DANCING WITH THE WOLVES:

Localization of Multinational Corporations' R&D centers in Shanghai

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INTRODUCTION

Most research on multinational corporations (MNCs) holds that they function according to a global locational hierarchy: the most advanced countries are driven by more 'intellectual' activities, while developing countries are relegated toward the more routine production roles. This divide is further mirrored in a long-standing concern of development economics. They show that developing countries have great difficulty in becoming creators of technology. They can only be the follower of new technology at best (Amsden, 1989). Some disagree with this pessimistic conclusion, arguing that in some developing countries, local firms not only learn to innovate, but can become technology leaders in certain fields, given proper capability building. (Ernst, Ganiotsos and Mytelka, 1998). An often quoted example is the local firms of Asian NICs (newly industrialized countries) in the 1980s and 1990s that took the lead in global OEM[2] and ODM[3] manufacturing technology in the electronics sector (Hobday, 1995). The NICs rewrite the international division of labor. It is no longer simply "innovation in the core countries vs. production in semi-peripheral countries." The new division of labor between the developed countries and the NICs is that of "product innovation in core countries vs. production innovation in the peripheral countries."[4]

My fieldwork[5] on the new form of foreign direct investment (FDI) in China reveals yet another step in this much more complex division of labor. These MNCs do not simply use China as a cheap production site, but increasingly an innovation site. More surprisingly, the spectrum of their innovation activities is much beyond low-end routine software decoding. These world class MNCs involve their China labs not only in "process innovation," but also in advanced "product innovation" and even "applied and basic research," all of which used to exist only in more advanced OECD countries. China, once principally a mass producer, is seemingly emerging as a 'center of excellence' in global innovation activities. Microsoft, for example, located its first academic-style Research Institute in Beijing in 1998 before setting up another one in Silicon Valley in 2001. This type of MNC activity in China represents not only an important turning point in China's development, but a phenomenon potentially important to other big developing

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[2] OEM stands for Original Equipment Manufacturing. OEM firms from NICs shape their technological capability to make products according to the specificities of the brand name manufacturer from the advanced country.

[3] ODM stands for Original Design Manufacturing. Firms with ODM capacities are more technologically capable than OEM firms because they do not need to follow any specificities. They can do the whole product according the functions and styles required by the brand name manufacturer from the advanced country.

[4] However, it is difficult to imitate the NICs success in integrating into the global production network, even though most hopeful developing countries are learning from the NICs' experiences.

[5] I have interviewed around 80 informants during my 11 months fieldwork in Beijing and Shanghai in Spring 2001 and Summer and Spring 2002. These informants include: engineers and managers from MNCs and local IT firms; technocrats who are in charge of innovation-related public and semi-public agencies; scholars and students in engineering; university officials in charge of incubators, university-run firms and technology parks.

countries, with major implications for globalization as a whole.

There are roughly 30 notable MNCs' R&D centers in Shanghai, half the number of their Beijing counterparts.[6] This paper will focus on the dynamics of MNC R&D centers in the IT[7] sector in Shanghai, with understanding that there are R&D investment in other sectors such as pharmaceuticals, automobile and machinery. The MNC R&D centers in question are not confined to the "technology transfer unit" that is physically attached to the MNC branch factories. These MNC R&D centers are often independent units, geographically detached and often is not related to the operation of the MNC branch factories, except for the production-driven R&D center.[8] These wholly owned R&D centers are often located inside or near to the Central Business District (CBD) and major universities. The main reason for locating in the large metropolitan region is to tab into the skilled human resource embedded in these selected cites, such as Shanghai, Beijing and Nanjing. These skilled labors mainly consist of graduates who prefer to stay in the city where they graduate rather than to a remote factory for various reasons. The skilled labors that make a career decision on 'research' often benefit the dense faculty and alumni networks that formed around the campus. For example, an alumni start up in the university-run incubator will benefit from recruiting cheap juniors in his/her department to help in their startup for an exploitative price. If the startups locate too far away from the campus, the juniors will be less willing to commute between the startup and campus on a daily basis.

