				0.721*
				(0.162)				(0.378)
Manuf				0.654***				0.349
				(0.095)				(0.252)
_cons				-0.096				-0.150
				(0.104)				(0.407)
rho			0.524	1.000***			1.000	0.987*
			(0.724)	(5.34e-11)			(0.001)	(0.036)
Wald test (rho=0)			0.34	16.23***			0.01	3.30*
Obs.	87	69	4448	83	69	69	4448	83
Censored obs.			4379	14			4379	14
Uncensored obs.			69	69			69	69
Wald test (full model)	1.44	7.15	2.58	1.28e+06***	0.79	10.21	13.49**	11.85*

Note: significant at 10% (*), 5% (**), 1% (***) level. One-tailed tests (based on hypotheses specified in Section 2) are applied for policy-related independent variables and two-tailed tests for variables of company characteristics in outcome models. In selection models, two-tailed tests are applied. Numbers in parentheses refer to robust standard errors. Instead of "rho", Stata directly estimated the inverse hyperbolic tangent of "rho", called "/athrho". The significance level of "rho" shown here is for "/athrho", from which "rho" was derived. Source: Own HK Company Survey 2007

and other independent variables at their mean levels, the magnitude of marginal effects remains as those shown in Table 5. In case of setting only complementary dummy variables equal to 0 and other variables at their mean levels, marginal effects w.r.t. academic institutions as innovation sources remain as those presented, while marginal effect of the variable (policy_st) w.r.t. academic institutions as innovation partners becomes even larger.

In total, four major findings are worth being explained in more detail. First, the null hypothesis that all regression coefficients are equal to zero cannot always be rejected across the different model constructions. However, for both groups of the probit models (*source* and *partner*), such a null hypothesis can be rejected, based on the last model construction with the second selection model, which coped with sample selection bias caused by the innovation classification of companies in the study.[36] Moreover, the correlation between the error term in the outcome model and the error term in this selection model (rho)[37] is found to be significantly different from zero in both groups, which suggests that the sample selection bias caused by classifying companies into innovative and non-innovative companies and by only considering innovative companies' relationships with academic institutions is significant. The existence of this type of selection bias makes it necessary and more appropriate to consider the second selection model in this study in addition to the corresponding outcome model. In contrast, the first selection model (responding or not) does not seem to need to be considered in addition because the corresponding error correlations in both groups are not found to be significantly different from zero, which suggests that the potential self-selection bias problem is not significantly relevant in our study.

Second, despite the different specification quality of the different model constructions, the first policy-related variable (*policy*) is found to matter for companies' decisions to engage in academia-industry linkages. For the case regarding academic institutions as at least a little important innovation sources for companies, both corresponding dummy variables are found to be significantly and positively relevant. Such positive relationships suggest that the more important governmental preferential treatments for companies' decisions regarding innovation locations, the higher the possibility that academic institutions are perceived by companies as at least a little important innovation sources. Table 5 shows that when a reference company turns to have a moderately (strongly) positive attitude towards governmental policies, the probability that it evaluates academic institutions as being its at least a little important innovation sources is expected to increase from 35.5% to 59.3% (61.4%). Such positive relationships are found to be weaker in the case in which companies consider academic

[36] The null hypothesis that all coefficients are equal to zero can only also be rejected based on the third model construction for the case of having academic institutions as innovation partners.

[37] Note that Stata does not directly estimate the correlation term "rho". Instead, it estimates the inverse hyperbolic tangent of rho, called "/athrho". The value of rho is indirectly derived from the estimated "/athrho". The significance level of "rho" shown in Table 4 for "/athrho" from which "rho is derived. See Stata Press (2005a) p454-455 for more information.

institutions as their innovation partners.[38] In this case, only whether companies have a strongly positive attitude towards governmental policies matters. According to Table 5, when a reference company turns to have a strongly positive attitude towards governmental policies, the probability of having academic institutions as innovation partners is expected to be increased from 2.7% to 8.4%. These findings, together with the fact that HK companies have a prevalently positive attitude towards governmental policies,[39] seem to suggest that positive influences of HK active innovation policies on HK companies' tendency to source from and cooperate with academic institutions may indeed be expected.

