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The organization of scientists and its relation to scientific productivity: Perceptions of Chinese stem cell researchers

Joy Yueyue Zhang

BIOS Centre, London School of Economics and Political Science, Houghton Street, London WC2A 2AE, UK

Abstract

Chinese government funding of R&D ranks third in the world. Yet China ranks only 17th in terms of scientific productivity per unit of investment. The author recently conducted fieldwork on the team structure of 22 Chinese stem cell research groups. Interview data suggest that although Chinese research groups closely resemble their international counter-parts in many respects, there are also significant differences which are perceived by interviewees to affect levels of scientific productivity. One characteristic of Chinese research teams is a common deficiency in middle-layer positions. This shortage of experienced professionals is perceived by scientists participating in this study to have led to two consequences. First, inexperienced student researchers often form the backbone of scientific teams in China, which leads to frequent interruptions of research and extended laboratory training. Second, research teams consist of a relatively small number of personnel. These structural features are seen to create excessive social boundaries, which impede the exchange of information and further worsens the segmentation of resources. This article engages the question of the extent to which interviewees' local 'embedded' understandings of these difficulties may make a productive contribution to the analysis of the structural, and infra-structural, organization of Chinese professional bioscience teams.

Keywords

research efficiency; team structure; Chinese bioscience; stem cells

Introduction

Scientific development is of upmost importance to China. Stimulated by Deng Xiaoping's endorsement of the High Technology R&D programme in 1986, the Chinese government has increased its support for scientific research by launching a series of high profile, innovative national funding schemes, such as the Torch Program (aimed at high-tech industries) and the National Basic Research Program (also known as the 973 program). In addition, China has been highly active in importing Western regulatory frameworks and 'gearing to international standards' (*yu guoji jiegui*). Yet despite its administrative efforts to promote research advancement, China's publication performance in internationally recognized journals is low in terms of both numbers and quality (Wang and Wang, 2006). Although Chinese government financial support for R&D ranks 3rd in the world (OECD, 2007a), in terms of science productivity per unit of investment, it ranked only 17th (Corbyn, 2008). A recent quantitative study of China's patent and publication record per unit of investment from 1991 to 2003 indicated a 'scientific productivity paradox' in which despite

the increasing R&D input, the ‘growth rate of scientific productivity of China’s S&T institutes has been negative since the 1990s’ (Huang *et al*, 2006). As has been observed by other researchers, many overseas star researchers seem to be incapable of maintaining their research level once settled back in China (Hao and Liu, 2005; Solo and Pressberg, 2007).

Numerous studies have been undertaken to identify mechanisms to improve scientific productivity. From a national-administration perspective, researchers have investigated the features of Chinese scientific administrative and financing mechanisms (Salter and Cooper, 2006), the implementation of regulations (Hennig, 2006), and the characteristics of policy making (Doering, 2003, 2004). In relation to group productivity, studies range from the search for optimal group patterns (Wallmark *et al*, 1973; Cohen, 1980; Kretschmer, 1985; Tang *et al*, 2008), to exploring communicative efficiency in relation to social network structures (Leavitt, 1951; Burt, 1992) to the nature of how social ties affect knowledge transfer (Hensen, 1999; Reagans and McEvily, 2003), to workplace intellectual capital management (Mehra *et al*, 2001; Ajmal and Koskinen, 2008).

Yet there seems to be a ‘blind spot’ within existing research concerning how productivity encouraged by national administrative endeavours is constrained by the actual structure of research groups. Empirical study of this topic in the context of the life sciences in China is especially rare. Based on interview data collected from Chinese stem cell research teams in six cities (Beijing, Tianjin, Shanghai, Hangzhou, Changsha, Guangzhou) in early 2008, this article addresses this under explored question and examines scientists’ perceptions of how the organization of scientists from a grass-roots level influences scientific productivity in China. Because it is limited in scope for practical reasons, the qualitative data presented here are not representative. It may, however, be indicative of pattern of perception that indicates real weaknesses in research infrastructure and governance. The argument offered here alerts scientific administrators to the possibility that research teams are not just freight stations along the information highway, but are crucial vehicles for knowledge circulation. Besides China’s continuous enthusiasm for launching reforms and renovating policy agendas on the macro-level, alternative strategies of how to facilitate grass-root team restructuring may also be a fruitful line of inquiry in sustaining an efficient system of innovation. I conclude that the most basic and common form of organizing scientists, namely research teams, may exert an influence on the nature of research proceedings and the distribution of resources.