Moreover, a promise of residency in Shanghai, Beijing or other developed cities is always more attractive than a higher pay job in the special economic zones outside these cities. Working in MNC R&D centers will guarantee a Shanghai residency (city-based green card). This term of employment is crucial in China because of the strict residential control to prevent migration from the rural to the coastal cities. Despite the symbolic status of gaining a new residency, there are many real benefits for urban migration, such as better schools, quota protection for access to higher education, better medical service, government services and urban services in general. As financial decentralization unfolds in China, local governments are taking up most of the burden of social welfare. The richer the cities, the better it can provide to its citizen or corporations. This has created greater regional inequality that privileges the coastal region against the rest of China. Increasingly, a few privileged cities that enjoy a head start because of preferential policies such as Shanghai, has gradually transformed into a "proxy first world city." By "Proxy", I mean "more international" than the rest of the Chinese cities in the eyes of foreign expatriates and overseas Chinese returnees. In the quest to become a best "proxy first world city," Shanghai has

[6] Beijing case is written in other chapter of my ongoing dissertation.
[7] IT stands for information technology sector that include telecommunication equipment, computer, consumer electronics, Internet & web-based technology and software.
[8] I will elaborate different type of R&D centers in the next section.

successfully attracted the return of Chinese experts and senior engineers with 10-30 years of working experience in world class MNC research labs. Many of these few but critical Chinese returnees have become the directors of MNC R&D centers in China because of their ability to communicate between Western R&D project management and local bred Chinese engineering culture.[9] These people are what Saxenian called "brain circulation" as they do not merely 'return' to China, but would constantly fly back and forth between China and the West, especially the Silicon Valley.[10]

Despite the insignificance of these MNC R&D centers in China in terms of numbers and investment volume compared to overall FDI numbers, I argue that it is nevertheless a significant indicator that reflects a certain *quality* of the innovation system or knowledge assets embedded in particular cities. It is rather unusual for latecomer cities[11] in developing countries to attract higher level R&D investment and I want to explain why and how so. This paper analyzes the locational logic and operational dynamics of MNC R&D centers as a way (or a proxy) to analyze the innovation system of a city. In other words, this paper analyzes a city's innovation system through the eyes of the MNC R&D centers located there. The case study I focus on here is Shanghai.

I have one major reason to justify this proxy approach. The innovation system of post-NIC latecomer countries[12] still depends heavily on international technology transfer through licensing, turnkey project, trade, joint venture and FDI in general. The standard desired endogenous approach (bottom-up approach) generated from the experience of the advanced economies and NICs however, often neglect the 'exogenous' technology dependent structure of these latecomers. On the other hand, I do not subscribe to the other extreme of the 'leap-frog' theory, which suggests that latecomers can jump start (or catch-up) through modernizing physical infrastructure and utilizing latest equipments. Instead, I prefer a certain form of innovation system approach that do not (and cannot) break away entirely with its historical path of technology dependency.

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[9] Most of these Chinese returnees graduate from the top university in China. Some of them are overseas Chinese from Taiwan, Hong Kong and Southeast Asia.

[10] They constant return to the West for family visit as most of them have family in the West. More crucially, they are assigned the leadership of the R&D center is to have them constantly coming back to the MNCs headquarter for report and briefing of the daily operation of the center.

[11] Latecomer is a boarder term referring to countries with middle range GDP per capita (sounds like 'semi-peripheral' countries, but in a more dynamic & less structural sense). It includes the countries that fall out of the Triad (or OECD) like Ireland, Portugal, Spain, but also developing countries with rapid development as a whole , like Taiwan and Singapore, or partially, like India, China, Brazil. In this sense, they are not developing countries, or third world countries.

[12] I use the term Post-NICs is because it is difficult for other development country (or city-regions) to imitate the NICs strategy that find a place in the global production networks. Latecomer cities/countries now facing both the master innovators of the advanced economies and the master manufacturer of the NICs. It is unlikely that China nor other latecomer city can following follow the path of NICs after 30 years of late start.

Besides, the experience of Asian NICs is never endogenous to begin with.[13] Based on this assumption, it is logical to follow the existing technology dependent structure in analyzing this new form of R&D-based FDI to understand: 1) why and how MNCs invest in latecomer cities in the first place 2) how this MNC R&D investment affects the existing innovation system in such latecomer locales. Comparing the different types and operational logics of MNCs in particular latecomer cities will be a good assessment of how well or badly the innovation system is working in particular cities and how we can fix their problems.