Table 5 Estimation results (marginal effects)

	Source Based on (4) – Table 4	Partner Based on (8) – Table 4
Pr(Y=1)	0.355	0.027
Policy_md	0.238***	-0.018
	(0.069)	(0.049)
Policy_st	0.259***	0.057*
	(0.088)	(0.039)
Predict_dm	0.117***	0.057
	(0.050)	(0.063)
Size	0.005	0.002
	(0.024)	(0.010)
Age	0.002	-0.002
	(0.005)	(0.002)
Capability	0.001	-0.000
	(0.001)	(0.000)

Note: To fix the reference point for measuring the corresponding marginal effects, dummy variables in the outcome models are set to be zero, the other independent variables are set to be at their mean levels. Marginal effects of dummy variables are based on discrete value change from 0 to 1. Marginal effects with stars are significant at 10% (*), 5% (**), 1% (***) level. One-tailed tests (based on hypotheses specified in Section 2) are applied for the policy-related independent variables and two-tailed tests for the other variables in the outcome models. Numbers in parentheses refer to standard errors. Source: Own HK Company Survey 2007

Third, the second policy-related variable (*predict_dm*) is also found to be significantly and positively relevant, at least based on the last but better-specified model construction for the case in which companies consider academic institutions to be at least a little important innovation sources. Such a positive relationship suggests that the more predictable the policy changes for companies, the higher the possibility that they may perceive academic institutions to be at least a little important innovation sources for them. As shown in Table 5, when a reference company becomes to be capable to predict policy changes, the probability that it would consider academic institutions to be at least a little important innovation sources increases from 35.5% to 47.2%. On the other hand, such a significantly positive relationship cannot be found in any model construction for the case in which companies consider

[38] Only the second dummy variable representing a strongly positive attitude of companies towards governmental policies is found to be marginally significant in the second and fourth model constructions.
[39] More than 65% of HK companies perceive taxes and other preferential treatments from governments as being at least a little important reasons why they chose certain cities in the PRD as their innovation locations.

academic institutions to be their innovation partners. The lower relevance of both policy-related variables for companies' decisions to cooperate with academic institutions as compared to source from academic institutions may be attributable, firstly, to the fact that policies to promote innovation cooperation were implemented later in HK. Secondly, it can also be attributable to potentially higher costs and risks generally embedded in large innovation cooperation projects and the potentially higher technological requirements placed on companies in these projects, which force companies to think and plan more thoroughly before they start to cooperate with academic institutions.

Finally, the three company characteristics considered (size, age and capability) do not seem to matter for whether HK companies consider academic institutions to be their innovation sources or to be their innovation partners, irrespective of model constructions considered. This result is different from that suggested in prior studies conducted in Western countries. Such a low relevance of company characteristics in HK may, on the one hand, be just a result of limited sample size and thus limited variability of the corresponding variables. On the other hand, it may be attributable to the fact that most HK companies lack in innovation experiences and did not start to innovate until quite late. When they start to innovate, HK companies, regardless of their different characteristics, probably try to work on small innovation projects on their own, before they are able to work more intensively with academic institutions on larger innovation projects.

Our findings that innovation policies possibly have positive effects on companies' tendency to source from or cooperate with academic institutions for innovation purposes suggest that the low importance of academic institutions as innovation sources or innovation partners found in the Section 5.1.2 may be also attributable to time lags between the implementation of policies and the full unfolding of their potential effects. In addition, mismatches may exist between the knowledge and technologies provided by academic institutions and the real needs of companies. Such mismatches may be partially attributable to inefficient communication channels between academic institutions and companies.

6 Conclusions

Academia-industry linkages are often argued to be advantageous for innovation performance and for sustaining economic growth. This paper analysed the relevance of academia-industry linkages for the innovation activities of the HK electronics SMEs operating in the PRD on the

one hand, focusing on three linkage types: academic institutions as training bases, as innovation sources and innovation partners. On the other hand, it analysed the role of HK innovation policies in this regard. It used a subset of data collected by our own questionnaire survey in HK.