Methodology and Structure

Data used in this paper form one part of a larger study on China’s governance of stem cell research funded by the Wellcome Trust.¹ In-depth semi-structured interviews were conducted by the author and lasted on average 1 h each. Interviews were recorded and transcribed. Twenty-two senior scientists with, on average, more than 10 years working experience and 16 junior researchers with an average of three years working or training experience in China were interviewed. Interviews addressed a range of topics relevant to the governance of stem cell science. Questions were drawn from the author’s own medical training and experience of working in Chinese scientific laboratories, and from extensive review of social studies of the life sciences and other relevant literature. The interviews were then transcribed and analysed by sorting the data according to major themes and identifying reoccurring concepts (Corbin and Strauss, 1990).

¹Data collected as part of PhD in progress at the BIOS Centre, LSE, titled ‘The Regulation of China’s Stem Cell Research in the Context of Cosmopolitanization’. These are by definition preliminary findings comprising part of a larger study. The themes in other parts of this PhD include Chinese scientists’ views on research motivation and systems of assessment, the nature of international collaborations, and how stem cell governance is impacted by government and institutional regulatory frameworks within China.

Although it must be emphasized that this non-random sample of interviewees is not representative of the sciences as a whole, nor even of the life sciences or the stem cell community, it is equally important to note that small amounts of data analyzed in greater qualitative depth may serve an important function by identifying core themes which may profit from more systematic analysis. This ‘factor finding’ approach is often seen to be of particular value in addressing under researched areas at an early stage in their emergence as sociological problems. This research should thus be interpreted as similar to other qualitative studies of scientific practice in China (see Cao and Suttmeier, 2001; Doering, 2004; Sui and Sleenboom-Faulkner, 2007) and small-scale studies of professional science communities (Parry, 2006; Wainwright *et al*, 2006). More specifically, the analysis of this article adopted a grounded theory approach and drew insights from sociologist David Silverman’s (2005) argument on the strength of qualitative research. That is, the question of *why* a phenomenon occurred in a particular context is better answered after locating *how* interviewees deploy social meaning to their situation. Thus, in the case of this article, to understand *why* researchers’ productivity is low in China, it is necessary to explore *how* Chinese researchers interpret their structural positions and comprehend their roles within them. The focus on Chinese researchers’ perception and interpretation of their research context is not intended to claim anything as exclusively ‘Chinese’, or to be representative. But it is nonetheless of value in understanding professional culture, in particular organizational conventions in China. As will be noted in the analysis, these perceptions are also to an extent supported by existing literature.

This article is divided into two sections. The first section identifies interviewees’ accounts of the missing ‘middle-layer’ as a key characteristic of common team structures in China. That is to say, most teams are seen to have few personnel that fill in the position levels between the top rank (principal investigator, in most cases a professor) and the base rank (research student). The lack of ‘middle-layer’ researchers and the consequent proliferation of ‘one-professor-many-students’ team structures together comprise one of the dominant interpretations offered by interviewees for why the Chinese scientific sector is seen to consist of a ‘very large number of “innovative islands”’ (OECD, 2007b, p. 22). The second section further discusses how a thin middle-layer in team structure is similarly perceived to have undermined national incentives in promoting scientific productivity. This interpretation suggests that the absence of a robust middle-layer structure reduced scientific groups’ capacity in terms of both research scale and efficiency. In terms of intra-group efficiency, as skilled researchers are rushed into setting up their own team, flat team structures are mostly filled with inexperienced transitory members, namely post-graduate students. This has led to continuous suspension of research groups and unnecessary delay in training new members. In terms of inter-group efficiency, the proliferation of research teams has added avoidable social boundaries in resource distribution and information exchange. The importance of efficient knowledge flows to scientific advancement is widely recognized. This article is not intended to conclude what is the optimal scientometric correlation between team structure and productivity, but rather to elucidate *how* the structural arrangement of researchers within a team has affected the proficiency of Chinese stem cell research.

Common team structure

According to K-Q Wang (Wang and Wang, 2007), Deputy Director of the Bureau of General Affairs at China’s Academy of Sciences, structural reforms on Chinese research institutions have been continuously carried out ever since the 1980s. In an attempt to break the ‘bottle neck’ of Chinese research productivity, a new wave of introducing international experience and modernizing scientific organizations was the highlight of the late 1990s. As the nature of contemporary research has grown in its scale, interdisciplinary collaboration, cross-regional partnership and multi-expertise teams have all become essential for scientific

research. Consequently, China's science and technology policies have emphasized upgrading national scientific frameworks, such as reforming institutional infrastructures (CAS, 1998), improving resource allocation mechanisms (State Council, China, 2006) and supporting innovation parks (MOST, 2002; MOST and MOE, 2006).

