

Knowledge workers and regional innovation in China's ICT sector

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Introduction

This paper considers the evolution of China's system of innovation through a discussion of the interrelationship between regional innovation and the emergence of a labour market of knowledge workers around China's largest high technology park, the Zhongguancun science park in the Beijing area of China. The background to this discussion is the intriguing debate over the strength and potential of China's innovation system. China's entry into the WTO raises an important question over whether Chinese firms will develop the capability to compete with the large Western and Japanese multinationals. Competition will not only impact China's export industry, the burgeoning domestic market will be open to foreign firms that can quickly establish a foothold in areas previously protected for the state owned firms (SOEs). Over the past twenty years or more industrial policy in China has attempted to strengthen indigenous innovation capability through a combination of policies, amongst which the creation of regional science parks has been central. Industrial policy has been oriented to create "Chinese Silicon Valleys" as means to underpin high levels of dynamism. Indeed, according to official figures, the science parks that the government has promoted contains three quarters of all high tech firms in China, employing close to 4 million people.

The literature relating the existence of firm clusters to competence building provides a complex and mixed picture, stressing little uniform evidence that the existence of regional concentrations of economic activity, even when this is high technology in nature, will lead to agglomeration efficiencies. By contrast, the history of regions, their traditions, their industrial composition, relationship with universities, maturity and the nature of institutions combine to provide specific and contrasting characteristics. Nevertheless, a common thread that does appear to run through the literature relating innovation and capacity building to localised learning is the key role played by knowledge workers³. Thus, although numerous studies now question the degree to which inter-firm local collaborations exist and lead to agglomeration economies (Hakanson 2005, Hendry et al 2000), there is more general evidence suggesting that localized clusters can act as concentrations of academic entrepreneurs (Zucker and Darby 1995), as centres of high skills (Krugman 1991) and as spaces within which unique networks of individuals share specialized knowledge (Casper and Murray 2005) through non-transactional means. Given the dominant position they have achieved, understanding how the internal dynamics of knowledge flows in these science parks have influenced the development of the ICT sector is clearly important.

In this sense, the case of China's high technology clusters is particularly interesting. Along with an emphasis on industrial clusters, industrial policy has also focussed on restructuring of State Owned Enterprises (SOEs) and on promoting

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³ Knowledge workers here are broadly defined as playing a "problem-solving" role in innovation projects at basic and/or applied levels in organisation and/or institutions.

entrepreneurial activity from the university and research sector. These factors play an important role in explaining how networks and knowledge flows may be structured with a process of local knowledge generation.

With this in mind, in this paper we present the results on a survey undertaken between February and April of 2006 of knowledge workers in Beijing's Zhongguancun (ZGC) high technology park. The survey includes the responses of 381 knowledge workers employed in 71 high technology Chinese ICT firms located in the park. Initial analysis suggests that large numbers of knowledge workers are involved in different types of external networking activities, although not all workers, nor all activities are rewarded by the firm and only some of these activities impact performance on innovation.

Bringing labour into the study of regional innovation

The optimistic premise upon which the Chinese authorities set up innovation parks throughout all of China's regions was driven by the desire to replicate the experience of Silicon Valley, although in reality broadly defined science parks vary enormously in their nature, degree to which they undertake innovation and relative success. Moreover, there exists a degree of controversy within the innovation literature over the exact nature of interactive learning in regional agglomerations. The debate, as for example expressed in the December 2005 issue of *Industry and Innovation*, hinges around whether regional concentrations of firms accrue agglomeration economies by inter-firm knowledge flows or alternatively if the economic dynamism witnessed by some regions emerges as a consequence of new firm formation that is more prevalent where large firms appear.

There exists a large body of literature analyzing relationship between regional networks and economic activity, including its relation to innovation activity. A brief account would begin with Marshall's contribution (1920), who cited three essential advantages to spatial agglomerations that will lead to greater specialization and efficiency. Firstly is preferential access to local specialised suppliers, to which we could include specialized services and from which follows, access to specialized knowledge. The existence of a wide population of suppliers also enables companies to outsource some of their peripheral activities to concentrate on their core competencies. Secondly, firms have access to richer pools of workers with specialized skills. In this argument, labour is seen as providing both static capabilities (flexible inputs that can be varied as demand changes) and dynamic capabilities (highly specialized labour that can encourage innovation and increase efficiency). Finally, firms in spatial agglomerations are said to benefit from knowledge spillovers, particularly through access to tacit knowledge that is available locally. To this we may add Porter's (1990) argument that local rivalry will create the conditions for intense competition between firms in similar markets, thus driving forward specialization and innovation.