Survey results suggest that innovation activities are gaining in importance for HK electronics SMEs. Regarding academia-industry linkages, we find, however, that academic institutions do not yet play important roles as innovation sources or innovation partners for HK electronics SMEs. In contrast, HK electronics SMEs seem to benefit more from academic research by relying on hiring highly-qualified labour trained by academic institutions.

The low relevance of academic institutions as innovation sources or innovation partners found above should, however, not be directly interpreted to mean that the HK active innovation policies are not effective. In contrast, the estimation results suggest that innovation policies possibly have a positive effect on companies' tendency to source from or cooperate with academic institutions in case of HK. The finding of low importance of academic institutions as innovation sources or innovation partners may be attributable to other influential factors such as time lags of potential policy effects, mismatches between the knowledge and technologies provided by academic institutions and the real needs of companies or inefficient communication between academic institutions and companies.

References

Acs, Z. J. and D. B. Audretsch (1990), Innovation and Small Firms, The MIT Press, Cambridge, Massachusetts.

Acs, Z. J., D. B. Audretsch and M. P. Feldman (1994), R&D Spillovers and Recipient Firm Size, The Review of Economics and Statistics, 76, p336-340.

Aghion, P., N. Bloom, R. Blumdell, R. Griffith and P. Howitt (2005), Competition and Innovation: An Inversed-U Relationship, The Quarterly Journal of Economics, 120, p701-728.

Anselin, L., A. Varga and Z. Acs (1997), Local Geographic Spillovers between University Research and High Technology Innovations, Journal of Urban Economics, 42, p422-448.

Arundel, A. and A. Geuna (2004), Proximity and the Use of Public Science by Innovative European Firms, Economics of Innovation and New Technologies, 13, p559-580.

Baark, E. and N. Sharif (2006), Hong Kong's Innovation System in Transition: Challenges of Regional Integration and Promotion of High Technology, in: Lundvall, B.-Å, P. Intarakumnerd and J. Vang (ed.), Asia's Innovation Systems in Transition, p123-147, Edward Elgar, Cheltenham, UK and Northampton, MA, USA.

Balconi, M. and H. Stahl (1999), University-Industry Interactions in Applied Research: the Case of Microelectronics, Research Policy, 35, p1616-1630.

Bekkers, R. and I. M. Bodas Freitas (2008), Analysing Knowledge Transfer Channels between Universities and Industry: To What Degree Do Sectors Also Matter?, Research Policy, doi:10.1016/j.respol.2008.07.007.

Berger, S. and R. K. Lester (1997), Made by Hong Kong, Oxford University Press, Hong Kong, Oxford, New York.

Bozeman, B. and K. Coker (1992), Assessing the Effectiveness of Technology Transfer from US Government R&D Laboratories: the Impact of Market Orientation, Technovation, 12, p239-255.

Bozeman, B. (2000), Technology Transfer and Public Policy: A Review of Research and Theory, Research Policy, 29, p627-655.

Chiu, S. W. K. and K.-C. Wong (2001), Growth Without Catching Up – Organizational Dynamics in the Restructuring of the Electronics Industry in Hong Kong, Hong Kong Institute of Asia-Pacific Studies 115, The Chinese University of Hong Kong, Shatin, New Territories, Hong Kong.

Cohen, W. M., R. R. Nelson and J. P. Walsh (2002), Links and Impacts: the Influence of Public Research on Industrial R&D, Management Science, 48, p1-23.

Dasgupta, P. and P. A. David (1994), Toward a new Economics of Science, Research Policy, 23, p487-521.

D'Este, P. and P. Patel (2007), University-Industry Linkages in the UK: What Are the Factors Underlying the Variety of Interactions with Industry?, Research Policy, 46, p1295-1313.

Enright, M. J., E. Scott and K.-M. Chang (2005), Regional Powerhouse: The Greater Pearl River Delta and the Rise of China, Wiley, Singapore.