Despite China's recent efforts in reforming national networks and facilitating scientific resource flows, the common structure of research teams is perceived to have refrained scientists from fully taking advantage of these supportive administrations. One Chinese senior scientist, currently based at King's College London, described the circumstance of Chinese researchers as follows:

Senior scientist 01: I have a very good friend who used to work at NIH, returned to China a few years ago. How long has he been back? Umm, a couple of years already, I am worried that he cannot maintain the level of research as he used to at NIH. He can't, although he was generously given lots of funds. The government invested 100 million RMB to establish a lab in Peking University, you may have heard of him. Lots of money, but he is not able to keep up with his research.

Interviewer: Is it because of lack of research personnel or of management issues?

Senior scientist 01: Personnel! Just think about it, he returned with no other people in his lab, and his new employees are all PhD students. Research project cannot be accomplished in this way. The biggest problem China facing now is that the only inferior to a professor is PhD student, there is no way to build a 'team'.

Interviewer: Why is it hard to build a team in China?

Senior scientist 01: Too many professors. It's not like in the West, where a professor for example, me, I have three lectures, then senior post-docs, then several post-docs, then some PhD students. It's a team where everybody has different roles, make different contributions ... In China, everybody is a professor; everybody works on their own project; there is no connection between groups. Everybody is their own team-leader. Thus it's hard to make progress.

Senior scientist 01 pointed out that in order to make research progress, abundant financial backing, administrative support and academic excellence of the team leader are of course important. Yet he emphasized that how researchers are organized within a group may be more vital than all of these. In fact, despite the fact that his overseas-return friend got 'lots of funds' along with governmental support this friend simply was 'not able to keep up with' his previous research level. The foremost reason, in the eyes of senior scientist 01, was that 'there is no way to build a "team"'. This respondent made a comparison between his multilayer team in London 'where everybody has different roles, make different contributions' and the rather flat structure common among Chinese research groups where 'the only inferior to a professor is PhD student'. In senior scientist 01's view, this could hardly be called a 'team', but rather a large number of small research islands where 'there is no connection between groups. Everybody is their own team-leader'.

It must be noted that most Chinese institutions have adopted a similar position ranking system as their international counterparts. Job titles, such as professor, associate professor, senior researcher, researcher, post-doc, lab technician do exist in Chinese institutions. Yet as the time length for a PhD to acquire associate professorship can be as short as 2 years (Zhang, 2004), skilled researchers are often hurried into setting up their own group rather than working under senior people. Thus, the layers between the top part of the team structure, the leader (professor) and the broad bottom layer, the students, are often very thin. The role of middle-layer positions such as associate professors and research fellows are often absent from Chinese team structures. Among the 22 research teams in key Chinese

institutions included in this research, six have the bare structure of ‘one-professor- and-many-students’: one in Sun Yat-sen University, one in Nankai University, one in Chinese Academy of Sciences, one from Beijing Chinese Traditional Medicine Hospital and two from Peking University Health Science Centre. Even when middle-layer positions do appear in team structures, they play more of a nominal role than serving an essential contribution to research. One professor in Nankai University is an overseas-return who previously had working experience in the United States. He said although his team ‘looks’ like a multi-layer group, in reality, it still resembles a ‘one-professor-many-students’ model:

I have two associate professors in my team and one technician with undergraduate training ... this is my group ... I did a count the other day, in this academic year we have about 30 students [in my lab], undergraduates, masters, PhDs ... My two assistants [the two associate professors] don’t participate in laboratory works ... Well, they are my assistants. I could give them assignments, ask them to contribute to the research, but they are relatively independent. I cannot say ... [really count on them]. In comparison [with principal investigators in Western teams], I have less commanding authority over them. (Senior scientist 06)

With 30 students to be supervised within laboratory settings, the two associate professors and senior scientist 06 are barely adequate for the full-functioning of the team in terms of student-tutor ratio. Yet the situation is worse in practice, as senior scientist 06 assumes little executive authority over the two middle-layer researchers, he felt he could not rely on their contribution to the team’s progress. Although theoretically, senior scientist 06 is in charge of a research group with 34 people, 30 of them are students that still need to be trained. In essence, this senior scientist is mostly carrying on his research project by himself. Senior scientist 05, president of one of Beijing’s IVF hospitals also saw the missing middle-layer in research teams and the overpopulation of team leaders as a drawback for research progress.