Empirical evidence providing uniform support for Marshall's propositions between different regions that have high agglomerations of economic activity has been difficult to maintain, in part because the characteristics of economic agglomerations appear to vary according to industry sector, size of firms and maturity of the cluster (Bresnahan et al 2001). There is also the question of how to measure the nature and impact of knowledge spillovers. Thus, Carlsson (2002) prefers to argue that the key elements of a system of innovation is its dynamic properties, consisting of diversity (as a measure of robustness), its flexibility, that can be interpreted as a measure of the ability of

entrepreneurial firms in the system to develop dynamic rather than static capabilities (largely a function of core capability) and the system's responsiveness i.e. the ability to generate and respond to change.

The relevance of the above discussion for labour markets lies in at least two separate areas. The first is that, despite their different characteristics, it appears that across the board, the existence of high skilled labour markets play a key role in local concentrations of economic activity (Malmberg and Power, 2005). In this case a high skilled labour market is clearly a factor in the growth of cluster activities. However, in addition to the existence of high skills, there is growing interest in studying the extent to which the functioning of labour markets has an added impact on knowledge transfers. In these cases, the particular local features of labour markets can be used as a proxy for the degree to which an organisation is able to access outside knowledge and has sufficient diversity of sources of knowledge to allow it to seize the opportunities. In the following discussion we specify the literature and some of the methodology used to measure the effects of different networking activities of knowledge workers.

The principle concepts that have emerged to explain the specific role of high skilled workers in inter-firm knowledge transfer, emerge firstly from a new division of labour that emphasises skills that act as intermediates, bridges and scanning devices for organizations that cannot find all the knowledge they need in-house. Below, a number of different types of networking activities are distinguished, nevertheless, institutionally it is clear that for a new division of labour to emerge, organisations need to encourage and reward employees who combine skills and knowledge of hitherto separate areas, for example scientists that combine disciplines or R&D employees that combine technical with business knowledge.

We firstly highlight a type of work that involves searching and scanning technological and/or managerial techniques that keep the organisation up-to date with recent developments. These may form the basis of future collaboration, provide knowledge of the competition or simply act as a benchmarking exercise. A number of authors have referred to this as gatekeeping (Allen 1979, Leonard-Barton 1995, Macdonald 1992), whose job is to filter out information from outside the firms and decide what is useful within the firm. A study of gatekeepers by McDonald (ibid.) suggested that they were highly qualified, mostly engineers and the relationship with other employees was very much on a professional rather than personal basis. We can also include here external activities employees are involved in to access general outside knowledge to the firm such as attending conferences. In the context of a regional concentration of economic activity one might expect this activity to be particularly prominent. We label this *Scanning activity*

Secondly we can point to individuals that play a prominent role in bridging the cognitive gaps that can exist in collaboration around specific innovation projects. For this to be successful it is argued that firms need to nurture boundary spanners, individuals that are able to understand the world of the source and the world of the receiver (Leonard-Barton, 1995) and well as disseminate knowledge and are therefore key for successful alliances. We label employees involved in these activities as *Inter-organizational problem solving* (IOPS).

Another major source of cluster dynamic activity that strongly impinges labour markets of knowledge workers is associated with networking that essentially relies on personal relations of knowledge workers. Macdonald and Piekkari (2005) suggest that personal networks emerge because of the difficulty of getting the right information at

the right time, hence market failure and to overcome the problems that contractual arrangements of collaboration cannot. These networks resemble much of the work developed by Granovetter (1988, 1995) who emphasized the embeddedness of labour markets and where effectiveness of career mobility depends on social networks that transcend the boundaries between economy and local social life. In other words professional networks minimize the costs of search and the costs of switching jobs. Relational networks therefore provide the information signals needed to ensure success outside of internal labour markets.

It is useful to differentiate the three types of network activities described, for their importance in economic activity may vary both by industry, because of institutional differences or indeed through different cultural traditions inherent in different geographical locations. Thus for example we can differentiate between different methods of coordination involved in the above examples of collaboration, the first governed by the hierarchy of the firm, the second by a transactional market relation, the third by the networks itself, that relies on notions of trust and intensity of contact (Thompson, 2003). Similarly, we can differentiate between different degrees of formality, that is between the relative formality of *general networking* and IOPS and the informality of relational networks.