Eriksson, S. (2005), Innovation Policies in South Korea and Taiwan, VINNOVA ANALYSIS, VA 2005:03, Jönköping International Business School, URL: http://www.vinnova.se/In-English/Publications/Products-hidden/Innovation-Policies-in-South-Korea--Taiwan/.

Feldman, M. P., I. Feller, J. Bercovitz. and R. Burton (2002), University Technology Transfer and the System of Innovation, in: Feldman, M. and Massard, N. (ed.), Institutions and Systems in the Geography of Innovation, p. 55-77, Kluwer Academic Publishers.

FHKI, Federation of Hong Kong Industries (2003), Made in PRD – The Changing Face of Hong Kong Manufacturers, FHKI, Hong Kong.

FHKI, Federation of Hong Kong Industries (2007), Made in PRD – Challenges and Opportunities for HK Industry, FHKI, Hong Kong.

Fontana, R., A. Geuna and M. Matt (2006), Factors Affecting University-Industry R&D Projects: the Importance of Searching, Screening and Signalling, Research Policy, 35, p309-323.

GDGOV, People's Government of Guangdong Province (2007), The 11th Five-Year Plan for Science and Technology Development in Guangdong, URL: www.gdstc.gov.cn/html/zwgk/fzgh/gd115/1222156421495-27305332458023376 10.html.

GDSTC, Guangdong Science and Technology Department (2004), Guangdong Regional Innovation System: Research Report, URL: http://www.most.gov.cn/ztzl/qycxtxjs/200501/P020050105395973125687.doc

GPBS, Guangdong Provincial Bureau of Statistics (2007), Guangdong Statistical Yearbook 2007, China Statistics Press, Beijing, China.

Greene, W. H. (2003), Econometric Analysis, 5th Edition, Prentice Hall, New Jersey.

Gu, S. and B.-Å Lundvall (2006), China's Innovation System and the Move towards Harmonious Growth and Endogenous Innovation, Innovation: management, policy & practice, 8: p1-26.

Hall, B. H., A. N. Link and J. T. Scott (2001), Barriers Inhibiting Industry from Partnering with Universities: Evidence from the Advanced Technology Program, The Journal of Technology Transfer, 26, p87-98.

Ham, R. M. and D. Mowery (1998), Improving the Effectiveness of Public-Private R&D Collaboration: Case Studies at a US Weapons Laboratory, Research Policy, p661-675.

Heckman, J. J. (1979), Sample Selection Bias as a Specification Error, Econometrica, 47, p153-161.

HKCSD, Hong Kong Census and Statistics Department (2001), Report on 2001 Annual Survey of Innovation Activities in the Business Sector, Hong Kong.

HKCSD, Hong Kong Census and Statistics Department (2003a), Hong Kong Monthly Digest of Statistics July 2003 – Government Funding of Research and Development Innovation and Technology Upgrading, 1995/96-2001/02, Hong Kong.

HKCSD, Hong Kong Census and Statistics Department (2003b), Report on 2003 Annual Survey of Innovation Activities in the Business Sector, Hong Kong.

HKCSD, Hong Kong Census and Statistics Department (2004), Report on 2004 Annual Survey of Innovation Activities in the Business Sector, Hong Kong.

HKCSD, Hong Kong Census and Statistics Department (2005), Report on 2005 Annual Survey of Innovation Activities in the Business Sector, Hong Kong.

HKCSD, Hong Kong Census and Statistics Department (2006), Report on 2006 Annual Survey of Innovation Activities in the Business Sector, Hong Kong.

HKCSD, Hong Kong Census and Statistics Department (2007a), Gross Domestic Product (GDP), Implicit Price Deflator of GDP and Per Capita GDP, URL: http://www.censtatd.gov.hk/hong_kong_statistics/statistical_tables/index.jsp?charsetID=1&subjectID=12&tableID=030.

HKCSD, Hong Kong Census and Statistics Department (2007b), Hong Kong Monthly Digest of Statistics March 2007 – Statistics on Innovation Activities in the Business Sector, 2001-2005, Hong Kong.