Too many tigers, and everybody wants to be the king among the group. I’d say, the problem with our academia is a system problem (*tizhi wenti*) ... You care too much about competing for the title, it actually hampers your progress. However talented you are, you don’t communicate with others, you are closed to your own circle, it really affects your research y. the convention (*fengqi*) is really bad. (Senior scientist 05)

In short, in the eyes of scientists interviewed, the ‘particular contextual framework’ many Chinese researchers work in has the feature of thin middle-layer researchers, which generates potential adverse factors for research efficiency, such as lacking group authority, isolation of researchers and overpopulation of ‘tigers’. Despite China’s continuous efforts in reforming administrative measures in the past two decades, a common theme among interviewees’ narratives seems to indicate that the organization of researchers at the grass-root level is still far from favourable. According to scientists interviewed, the difference between common team structures in China and those of the ‘West’ can be shown in Figures 1 and 2, respectively.

Two points need to be noted here. Firstly, the contrast between ‘China’ and the ‘West’ repeatedly employed by Chinese scientists seems to underline the particularity of the ‘one-professor-many-students’ team structures. This is not to assume that *all* group structures in China are as Figure 1 or *all* other countries as Figure 2.² Certainly not only are there different team structures among the ‘West’, but there are also variations within any given country. What is highlighted by scientists interviewed, however, is the ‘convention’ (*fengqi*,

²I recognize that team structures in the United States may differ from those described in the European-based studies cited here. Although I have been told anecdotally that US teams are flat – not unlike the Chinese – I have yet to find studies to confirm this.

senior scientist 05) of how scientists are organized in China. My findings are in line with many previous studies. The practice of life science in China has been described as ‘an uncoordinated “bunch of loose ends”’ (Cyranoski, 2001, p. 12) ‘with limited synergies between them’ (OECD, 2007b, p. 22). In comparison, existing data suggest that average European research groups consists of 4–6 *core* members, that is non-student researchers (Franklin, 1988; Johnston, 1994). A more recent study in France found that on average in well-functioning research-intensive groups, half of the members are full-time researchers (Carayol and Matt, 2004). An earlier study offered more specific indication that higher productivity can be found in research groups that have around six fully qualified scientists with another dozen support staff, such as post-doctoral fellows and graduate students (Ziman, 1989, p. 24). These results stand in stark contrast to the situation in China described above, that of ‘one-professor-many-students’.

Secondly, as pointed out by Martin-Sempere and his colleagues, who have done extensive research on relations between team integration and scientific performance, teamwork within scientific settings is not just ‘two or more scientists working together to solve a problem’, but ‘a complex process involving interactions and interpersonal relations within a particular contextual framework’ (Martin-Sempere *et al*, 2008, p. 480). As we have seen, the data cited above also stressed the importance of how an integral combination of expertise can enable a research group as a whole to excel beyond the sum of its individual capacity. Yet, with the growing scale of research, it is a common practice for large teams to divide projects into temporary sub-groups, each headed by a senior researcher. Each member in smaller sub-groups is then assigned to a specific part of the research and it is the principal investigator who oversees the coordination among sub-groups. Therefore, in terms of research productivity, what is the difference between sub-groups working within a team and different teams working together? In other words, how significant is the existence of a middle-layer researcher? What is the empirical evidence on the consequential effects of the absence of such a structure? These questions are addressed in the following section.

The consequence of the missing middle-layer

The downside of being forever young

As demonstrated in the last section, a widely perceived consequence of the inadequacy of experienced research personnel within a group is that students become the main force in the physical proceeding of laboratory experiments. One immediate consequence of this is that the prime concern and ‘practical’ way of setting research agendas is shifted from the nature of research to the ‘capacity building’ question of how to ensure that temporary team members (that is, students) graduate on time. An example is the 30-to-1 student/staff ratio mentioned by senior scientist 06 in the previous section – a situation that is further described as impeding graduate student progress:

I have so many students as helpers, but at the end of 2 to 3 years, I have to let them complete *something* to graduate, right? Especially for those master degree students, or else, they would question me by saying: how come we meet the graduation criteria set by the school [course attending and laboratory research], but still cannot graduate because of you? (Senior scientist 06, original emphasis)

By establishing an independent research group, senior scientist 06 was able to handle big research projects. Yet however efficient a research route this respondent might have had in mind, the actual planning of a research schedule was forced to comply with the calendar of post-graduate training. Thus, instead of allocating laboratory tasks according to the scientific demands of the project, he must break up his research programmes into a number of 2 to 3 year segments, so that his only ‘*helpers*’, namely the students, will have ‘*something to graduate*’ at the end of their school year. In most groups the author visited, large research

projects are frequently fragmentized in exactly this way into a number of consecutive master or PhD projects, an older class of graduates handing down the line of inquiry to the new comers.