I acknowledge that this proxy or alternative way of studying innovation system has many inherited limitations as well. Most innovation studies focus on the inter-linkage of various local agencies in breeding innovative local firms or network of firms. The network of local firms is always the subject of the analysis. The assumption is that the more innovative or better learning ability of these networked firms, the more competitive the given regions. If the regions are somehow transformed into vibrant learning economies (or knowledge economies), it will most likely attract technology-sourcing MNCs. Therefore, the significant clustering of MNC R&D centers in a region is the *result* of the unfolding of the innovation system. My approach can be seen as a reverse process of this approach. By studying the – arrival of MNC R&D centers – I trace backwards to see how all these ingredients (or knowledge assets) were put in place for this new form of FDI phenomenon to take place at all. The limitation of this approach is obvious, as the primary subject of the investigation is not local firms, even though I will explain the relations of MNCs with the local firms, universities and other agencies. Therefore, this proxy method is just a partial understanding of the innovation system. However, this approach puts into consideration both the 'exogenous' factors of the innovation system and the "exogenous" learning process of the cities. The inter-relation of these factors is often neglected in innovation system studies.

In the end, how to 'endogenize' MNC R&D centers into the innovation system of Shanghai is still an open question. Shanghai city planners and policy makers are very aware this issue. Without endogenizing (or localizing) the MNC R&D centers, the city might end up like any other site that ends up selling abundant cheap and obedient engineers to FDI without incurring much impact on improving the local innovation system of the city.

Despite relative rich literature on the connection of Shanghai with global economies, there is so far very few works approaching the innovation system of Shanghai in either English or

[13] I agree with many development economics that focus on the "absorpting" capability of a local towards foreign technology. Without certain level of this capability, a locality will not benefit from much from the technology transfer. Unfortunately, this kind of perspective seems to lost in innovation system studies, especially from the latecomers' standpoint.

Chinese. In fact, the city and regional innovation systems in China are still in the making. The idea of knowledge economy was introduced to China in 1996 through the publication of the United Nations reports (United Nations, 1996). Since then, the study of knowledge economy has attracted the attention of Chinese academics and policy makers. The concept of the national system of innovation was later applied to China in local research (Liu and White 2001, Gu,1999, Lan, 1997). Most of the discussions focus on the national level of analysis. Empirical studies on the level of a city or regional innovation system is a useful addition to the existing literature.

This paper consists of three parts. Part I analyses the motive of MNCs to invest in Shanghai. It is a demand side analysis. Ten MNC R&D centers, making up four types of R&D investment in Shanghai, will be closely examined to understand what knowledge assets they are looking for in Shanghai. Part II analyzes how the demand of these MNCs is met in Shanghai's innovation system. In Part III, I will offer a more dynamic explanation for the technology-spillover effects of MNC R&D investment in the innovation system of Shanghai. In conclusion, I will layout the problems, contradictions and prospects of Shanghai's model of endorgenizing MNC R&D centers into its innovation system. These Shanghai case studies will help us understand better how latecomer cities integrate into global innovation networks dominated by MNCs.

Part I: MNC R&D investment in Shanghai

Since 1990, Shanghai and the lower Yangtze delta have surpassed Southern China in attracting the new round of foreign direct investment (FDI), thanks to the increase of China's share in global FDI. Against the backdrop of global FDI downturn (minus 51%) and the decline in FDI in developing countries (minus 14%), China attracted US$47 billion overseas investment in 2001. In the first half of 2002 alone, China's FDI surpass the U.S. to become the largest FDI recipient country in the world.

There are three possible reasons for the growth of FDI in the Shanghai and its Yangtze River Delta (I will call this area in sum as the Shanghai city-region from now on). Firstly, it is due to the intense competition among various cities in the region. Many municipal and county governments in the region are actually bankrupt after heavily subsidizing the MNCs that locate in their industrial estates. Even within the Shanghai city, almost every county government has its own industrial park despite objections from the Shanghai city government. Local tournaments benefit and attract MNCs, allowing them to play one government against another for favorable investment deals.

Secondly, despite the cut throat competition, the Shanghai government still manage the best out of most FDI (in terms of the size and technology-level of the MNCs) mainly because of 1) the

opening up of the Pudong Development Area in eastern Shanghai, 2) pro-active government agencies, 3) exclusive privileged policies given to Shanghai by Beijing, and 4) proper implementation of many new Chinese laws. These improvements in law include a) the promulgation of an amended law on Sino-foreign joint ventures in April 1990, b) the legalization of the transfer and re-transfer of usage rights for state-owned land in Chinese cities, and c) the lifting of previously restricted large-scale land development schemes by foreign investors.[14] Moreover, Shanghai has exceeded other local governments in the region in utilizing overseas Chinese capital to fund the urban renewal in the old city. Major infrastructure construction (bridges, highway, industrial parks) and rapid land development in Pudong followed suit.