HKCSD, Hong Kong Census and Statistics Department (2008), Public Accounts, Money and Finance, URL: http://www.censtatd.gov.hk/FileManager/EN/Content_805/pub_account.pdf.

HKSAR (1998), Commission on Innovation and Technology First Report, Hong Kong.

HKSCC, Hong Kong Support and Consultation Centre for SMEs (2008), SMEs in HK, URL: http://www.success.tid.gov.hk/english/lin_sup_org/gov_dep/service_detail_6863.html.

ITC, Innovation and Technology Commission (2004), Consultation Paper – New Strategy of Innovation and Technology Development, URL: http://www.itc.gov.hk/en/doc/consultation/consultation_paper_e.pdf.

ITC, Innovation and Technology Commission (2005), Report on Public Consultation on the New Strategy of Innovation and Technology Development, URL: http://www.itc.gov.hk/en/doc/consultation/R-New_strategy_consultation-180105.pdf.

ITC, Innovation and Technology Commission (2007), Laying the Foundation and Forging Ahead, Hong Kong.

Jaffe, A. (1989), Real Effects of Academic Research, The American Economic Review, 79, p957-970.

Jensen, R. A. and M. C. Thursby (2001), Proofs and Prototypes for Sale – The Licensing of University Inventions, American Economic Review, 91, p240-259.

Kash, D. E. and R. W. Rycroft (1994), Technology Policy: Fitting Concept with Reality, Technological Forecasting and Social Change, 47, p35-48.

Kwong, K.-S. (1997), Technology and Industry, The Hong Kong Economic Policy Studies Series, City University of Hong Kong Press, Kowloon, Hong Kong.

Lau, H.-F and S. Green (2001), The Electronics Industry: Can Manufacturing Continue in Hong Kong?, The World Economy, 24, p1075-1090.

Link, A. N. (1996), Research Joint Ventures: Patterns from Federal Register Filings, Review of Industrial Organisation, 11, p617-628.

Link, A. N. and J. T. Scott (2005), Universities as Partners in U.S. Research Joint Ventures, Research Policy, 34, p385-393.

NBSC, National Bureau of Statistics of China (2007), China Statistical Yearbook 2007, China Statistics Press, Beijing, China.

OECD, Organisation for Economic Co-operation and Development (2005), OSLO Manual – Guidelines for Collecting and Interpreting Innovation Data, 3rd Edition, OECD Publishing, France.

OECD, Organisation for Economic Co-operation and Development (2008), OECD Reviews of Innovation Policy: China, OECD Publishing, France.

Revilla Diez, J. and B. Mildahn (2007), Universities as Entrepreneurship Engines in the Periphery: More than Wishful Thinking? The Example of Kiel in Northern Germany, International Journal of Entrepreneurship and Innovation Management, 7, p385-404.

Rothwell, R. and M. Dogson (1992), European Technology Policy Evolution: Convergence towards SMEs and Regional Technology Transfer, Technovation, 12, p223-238.

Santoro, M. D. and A. K. Chakrabarti (2002), Firm Size and Technology Centrality in Industry-University Interactions, Research Policy, 31, p1163-1180.

Schartinger, D., C. Rammer, M. M. Fischer and J. Fröhlich (2002), Knowledge Interactions between Universities and Industry in Austria: Sectoral Patterns and Determinants, Research Policy, 31, p303-328.

Scott, J. T. (2009), Competition in Research and Development: A Theory for Contradictory Predictions, Review of Industrial Organisation, 34, p153-171.

Stata Press (2005a), Base Reference Manual, Release 9, 1, Texas, Stata Press.

Stata Press (2005b), Base Reference Manual, Release 9, 2, Texas, Stata Press.

Stata Press (2005c), Base Reference Manual, Release 9, 2, Texas, Stata Press.

Trajtenberg, M., R. Henderson and A. Jaffe (1997), University versus Corporate Patents: A Window on the Basicness of Inventions, Economics of Innovation and New technologies, 5, p19-50.