I started doing stem cell research in my master years. There were several of us. One graduated in 2004, she did the in vitro differentiation. I started in 2002. I took over from 2002, from a *shixiong* [senior student] who was doing the mobilization of stem cells. But he only had enough time to discover the phenomenon, but he doesn't know [how it happened]. By the year he finished his master degree, he didn't want to carry on this topic ... I just started [my master], so I took over from him. (Junior scientist 07)

It is interesting to note that the phrase employed by junior scientist 07 in recollecting how she started in the lab was not 'taking up' a topic, but 'taking over'. Many respondents confirmed junior scientist 07's experience. During the few years of their study, Chinese science students go through a transient period both at the beginning and at the end of their study. The one-to-one handing over process enables the taking over of the research from a *shixiong* by a *shidi* (junior student). Although such a handing-over period for new research students may not be unique to China, its impact on research may be of special significance for those 'one-professor-many-students' teams.

First, recurring requirements for training new students generates interruption to research progress. In fact, many Chinese team leaders interviewed preferred taking on long-term students (PhDs), than short-term ones as a way to reduce the time loss caused by frequent handing-over. One professor at Zhejiang University commented 'I stopped taking master students now. They just come and go too quickly, with nothing serious can be done. I only take those who are committed to take a doctoral degree after their master studies. This expands their research here to 5 years'. Even with such a strategy, the actual contribution of long-term students cannot be equal to that of long-term staff members. The difference can be seen even in terms of a pure time span. When taking into account the 'handing over' at both ends of one's study, and also minus the time in meeting course requirements, the effective working span for doctoral students in the lab is less than 3 years, and master students less than 1 year.

Second, student researchers require an extra transition period than experienced researchers in preparing for a specific project. Yet training a novice in labs with a flat structure requires much more time and effort. One example is junior researcher 08 at the Chinese Academy of Sciences. The lab she studies in also lacks middle-layer researchers, as it consists of one professor, one laboratory technician and 10 post-graduates. Her research topic is on the culture of germline stem cell. Similar to junior scientist 07 quoted above, the research 'torch' was passed down to her from a *shixiong* (senior student). Within the limited years of his PhD study, this *shixiong* was only able to sketch out the basic research procedure, namely setting up a stem cell line. 'And now' explained junior scientist 08, 'what I need to do [in my PhD years] is to confirm that is definitely germline stem cells'. Although the aim was quite clear, and some ground work has been done by her *shixiong*, junior scientist 08 didn't have a smooth or quick start with her work. It took more than a year before junior scientist 08 got familiar with what the research was about:

At first you know nothing about this research, as a newcomer you have no ability to make your own judgment on data and how the experiment should run. For you, it's new. You have to listen to the older students' guidance. Nobody knows about the research as well as your *shixiong*: the professor doesn't do it personally, others are either new as you, or have been busying with their assigned experiments. Gradually you get to know their logic, get to know how to read their data, and you gradually

realize what should be improved, or even what was wrong with it [previous experiment] ... but the thing is the overlapping period, about half of the year, your shixiong is extremely busy. He needs to finish his own thesis and prepare for his own viva first, or busy applying for research post abroad ... Sometime the supervision doesn't really exist, because he has his own business to worry about. (Junior scientist 08)

Junior scientist 08 attributes the lengthy transition at the start of her study not to being a novice, but to the fact that her training procedure was carried out by soon-to-leave students, rather than alternative researchers in the team. Her observation resembles the finding of organizational behaviour specialist Daan van Knippenberg (2000), who in his study of group performance found that an individual's recognition of their 'social identity' (such as how to identify oneself in relation to a group) is positively related to their 'contextual performance' (such as the rendering of tutorials to new students in the group). That is to say, although the *shixiong* (senior student) accomplished his part of the research ('task performance'), since he didn't socially identify himself with the research team, he seems to have been less interested in his 'contextual performance', that is in helping others in the lab, sharing information, or taking others' interests into consideration (van Knippenberg, 2000; Reagans and McEvily, 2003). As is common among many Chinese stem cell PhD students, the *shixiong*'s prime purpose in completing the research 'task' was to 'to finish his own thesis and prepare for his own viva' so as to have a better chance in 'applying for research post abroad'. Since this *shixiong* identified his research commitment as spatially and temporally 'outside' his experience in CAS, junior scientist 08's progress in familiarizing herself with research procedures was compromised between *shixiong*'s tight schedule and her own learning curve as a novice.

Despite her own unproductive experience in the first year of her study in the lab, further dialogue with junior scientist 08 indicated that she considered such inefficiency generated from frequent and extended intervals of new student training as *inevitable* in the Chinese context:

Interviewer: But does that mean that your professor would spend 3–5 years to finally train somebody like your shixiong, who is good and experienced with the topic, but then, she graduated. Then it switched to be you who are doing the topic. It took you a year to get to know the topic, then when you are experienced, you are about to go as well?