Thirdly, since early 1990s, Shanghai benefited from another policy change. A couple of major cities including Shanghai were granted rights to open up tertiary/service industries to foreign investors. These service sectors include finance, insurance, land rent, retail, wholesale sectors, and telecommunications. These are industries that were virtually monopolized by the state-owned enterprises. After joining the WTO, service oriented FDI will increase tremendously. This changes the city's focus towards becoming both an industrial center and a business center. In recent years, FDI in tertiary industries has increased rapidly and surpassed that of secondary industries. Many of these services are producer services, such as insurance. Shanghai provides extra service to MNCs not readily available in most cities in the region.

In the past decade, MNCs are encouraged to start up in areas such as high-technology industries and energy-related investments. To nurture these industries, the Shanghai government has chosen a batch of large and medium-sized state-owned enterprises for cooperation with MNCs. Shanghai, especially the Pudong District, has grown fast. Pudong alone has attracted US$39.2 billion in FDI over the past 12 years, about one-third of Shanghai's total FDI. In 2002, the total FDI in Shanghai reached US$8 billion. FDI in the service sector grew 75.5 per cent year-on-year. In addition, the Shanghai government also set new incentives for MNCs to shift their regional headquarters to Shanghai. Recent headquarter moves include the US-based GE Industrial and GE Plastic, and Advanced Micro Devices, Inc.

In short, the resurging of FDI in the Shanghai city-region is both the result of MNC’s search for new growth areas after Guandong, and the aggressive Shanghai governmental interventions that have transformed the landscape of Shanghai today. As a result, Shanghai’s GDP grows faster than the national average in the 1990s, a reversal of the trend in past 2 decades.

[14] There are also other crucial regulations established, such as protection of intellectual property rights, the Copyright Law, the Computer Software Protection Articles, and the amended Patent and Trade Mark Law.

Four Different types of MNC R&D investment in Shanghai – a demand side explanation

This section will explain why MNCs set up their advanced R&D centers in Shanghai. Since the mid 1990s, more than 30 world-class MNCs have located their wholly owned R&D centers (or Laboratories) in Shanghai. This new phenomenon challenges the theories of Globalization of Innovation (R&D), most of which argue that MNCs only invest their R&D among the more advanced OECD countries in order to seek complementary technologies.[15] These theories assume that developing countries have difficulty competing for global R&D investment because of poor human capital, poor IT infrastructure and lack of intellectual property protection regulations. They assume that developing countries can compete for FDI only in higher valued added *production* (subcontract manufacturing or OEM/ODM for MNCs). This assumption has been challenged recently. Actually, some 5-10% of global R&D goes to developing countries, albeit with great unevenness. The primary purpose of such FDI is to exploit the over-supply of engineers in countries such as India, and the main R&D task in such FDI is often confined to low-end R&D activities (software decoding). (Reddy, 1997).

However, Reddy's latest work (2000) that compares the incentives of R&D investment in India and Singapore, and also Amsden and Tschang (2003)'s work on Singapore, both suggest that the motive is no longer merely to target cheap engineers. There is a wider range of locational advantages embedded in these localities such as a higher level of technology research and development, which all attract FDI. This paper extends the latter argument by demonstrating why and how MNC R&D FDI co-exist in Shanghai for various motives that go beyond the exploitation of the region's oversupply of cheap engineers. In fact, this paper argues that MNCs choose to locate their R&D centers in Shanghai because of its embedded knowledge assets, competitive market, IT industrial cluster and aggressive government policies. These factors are further elaborated in the Part II.

There are many ways to classify types of MNC R&D FDI, the variables include: Technology level (Research, Development and Support); Organization (Dispersed, Concentrated or Integrated); Geographical (Global or Local) and Motivation or Driver (Technology, Market, Production, Cost) and others. For the purpose of this paper, I will discuss only three dimensions – Motivation, Geographical Orientation and Technology level. This is because such factors are

[15] See Edler, J., Meyer-Krahmer, F. and Reger, G. (2002) "Changing in the strategic management of technology: results of a global benchmarking study, *R&D management* **32** 2. Cantwell, J. and Janne, O. (1999) "Technological Globalization and Innovative Centres: he Role of Corporate Technological Leadership and Locational Hierarchy." *Research Policy* 119-44. Also see works of Roman Boutellier, Oliver Gassmann, John H. Dunning, Keith Pavitt, Pari Patel and Michael Storper.

easier to approach and also more relevant to the nature of the Shanghai innovation system.