Work of this nature is promising, for it may help to understand the mechanisms by which different forms of inter-firm knowledge transfer can impact firm level performance, although little empirical work has been undertaken to establish relationships between formal and informal labour institutions and innovation performance outcomes. Perhaps the most cited contribution in this field is Saxenian's (1994) detailed comparison of Silicon Valley and Route 128 in Massachusetts. The strength of Silicon Valley, it is argued, was initially based around its professional network rather than any specific firm. Key dimensions here include high labour mobility and professional links, underlined by cultural factors such as loyalty to a network and craft rather a firm (ibid). Arthur (1996) furthermore suggests that as industrial structures came under pressure to change, so greater emphasis was placed upon "boundaryless careers", where regional learning is underpinned by high rates of labour mobility and career paths that are built around participation in local networks. Indeed, breaking down traditional corporate career trajectories has been a key element in creating a regional entrepreneurial drive (Saxenian 1996). Thus, mobility in this context can be seen as knowledge that is shared within communities rather than as individuals that carry specific bits of knowledge.

Insert table 1

Table 1 summarises the above categories, and additionally highlights the importance of firm practices that are necessary to encourage networking type activities to take place and secondly the regional labour market institutions that act to support cross-organisational knowledge flows. The organisational characteristics suggest firms need to create and reward skills that hone in on working on the boundary of the firm rather than at the more traditional core. Similarly, recruitment needs to take place in more diverse knowledge areas to reflect the need to combine knowledge from inside and outside the firm.

From an institutional perspective, labour market analysis would suggest that the existence of occupational type labour market institutions, such as recognition of industry experience and industry qualifications is most likely to encourage the mobility of employees (Mincer 1964). However, the degree to which firms in a cluster coordinate economic activity, such as investments in technology, will also encourage the transferability of local skills. Saxenian (1996) on the other hand goes back to the community of practice concept, focussing on “open labour markets”, which refers to the ability of individuals to develop and experiment with different career options that derive from their participation in networks. Open labour markets are essential for underpinning networks, spin-offs and the creation of new service functions and other entrepreneurial activities and for establishing diverse sources of knowledge within a region. Often the existence of intermediary institutions, such as specialised contractors and employment agencies can facilitate the mobility process.

Emerging knowledge workers in China

In this section we briefly trace the evolution of the scientific labour market in China since the introduction of the market reforms some twenty years ago and discuss some specific characteristics that impinge upon the earlier discussion of network relations. The emergence of what can be called a genuine labour market within the science and technology system in China is closely tied in with the growth of new technology enterprises, the growth of high technology multinational enterprises and the reforms associated to the Chinese higher education (HE) system. China's S&T structures were traditionally modelled closely on those of the Soviet Union in the 1950s. The Soviet innovation model was of a simple linear nature, with some similarities to the early generation demand-pull model proposed for Western societies (OECD 1969, Holloway, 1982). Of course, consumer/producer relations were entirely different to a market system, the consumer in the command system was the planning body and its demands were transmitted by administrative *fiat* through industrial ministries to S&T bodies. Each ministry was responsible for a particular industrial sector, e.g. telecoms, and had production enterprises, R&D institutes and often higher education bodies under its control.

The system was vertically integrated with very few if any formal horizontal linkages between production units on the one hand, and the R&D institutes responsible for innovation and HE bodies with industrial ministry affiliation. The role of such HE bodies was to provide a pool of highly specialised knowledge workers for the production units and R&D institutes. Other organisations existed outside the industrial ministries that had S&T functions, such as the institutes of the various academies of science and universities under non-industrial ministries, but they played little role, if any, in industrial innovation. Labour mobility was very limited and labour markets for knowledge workers did not exist, since jobs were allocated administratively, and were usually for life. In China the structures for innovation were extensive, with 800 industry branch R&D institutes existing before the market orientated changes began in the mid 1980s (Suttmeier, 1997).

The 1985 policy initiative concerning the S&T sector was accompanied by similar measures concerning higher education, since the HE sector was seen as the main driver

in Chinese high-tech development (Yin and White, 1994). Its role in the formation of NTEs has already been mentioned. The aims of the HE changes were to expand the autonomy, financial and otherwise, of institutions, to strengthen links with production organisations and to develop a labour market for HE workers. The greater financial autonomy was to be achieved in two ways. Firstly by charging students for their tuition fees and secondly by developing commercial structures to sell expertise or to invest in spin-off ventures of various kinds. The main vehicles for the new approach were the new vocational universities, which first appeared in the 1980s. All students paid fees, in one form or another, to attend these bodies and the curriculum was flexible and market driven, with a strong vocational content (Fang 1991)

Dramatic changes in the make-up of R&D labour markets appear in the growing mobility of employees. There is evidence from the business and professional press that Chinese high-tech firms are experiencing double digit labour turnover and difficulty in retaining qualified staff, leading to the need to concede high salary rises (Raatikainen, 2003, Leininger, 2004), indicating that there is an active and mobile labour market in this sector. The new state HE policy discussed above could have facilitated this, because as well as trying to promote labour mobility in universities it also had an aim of developing a labour market in the S&T sector. A key feature of the new policy was that the system where jobs for graduates were allocated by the state was replaced in 1990 by the “two way selection” process. As the term implies, the prospective employer and employee both had a say in the transaction (Lewin and Xu, 1993).