Junior scientist 08: Yes. I think that's a very common practice among labs ... we have one person in the lab who keeps a writing record of the research progress, to record the core technique that is It is reasonable [for individuals to leave], but it is not good for the lab's overall development ... ah, maybe it's just part of the process you have to go through, right?

The above respondent indicated that it is not so much that Chinese researchers *didn't realize* overreliance on inexperienced temporary student researchers was 'not good for the lab's overall development', but that this 'common practice' is 'just part of the process' constrained by the particularity of Chinese team structure. As most new students were expected to 'take over' unfinished tasks from soon-to-graduate students, young researchers interviewed for this research perceived the prime purpose for taking part in a team project is to acquire professional training rather than for the particular scientific inquiry itself. As soon as they receive 'something to graduate' with, they need newcomers to take over and their top priority is writing a thesis and finding jobs. With the convention being setting up one's own team, many of the senior scientists interviewed admitted they themselves were once the 'hurry-to-leave' skilled researchers. One professor in Zhejiang University (senior scientist 16) told me he was offered an associate professorship one year after he acquired his PhD

and another associate professor (senior scientist 21) in Sun Yat-sen University was also immediately promoted after her 3-year post-doc.

With the continuous flow of student researchers, Chinese research teams are ‘forever young’: there is a continuous cycle of new teams being set up, novices being trained, and key members splitting away to set up their own teams barely after the old team is about to mature, then the old team too becomes ‘new’ again by taking on beginners. However, for a research team, the downside of being forever young is constant research disruption, prolonged transition periods and potentially low proficiency.

Social boundaries and communicative efficiency

All scientists interviewed in this research acknowledged the importance of regular inter-group communication. The emphasis on mutual exchange of ideas, research collaborations and open academic atmosphere in general resonated in many interviews:

We do pay attention to exchange ideas with other scientists in this field. We are not like, errr ... say close ourselves into a small circle. We don't think it is a good idea. You can't just [do research] on your own all the time. (Senior scientist 07)

Professor Pei [the principal investigator] always emphasis one notion, that is whenever we collaborate with others, everything must keep open access. Everybody can come, can have a look, or can learn. In other words, [we encourage] a very open communication. (Junior scientist 11)

Hold back what one knows, play the secrecy card, or view one's peer as rivals, these are really old story in science circle. [They are] outdated tricks. Things are changing with young researchers joining in ... As for me, I don't see there is anything that should be kept in the box. I love talking my ideas with people, even if they are just some novel immature sparks in my mind. What I am most afraid of is people in this field don't like or don't understand my idea. I like talking, selling my ideas, that's how you attract potential partners. (Senior scientist 11)

Thus, it seems the importance of the missing middle-layer researchers can be down played as long as a team is open and willing to communicate with others. It doesn't seem to matter much whether experienced researchers are assembled within multi-layer big research groups, or each representing flattened individual small groups. Yet interviews have found a gap between what researchers said they *preferred to do* and what they found they *could actually achieve*.

Although many interviewees have been quite keen on rejecting the conventional image of a closed-self-sufficient scientific circle, generally fieldwork data still suggest ‘an inclination toward competition and secrecy, rather than openness, among the research labs’ (Solo and Pressberg, 2007, p. 106). From his own experience in China's scientific field, stem cell scientist Yang Xiangzhong noted in a *Nature* commentary that ‘it is not uncommon in China for one university to have several similar labs studying the same area but with no collaborations between them; sometimes even unethical and unfair competition exists’ (Yang, 2004). One immediate example of this lack of substantial collaborative initiatives is that despite the fact that senior scientist 11 described the disinclination among Chinese researchers to interact with each other as ‘old story’, he himself also noted the fact of a current lack of communication within China's stem cell field: When making a remark on how to improve the quality of Chinese research, his response was ‘I think it is mostly a matter of attracting people (renqi). We need to form a kind of circle, a circle that we know each other. [So that] we know who is good or bad at doing what kind of researchy [One could say, we already have a circle], but everybody is so loosely connected to each other, we have little communications’. Another senior scientist in Guangzhou is also a strong advocate

towards open academic communications. To put in his own words ‘we’d love to collaborate with anyone that wants to collaborate with us’. Despite this professor’s own passion in enhancing interactive contacts between research groups, he also regrets that ‘We have tried to build up collaborations, but eventually they didn’t work out’ (Senior scientist 18).