Tuan, C. and L. F. Y. Ng (1995), Evolution of Hong Kong's Electronics Industry under a Passive Industrial Policy, Manamerial and Decision Economics, 16, p509-523.

Yusuf, S., M. A. Altaf, B. Eichengreen, S. Gooptu, K. Nabeshima, C. Kenny, D. H. Perkins and M. Shotten (2003), Innovative East Asia – The Future of Growth, World Bank and Oxford University Press.

Appendix

Table A1 Company distribution by importance of different criteria of partner selection in %

n=51	CNLaw	Expertise	BusExp	Reputation	Personal	LocalWS	PubOfficial
1	4	37	35	31	4	4	4
2	2	29	31	41	26	24	12
3	16	22	26	20	29	29	22
4	12	8	6	4	16	12	14
5	67	4	2	4	26	31	49

Note: The same scale of importance was applied (see Table 1) with 1 as "very important" and 5 "not important". CNLaw: requirements of the Chinese laws and regulations; Expertise: partners' expertise; BusExp: good experiences in former business with partners; Reputation: partners' good reputation; Personal: personal or family ties; LocalWS: to get along with local workers and suppliers; PubOfficial: to get along with public officials well.
Source: Own HK Company Survey 2007

Table A2 List of variables and related descriptive statistics

	Variable description	Mean[a]	Std. Dev.[a]	Min.[a]	Max.[a]	Obs.[a]
Source	Academic institutions as at least a little important innovation sources (1) or not (0)	0.648	0.480	0	1	88
Partner	Academic institutions as innovation partners (1) or not (0)	0.071	0.259	0	1	70
Policy_md	Policy as a factor considered for choosing inno. location (a little or normally important)	0.471	0.503	0	1	70
Policy_st	Policy as a factor considered for choosing inno. location (important or very important)	0.186	0.392	0	1	70
Predict_dm	Policy was predictable or very predictable in the past five years	0.220	0.416	0	1	100
Size	Number of employees in total in 2006 in nat. log	4.523	1.920	0	8.179	102
Age	Age of company since its start in HK (till 2007)	14.039	9.280	1	40	102
Capability	Share of sales realised in ODM and OBM way	34.208	36.466	0	100	101
Responding	Responding survey questionnaire (1) or not (0)	1	0	1	1	102
		(0.023)	(0.149)	(0)	(1)	(4481)
Labequip	Producing laboratory and scientific equipments (1) or not(0)	0.020	0.139	0	1	102
		(0.008)	(0.087)	(0)	(1)	(4481)
Avprod	Producing audio-visual products (1) or not (0)	0.333	0.474	0	1	102
		(0.227)	(0.419)	(0)	(1)	(4481)
Pcperi	Producing computer and peripherals (1) or not (0)	0.245	0.432	0	1	102
		(0.127)	(0.332)	(0)	(1)	(4481)
Elecappli	Producing electrical appliances (1) or not (0)	0.186	0.391	0	1	102
		(0.166)	(0.372)	(0)	(1)	(4481)
Teleprod	Producing telecom products (1) or not (0)	0.127	0.335	0	1	102
		(0.120)	(0.325)	(0)	(1)	(4481)
Eleccompo	Producing electronic/electrical components and accessories (1) or not (0)	0.441	0.499	0	1	102
		(0.607)	(0.488)	(0)	(1)	(4481)
Photoequip	Producing cameras and photographic equipments (1) or not (0)	0.039	0.195	0	1	102
		(0.052)	(0.222)	(0)	(1)	(4481)
Inno	Carrying out innovation activities (1) or not (0)	0.863	0.346	0	1	102
Compet_md	Facing moderately increasing competition pressure (1) or not (0)	0.265	0.443	0	1	102
Compet_st	Facing strongly increasing competition pressure (1) or not (0)	0.647	0.480	0	1	102
Manuf	Being manufacturer (1) or not (0)	0.902	0.299	0	1	102
		(0.914)	(0.280)	(0)	(1)	(4481)

Note: [a]Numbers in parentheses refer to the whole population of the HK Electronics SMEs from the TDC data bank.
Source: Own HK Company Survey 2007.