The development of spin-off ventures may however have been the main driver in creating a high-tech labour market in China. The growth of this sector has been explosive, as revealed by the figures in the previous section that there are now 23,000 NTEs in the ‘Torch’ programme (Huang et al., 2004). These firms were spun-off both by research institutes affiliated to the academy of sciences or former industrial branch ministries and by HEIs. By the early 1990s in some HEIs, most of the staff held concurrent jobs in spin-offs from their own institutions. For example, 80% of the teachers in Jiamusi Technology Institute were also working in its 12 affiliated ventures (Yin and White 1994). The same study also reported that there was pressure on staff to leave the HE sector completely for business. The state actively encouraged this trend through financial mechanisms, i.e. budget cuts, on HEIs and has continued to do so.

Another driver of labour market mobility was the transformation of research institutes into private companies, where the ability to hire/fire staff was seen as a factor influencing the change (Suttmeier, 1997). A study of one of the leading ICT firms, Stone, noted that all the R&D team had acquired their skills in the state R&D sector. The same paper also concluded that mobility of key researchers from state institutes to the new spin-offs was a factor in accounting for their success (Lu, 2001).

Data analysis and methodology

As has been discussed, Chinese labour markets appear to have undergone important changes, although very little empirical work has been published in the English language to allow in-depth analysis to be carried out that draws out relationships between labour markets, regional dynamics, the firm’s innovation strategy and broader networks relationships between knowledge workers. Detailed cross sectional comparison of the workings of scientific and engineering Chinese labour markets with other major economies countries has been similarly lacking. With this in mind, in this

paper we present initial results on a survey undertaken between February and April of 2006 of knowledge workers in Beijing's Zhongguancun high technology park. The Zhongguancun high technology park (ZGC) is China's first and largest science park that covers a large part of the North West of Beijing. Since its inception, spin-off companies from the large number of universities have become some of the best known in China, such as the Founder Group of Beijing University, the Tongfang group of Tsinghua University and Lenovo (formerly Legend) spin off from the Institute of Computer Technology of the Chinese Academy of Science. There are now 14,000 companies, employing nearly 500,000 knowledge workers and 68 key universities, in addition to the Chinese academy of sciences (academics of the Chinese Academy of Sciences and Chinese academy of engineering comprise 36% of all academics in China (Wang 2000)). ICT is the dominant industrial sector in ZGC (70%), but there are also other significant players in bio-tech, advanced materials including optics and nano-technology (Wang, 2000).

In this paper we present results on two linked surveys undertaken between February and April of 2006 in Beijing's Zhongguancun high technology park. The following protocol was used to undertake the surveys:

- Organisations invited to participate in the study had the following profile: Indigenous Chinese ICT companies, undertaking innovation⁴ and located in the Zhongguancun area of Beijing, China. The firms fulfilling the above criteria were chosen at random from a database of firms located in the park.
- A senior R&D manager (or if he/she was not available, a senior person in R&D) was contacted by phone and asked if they would be prepared to participate in the research. If the answer was affirmative, the senior R&D manager was e-mailed the address of a website that they could log on to where the survey was available. The respondents were asked to nominate a major innovation project in the company over the past three years and in some cases answer questions in relation to this. The survey answers could be submitted on-line to a server that collected the data. This shall be referred to as the Senior Manager survey
- Senior R&D managers were also asked to nominate up to 10 R&D employees that worked in the above project, who in turn were asked to answer questions on a different survey and submit these on-line. This shall be referred to as the knowledge worker survey, although as shall be discussed, some of these included R&D line managers

A maximum of ten employees that had worked on this project in each firm were then asked to fill in the survey. All employees that answered the survey therefore were involved in at least one innovation project over the past three years and where relevant the answers refer to their experience of work on this innovation project. The methodology described above will allow a link to be made between firm strategy and innovation performance on each project with the employment relationships that emerge from knowledge workers involved in these projects and the implications for skill and

⁴ By innovative activity we specify that firms should have introduced at least one product or significantly improved a product over the past three years and be undertaking R&D activity. Changes of a cosmetic nature and re-sale of new goods purchased from another enterprise were excluded

career development. Where relevant, Likert scales between 0-3 were used in the surveys.