The gap between a widely shared open-attitude between Chinese researchers and the general deficiency in inter-group communication produces a strong impression that what the interviewees’ narratives really reflect is what they *want* the situation to be like, rather than what is *actually* taking place. The recognition of benefits of communication also prevails among junior scientists. One junior scientist in Beijing supposed that most researchers are willing to build up regular cross-group conversations, except, in her view, her group wasn’t one of them.

Junior scientist 08: It depends on labs really. Some labs may encourage communication between students. Some may also have regular inter-group networking. Basically it depends on the boss. If he doesn’t endorse communication, if he doesn’t like sharing with others, then we [students] can do nothing. All you do is read the papers, and email the author if there is something you cannot comprehend. That’s all.

Interviewer: What kind of lab is yours?

Junior scientist 08: Oh, we, we happen to be the kind of group that doesn’t like to communicate with other.

As I visited many labs that are not ardent in ‘socializing’ with other Chinese groups, I started to wonder if Chinese scientists, with their acknowledgement of the importance of information exchange, are hampered from doing so by a more practical reason. It is also useful to recall senior scientist 01’s remark on Chinese team structure as ‘the only inferior to a professor is PhD students’ and senior scientist 05’s account that the supposed middle-layer position of research teams is replaced by too many professors, which resulted with ‘too many tigers’. Contrary to the amicable open forum most scientists favour, senior scientist 05’s choice of words, ‘tigers’, indicates a rather distrustful and unpleasant relationship among research groups. It seems that despite all the good wishes hosted by each and every individual researcher, there is some invisible barrier that hampers them from achieving effective communication. Senior scientist 18, who leads a key state laboratory, reflected the tricky situation when one wants to reach out and build partnerships.

Under the current research environment in China, I feel that our inner-institutional collaboration is more frequent than other kinds of collaborations. In other words, it’s easier to work with other PIs [principal investigators] within our own institution ... There might be two of the reasons that hindered communication between Chinese researchers within China. One is because everybody is busy, right? The second is precaution. This might not be too significant factor, but it is one of my own concerns. ... There may be no mutual-benefit ... Back when I was in the US, conversations among research groups were more frequent and more in-depth. I don’t think there is much difference between China and the US from a technical perspective. US also encourage [research to be done by] individual groups, but substantial collaborations are also more popular. (Senior scientist 18)

The notion of open inter-group communication among Chinese team leaders, among which many are overseas-returns, is not just a concept they read in textbooks or academic journals, but is nurtured from their personal experience gained from their international counterparts, where they feel communication has been ‘more frequent and more in-depth’. It is worth highlighting that instead of seeking partnership regionally or nationally, a narrower focus on ‘inner-institutional collaboration’ is what senior scientist 18 preferred. Senior scientist 18’s

narrative also implies his ‘precaution’ that collaborating with distant groups may run a higher risk of not being mutually beneficial. But where does this precaution come from?

This invisible yet quite hard to ignore barrier between research groups reminds us of what sociologists Lamont and Molnar (2002) identified as two types of boundaries: symbolic and social. Symbolic boundaries consist of ‘conceptual distinctions made by social actors to categorize objects, people, practices, and even time and space’. Symbolic boundaries, such as the formation of a research group or assuming a job title from a team, provide the foundations for generating and fostering a second kind of boundary: a social boundary. These boundaries are ‘manifested in unequal access to unequal distributions of resources (material or nonmaterial) and social opportunities’. As in the case of China, it is not difficult to sense the existence of such boundaries through the general unexplained hesitation in collaboration, the ‘precaution’ over distant groups. To employ an over-simplified analogy: if inner-institution groups have one boundary to cross (group A to group B), then the symbolic boundaries for external groups includes several levels (group A to institution A to region A to region B to institution B to group B). All these social boundaries accumulate for potential collaborators to overcome.

Similar views on explaining the implication of social boundaries can also be found in Fei Xiaotong’s (1948[1992]) social theory, the ‘differential mode of association’ (*chaxugeju*). FEI theorized that social relations in China can be viewed as a series of concentric circles. With the individual as the centre of the circle, the closeness of relations diminishes as the circles expand outward. This is how one develops a *jia*, literally translated as ‘family’ but indicates a wider ‘solidarity’ oriented in overlapping interests. According to Fei (1948[1992], pp. 62–69), one consequence of such social networking is that a community, such as the science community, bond in a way that interest-relatedness is central on developing trust and mutual recognition. In other words, Chinese research teams are many small concentric circles, with professors being in the centre, enclosed by post-graduates. People working for the same professors are considered *zijiaren* (my own people). Meanwhile other researchers are projected as people outside the *jia*, and consequently imply a higher risk and less advantage in social exchange. Whereas stem cell research is about pooling resources, the dispersed research groups (*jia*) engender excessive social barriers in the public scientific space.