External learning and earnings

The literature review above highlighted the two main questions raised in the paper, whether labour markets in the park demonstrated features of fluidity and openness, thus facilitating knowledge flows, and whether the networking activities of knowledge workers were prevalent, rewarded by firms and if this had any impact on innovation performance. These questions are formalised around the following hypotheses:

1. *Knowledge workers will derive a wage premium for their tenure with high technology companies.*
2. *ZGC Park has a highly fluid labour market that demonstrates characteristics of occupational labour markets.*
3. *Firms in the ZGN will pay wage premiums for R&D employees to collaborate and network outside of the firm in innovation projects?*
4. *Networking activities of knowledge workers will have a positive impact on innovation performance*

The first step of the analysis is based around a study of R&D employees in the ZGC park. Following the early work of Mincer (1964) we will be able to distinguish between an occupational labour market (OLM) and an internal labour market (ILM). In this scheme an ILM is characterised by the development of collective competence based on an accumulation of mainly tacit knowledge that are developed and rewarded predominantly within the firm, and are therefore firm specific skills. On the other hand, an occupational labour market (OLM) is one where formal qualifications and/or experience outside of the firm are recognised and rewarded. Depending on the specific nature of the labour market, flexibility and rapid turnover of staff will also be evident.

The extent of ILMs/OLMs of knowledge workers in the Chinese ICT sector in the ZGC Park can be measured by comparing returns to job tenure (which reflects a management policy of building loyalty), with returns to professional experience in the external labour market. The first expresses the degree of monetary incentive offered to employees wishing to acquire firm specific knowledge, the second reflects the monetary value a firm places on professional experience acquired externally.

Hypothesis three requires us to create constructs that differentiate between different types of networking activities as undertaken by knowledge workers, as explained in table 1. To operationalise this analysis we undertook a factor analysis from the questions emerging from the knowledge worker survey regarding the relationships between work in the firm and external relationships. The conceptual similarities of

independent variables were explored judgmentally and on the basis of exploratory factor analyse outcomes. On this basis, items were allocated to sub-sets with each sub-set considered to represent a relatively broad construct of specific practices. Finally, allocation of items to sub-sets was checked objectively on the basis of their internal consistency. The constructs, items allocated to them and their levels of internal consistency, as quantified by Cronbach's α values are reported in table 2 below.

Insert table 2 here

An observation of each of the variables that go up to make the constructs conceptually suggest that they represent the three categories of networking that were discussed in the earlier part of the paper, that is, inter-organizational networking, that represents formal collaboration on innovation projects, relational networking, that represents the networks that are governed by individuals relationship and finally general networking, that represent scanning and searching by employees within the firm. The alpha values are all above 0.6, except for general networking, with a value of 0.57.

Firstly, figure 1 shows what proportion of knowledge workers undertake different types of networking activity and if there are significant differences for this activity by position of seniority. The results show that around 18% of knowledge workers undertake some or a great deal of inter-organizational networking activity on the innovation projects they are working on, for scanning activity this figure increases to around 51%. In both these cases there are no major differences according to seniority. In the case of relational networking around 38% and 30% of non-senior employees and senior R&D employees using relational networks respectively, highlighting important and perhaps surprising contrasts between employees. Figure 1 also makes clear that networking activity varies. Unsurprisingly, less knowledge workers are involved in formal networking activity and a very high proportion in scanning.

In the next step we build a regression model with wages as the dependent variable. The regression model is shown below:

$$W = \text{constant} + a_1 \text{EXP}_i + a_2 \text{EXP}_i^2 + b_1 \text{TENURE}_i + b_2 \text{TENURE}_i^2 + c_1 \text{Number of PREVIOUS JOBS} + d_1 \text{SEN} + d_2 \text{IOPS} + d_3 \text{REL} + d_4 \text{SCAN} + f_1 \text{IOPS*SEN} + f_2 \text{REL*SEN} + f_3 \text{SCAN*SEN}$$

The dependent variable W, is a banded response to gross annual wages including bonuses, EXP is years of experience prior to joining present firm and TENURE is years in current firm. EXP² and TEN² are the square terms of experience and tenure and are intended to show if there are diminishing returns experience and tenure over time. SEN is level of seniority (a dummy variable that distinguishes between managerial/senior engineers and non non-management R&D employees). IOPS is inter-organisational networking, REL is relational networking, SCAN is scanning and searching activity. A first order interaction was introduced between networking activities to capture the differentials in the return to networking depending on the position of seniority in the company. These are IOP*SEN, REL*SEN and SCAN*SEN. The results are shown in table 3.

Insert table 3

The regression shows provides strong evidence for hypothesis one and two. Both experience and tenure are rewarded, although the coefficient suggests that tenure is rewarded more strongly than experience. However, although returns to tenure appear to diminish at some point, this is not the case with experience. This may be because the workforce is very young and therefore have yet to experience negative returns to experience. If this were the case however, it also suggests that at some point the returns to experience will outpace the rewards for tenure, will begin to decrease at a certain point. The regression also shows positive returns to seniority, where unsurprisingly senior R&D employees are paid more than junior employees.

In terms of hypothesis three, the returns to networking activities, the regression shows no significant returns to any type of networking within the entire sample. However, the interactive variables shows that for senior employees only there are significant returns to scanning activities only. These results are significant. It suggests that skills to establish formal competencies that facilitate formal networking do not attract a wage premium. Similarly, employees that turn to their personal networks to problem solve also fail to attract a premium. On the other hand, knowledge workers that focus on keeping up with developments in managerial and technological developments do attract a premium, irrespective of their experience and tenure, but that this occurs only within management employees. Non-management employees, that the survey suggested were involved in scanning activity, and this constituted almost half of those surveyed, failed to receive a wage premium.

Networking and Innovation Performance

To investigate hypothesis 4, the next part of the discussion changes the dependent variables from the earnings of the individual employee, to the degree of success of the innovation project undertaken by the firm. In other words, the dependent variable becomes the performance, as reported by senior R&D manager. As explained earlier, the methodology chosen provides us with a matching sample of senior R&D leaders on the one hand that have an overall view of innovation strategy and projects on the one hand, with employees that have worked on specific projects on the other. Thus, independent reporting of innovation activity is achieved in this case. In operational terms, these relationships were evaluated using Multiple Regression with a dependent variable (DV) quantified as the senior R&D manager average ratings of project success in terms of meeting deadlines, levels of product sales and technical capability of the finalised product. These three variables provided a reliability Cronbach's alpha value of 0.62. The dependent variable and the constructs that will be discussed below all approximated a normal distribution. Where relevant, Likert scales between 0-3 were used in the surveys.

Breakdown of the total sample in terms of Size and Ownership are reported in Table 4. Unlike what might be expected in established capitalist countries, there is a high preponderance of State owned firms, predominantly cooperatives, in the sample. In the Chinese context, cooperatives are enterprises with minority stake owned by the State. Management is relatively autonomous and is responsible to majority stakeholders that are private.

[Insert Table 4 around here]

Given the limited sample size, the regression model is limited to the inclusion of 5 explanatory variables (IVs). The model is as follows:

$$\text{Innovation Success} = \text{constant} + a_1 \text{ Size} + b_1 \text{ Ownership} + c_1 \text{ SCAN} + c_2 \text{ IOPS} + c_3 \text{ REL}$$

As far as the IVs are concerned, Ownership is a dichotomous variable between private and State owned, while Size of firm is measured in number of employees. SCAN, IOPS and REL conceptually mirror the networking variables that were used earlier in the paper, although in this case, to achieve a value for the degree to which its R&D employees networks, the values on the variables were calculated as an average of score of the employees from each firm, with a minimum of two employees. These criteria were employed in order to optimise a balance between reliability of mean ratings and the sample size available for analysis. A two-step MR modelling protocol was adopted with Size and Ownership forced into the model at step one as control variables. The three constructs were then considered for entry on an empirically driven stepwise basis at the second step. Results of the MR analysis are reported in Table 5

[Insert Table 5 around here]

Inspection of Table 5 identifies that at the first step, size is not significant, however ownership is highly significant, explaining some 15% of innovation performance. The manner in which this was coded signifies publicly owned firms are more successful than privately owned firms in the innovation projects.

At the second step, there is a significant improvement in the MR model (R^2 values rising from 15% to 21%) identifying the fact that addition of one or more constructs makes a substantive contribution to the prediction of Project Success. Table 5 shows that the model improvement is attributable to the entry of just one of these constructs namely scanning activities, with a positive coefficient value indicating high levels of scanning typically being associated with more successful innovation projects. The result suggests that of the three networking activities, only searching and scanning appears to have an impact on performance.

Conclusions and implications

The objective of this paper has been to investigate the character of labour markets in a large Chinese high technology agglomeration and its relationship to inter-firm knowledge flows and innovation. Our survey showed that there are positive income returns both to inter-firm mobility and experience in the labour market, suggesting that skill formation will not be limited to firm-specific experience and will extend beyond the immediate place of work. Clearly many of the institutional features that characterised the labour market of scientific and technical employees in the State controlled planned economy era have given way to relatively a fluid labour market.