The founding of new research teams not only brings changes to senior researchers’ job titles, it is also inevitably set by social boundaries. Observations on the Chinese innovation system (Hao and Liu, 2005) has confirmed what Hensen (1999) proposed on inter-group knowledge-sharing: distant relation among groups may not obstruct the dissemination of simple knowledge (such as written report), but ‘impede the transfer of complex knowledge’ (such as practical know-how and context-dependent knowledge). Even when scattered groups come together to apply for major grants, the actual social exchange of resources is confined by the boundaries of the group. This has ‘made the temporary major-project-based research “team” more as a research “platter”’ (Hao and Liu, 2005). That is to say, although it seems as if all expert resources are pulled together onto the same plate, they still display clear group borders and are far from a well-blended knowledge pool. Just as in the case described by a senior scientist working with liver stem cells:

Senior scientist 04: Yes, from time to time, we do have collaborations with other groups: One group is within our own hospital, another in Peking University.

Interviewer: How does such collaboration operate?

Senior scientist 04: First we make funding application together. After the bidding is successful, we split the grant, and each take home part of the research ... I think that’s what most people do, right? It makes you look stronger on funding

application, but in actual practice ... I mean, what else can you do? Everybody is more comfortable in minding his own business.

The absence of experienced professionals as the sound middle-layer of a research team may not *directly* contribute to the inefficiency of laboratory productivity, but it appears to interviewees, such as senior scientist 04, to *signify* an excessive dispersal of intellectual assets. Comprehension of the team structure in research groups not only informs us how scientists are organized, but also help to identify the social boundary 'at work' which results in the unequal distribution of resources. Furthermore, the deficiency of middle-layer researchers may not *determine* the incompetence of steady research progress, but it restricts the choice of research personnel and is interpreted by some interviewees as indicative of the inefficiency in knowledge accumulation. In all, the main goal for scientific groups is to produce and interpret research data, but such a process shapes and is rightly perceived to be shaped by the existing channels of resource allocation and efficiency level of information flow.

Conclusion

Despite China's concerted effort to establish supportive science policies by importing Western administrative experience, and more importantly, investing heavily in attracting researchers internationally, experiences from scientists interviewed suggests they believe that 'China does not yet have the infrastructure in place to fully take advantage of this increased spending' (Lane, 2008, p. 256). Current low research productivity in China is consistently interpreted by interviewees to be because of a combination of factors. This article focused on one dimension of these interpretations which emerges as a common theme, namely how the organization of the research team affects its scientific productivity. As noted earlier, some research has suggested that one characteristic of Chinese research teams is a deficiency in middle-layer positions. The shortage of experienced professionals is similarly seen by the scientists interviewed for his study to have had two major consequences. First, as inexperienced student researchers became the backbone of scientific teams, delays occurred both in laboratory training and in frequent interruptions of research during students' handing-over periods. These constant gaps interrupted and thus delayed research proceedings in a large number of groups. Second, the rising number of small teams is perceived to create excessive social boundaries between them, which impede information exchange and further worsen the segmentation of research resources. These are two factors that may account in turn for the absence of a sound middle-layer in research teams which is interpreted by a majority of interviewees as symptomatic of a blockage to intellectual exchange both within and between groups. The findings from this research also indicate that the structure of research groups is as important as macro scientific administrative infrastructure to the improvement of research management schemes. Research teams cannot only be regarded as components that are *joined by* an information highway, but must be seen as the hubs that facilitate the exchange channels which extend from one research group to another, thus connecting them. From this perspective, a more complex, fluid and multi-layer team structure would do more than merely establish a more complex hierarchical arrangement or management strategy. More importantly, it would release the possibility of 'greater social and intellectual capital' (Rey-Rocha *et al*, 2006) by introducing capacities for intellectual exchange, the integration of capacity building and research goals, and thus greater productivity and efficiency. It would also produce a different culture of professional science. If the internal structure of research teams exerts profound influences over how individuals 'understan[d] their responsibilities toward such groups' (Lamont and Molnar, 2002; Reagans and McEvily, 2003), and subsequently how resources are disseminated and how information is processed, then something like the internal civic culture of professional science, as well as its intellectual and labour economies, are also changed.

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Biography

Joy Yueyue Zhang is a Wellcome Trust-funded PhD candidate at the BIOS Centre of the London School of Economics and Political Science. Her thesis investigates Chinese regulation of stem cell research in the context of cosmopolitanization. She completed her first degree in medicine at Peking University.

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Figure 1.
Chinese team structure in the eyes of interviewees.

Figure 2.
'Western' team structure in the eyes of interviewees.