Secondly, the paper investigated whether a new division of labour associated with gaining knowledge from organization's outside environment, that we can loosely describe as networking, has emerged amongst Chinese R&D employees, and if these skills are independently recognized and rewarded in the labour market.

Our results suggest firstly that the proportion of management and non-management employees engaged in networking activities will vary according to the type of activity, as we have defined it. However, it was found that only scanning activities attracted a wage premium and that this was only amongst senior and managerial R&D staff. Moreover, when regressed against innovation performance, only scanning activity was shown to have a significant impact. The paper takes this line of enquiry further by investigating whether networking activities of employees has any impact on the success of the innovation project.

Human Capital theory would suggest that these self-reinforcing results, whose dependent variables have been derived from separate sources, mean that scanning and searching attract a wage premium because, in contrast to boundary spanning and contacting personal networks, it is the only networking activity that positively impacts innovation outcomes. Organizational theory would moreover suggest that this arises because engagement with the outside environment increases the firm's absorptive capacity and dynamic capability. This may be especially evident for firms involved in innovation projects, where the need to keep up-to-date with technological and market developments is paramount. The fact that careers around boundary spanning and gatekeeping activities have developed in the West, indicates that in certain Western contexts, networking type skills are highly valued.

The findings may have significant policy implications. The experience of the advanced capitalist economies suggests that a sophisticated and innovative economy requires high levels of horizontal coordination and disintegration at industry level to achieve a specialised division of labour. The Science parks in China were formed to encourage this process. Therefore the finding that some forms of networking have no effect on innovation requires some discussion.

Interpreting the results however depends very much upon the type of theoretical schema that is used. A transaction cost approach might see that in comparison with informal mechanisms of gathering information, formal inter-firm collaborations carry a high transaction cost and therefore may not be significant activity particularly within SMEs. Relational networks on the other hand may also carry a high transaction costs because of the peculiarly cultural traditions of *Guanxi* relationships in China, whereby the use of personal networks carries a growing reciprocal obligation. This point is also made by Assimakopoulos and Yan (2006), who, in an empirical study of Chinese software engineers, find that patterns of advice seeking relations across project team boundaries highlight the use of Internet software technology forums as an important channel for technical information sharing across organizational boundaries, and relational contacts are used only occasionally because of the transaction costs they assume. Scanning activities on the other hand attain low transaction costs. A strategic management and resource based approach on the other hand may suggest that that firms involved in innovation projects will not readily engage in inter-firm collaboration to share their core competence, a point underlined by (Zucker et al, 2005) in her study of academic spin-offs. Searching and scanning activity on the other hand, that carries low formal commitments will be a crucial in understanding and interpreting the State of the art in managerial and technological techniques.

Our emphasis on labour markets however may also point to nature of institutions in shaping the type of networking activity that takes place. Labour markets play an important role in facilitating the creation of new skills and careers. For example, there may be resistance within firms, and amongst other employees, to reward skills that are not grounded solely in core of the organisation. In this sense, Leonard-Barton's "not invented here" syndrome may be relevant. Clearly further analysis will be necessary to forward our understanding of knowledge transfer in the context of regional agglomerations. However, using labour markets both as a proxy for understanding knowledge transfer and as key institutional mechanism that shapes how knowledge transfer takes place, appears to be a useful methodological tool for the study of innovation.

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Table 1

External dynamics	Objectives	Coordination	Formal firm practices	Regional LM institutions
Inter-organisational problem solving	Encourage collaboration by building cognitive bridges	Market and prices	Recruitment in diverse knowledge areas Premium for inter-firm/organisation negotiating role Creation of diverse job categories	Open labour market that encourage diversity of career and professional categories at university level and intermediate level.
Relational networks	Access tacit knowledge otherwise not available. Take advantage of “structural holes” and “weak networks”	Trust and Intensity of communication	Autonomy and discretion whereby social and business relations intermingle Maintain relations with ex-colleagues	Universities act to create common identity Knowledge workers live in the area
General networking	Search mechanism (disruptive innovation, problems solving, resources) Seed down longer term collaborations Short-term project based collaboration	Hierarchical	Attendance at fairs and conferences Participation in inter-firm communities of practice type networks Recruitment of individuals with strong networks and from strong firm/institutions	Specialised contractors and employment agencies attract non-standarsided employment relations.

Table 2

Construct	Item	Available	Crombach's alpha
Inter-organisational problem solving	Sharing knowledge with research institutes	343	0.74
	Sharing knowledge with founder bodies		
	Sharing knowledge with standard setting bodies		
Relational network	Sharing knowledge with former classmates	350	0.82
	Sharing knowledge with colleagues		
Searching and scanning	Attending conferences	360	0.56
	External communication via chat rooms etc		
	Informal contact with external acquaintances		

Figure 1

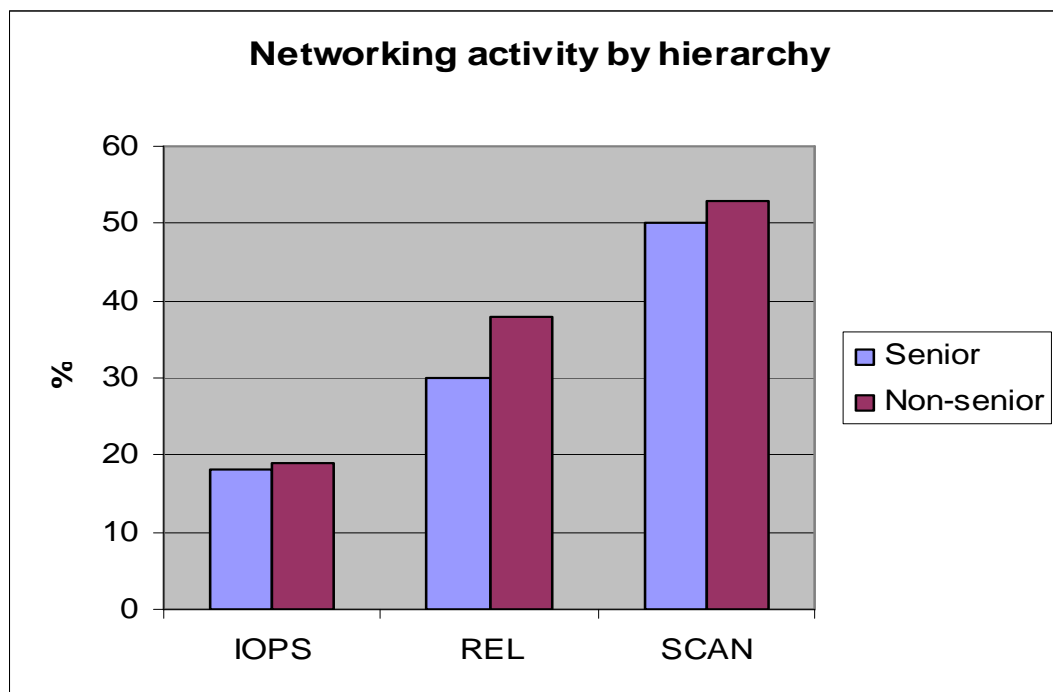


Table 3

Multiple Regression for Knowledge Workers

Explanatory Variable	Standardised Beta	t	Sig
Constant		7.692	.000
EXP	.278	2.119	.035
EXPSQ	-.120	-.937	.350
TENURE	.698	5.165	.000
TENURESQ	-.412	-3.073	.002
SEN	-.214	-1.302	.194
Number PREVIOUS JOBS	.174	3.174	.002
IOPS	.028	.506	.613
REL	-.028	-.504	.615
SCAN	-.049	-.762	.447
SCAN*SEN	.371	2.207	.028
IOPS*SEN	.052	.445	.180
REL*SEN	-.013	-.129	.234

Dependent Variable: gross monthly wage plus bonuses.

Model summary:

R²=.253, adjusted R²=.229, F=4.872, Sig=.028 n=381

Table 4 – Breakdowns of Sample in terms of Size and Ownership

Ownership	Size Categories			Total
	<100	500-499	>500	
State	29 (73%)	11 (65%)	4 (67%)	44 (70%)
No State	11 (27%)	6 (35%)	2 (33%)	19 (30%)
Total	40 (100%)	17 (100%)	6 (100%)	63 ^A

^A Eight cases omitted from table due to missing values on Size and/or Ownership

Table 5

Explanatory Variable	Standardised Beta	t	Sig
Constant		39.77	.00
Size	-0.15	-1.32	0.18
Ownership	-0.33	-3.31	0.00
Scan	0.24	2.14	0.03
IOPS	-.165	-1.54	0.13
REL	-.12	-1.11	0.27

Dependent Variable: Success on innovation project as measured by degree of success in meeting deadlines, market share and technical capability.

Model summary:

R²=.20, adjusted R²=.17, F=4.587, Sig=.036 n=71