Motivation / Geography	Technology-driven	Market- Driven	Production-driven	Cost-Driven
Global	-Using local talent to research on generic technology that is used in a global product. E.g. Basic Research in any field	-New product development that targets the global market. E.g. Consumer electronics	-New process development that can be applied in factories at multiple locations. e.g. chip design tools	-subcontract labor intensive parts of a global R&D project. or move an R&D subdivision to save cost. -technical support for global clients e.g. Software development; or global technology support
Local	-Using local talent to research on local/regional products. e.g. speech/language technology	-New product development for the local market. e.g. customized business software	-Process technology that is specific to local needs e.g. fiber optics customized for local requirement	-Localize Technical support for local clients e.g. Any form of Technology support for local clients

The Motivation (or Driver) of MNCs to set up a branch R&D center outside their home country is complex. I will only focus on their primary drive, i.e. Technology-Driven, Market Driven, Production-Driven or Cost-Driven R&D. The Geographical area where such centers collaborate with other agents are divided into global and local. Local refers to the major R&D activities in collaboration with and for local entities. Global on the other hand, refers to the R&D activities in collaboration with other entities outside the country, including clients or research labs in the MNC's home country or other countries. The Technological level refers to the standard classification of the Research (basic research, applied research), the Development (product technology and process technology) and the Technical support.

Table 1: The classification of different types of MNC R&D centers in a latecomer city

Technology driven R&D – this is narrowly define as basic and applied research – the "R" of the R&D. It often involves the discovery of new scientific knowledge, which has the potential to act as a platform for subsequent development of commercially viable products and manufacturing processes. The length of the result to market is often more than 10 years. The global aspect of the technology-driven R&D center involves basic research on generic technology, like algorithm. The result of the research is usually not confined to particular geographical regions. The local talents and the local technology community are most crucial inputs in this type of center. More

than 80% of the employees in the majority of Technology driven R&D centers have master and Ph.D. degrees. The local oriented technology-driven center often engage in exploring specific basic/applied research that primarily serves local clients. The best example is speech technology. However, even though this type of speech/linguistic technology research is very place specific, the results can often be applied to other linguistic regions as well.

Market Driven R&D – this refers to new product development or product innovation.[16] New product development is to create new, commercially viable products. It involves close collaboration among research, marketing and manufacturing. Most product innovations are becoming more and more 'buyer-driven.' Suppler-driven product innovation still exists, but is limited to fewer sectors such as CPU technology. IT product innovation in particular is becoming more and more buyer-driven.[17] I argue that new product developments are more sensitive than ever to market signals. It is becoming very common to involve sales team members in the early stages of product development. The tendency is for the market-driven new product innovation/development to get close to the sales team and the clients in specific markets.

The global dimension of market-driven R&D refers to the product developments that focus on global products sold both globally and locally. The local dimension often refers to specific products that are invented to meet local requirements. For example, the usage of palm pilot is never took off in China, therefore the design of handheld is not done in China. What is most popular in China instead is second generation handheld with cellphone functions, the so called smart phone. Therefore, the design of smart phones (a typical product development) are very likely to be done in China. For example, the Motorola Personal Communication Center's R&D arm is based in Beijing. However, such local market-driven R&D is usually not confined only to the local market. After its initial success in China, the modified and more mature products are sold to the global market as well. In short, most product developments begin with the local needs and soon end up serving the global market.

Production driven R&D – refers mostly to "process development" or "process innovation" of new commercially viable manufacturing processes. The purpose is to speed up the production to market time, make the production more efficiency and lower the cost of production. For complex manufacturing that involves customization and tweaking, such as fiber optics testing, process development also has a tendency to get close to the manufacturing site. In the past, after the prototype was produced in the lab of the mother company in the MNC's home country, the process technology needed to mass produce the prototype was also developed in the factory of the home country. Then technology transfer teams from overseas factories were sent to the

[16] Development often classify into product development and process development.
[17]

mother factory for training until they know how to reproduce the technology in the overseas manufacturing branches. New equipment, production procedures are all transferred directly from the mother labs and factory to branch factories with little local adaptation.

With production processes undergoing rapid changes and engineering skills of branch factories rising every day, more and more development of process technology are done in branch factories instead. As the result, the branch factories slowly transform into a OEM factories *within* the MNC.[18] During the earlier stage of the localization of process technology development, the headquarters usually comes up with a prototype, and pass it over to the branch factory for process technology development and mass production. During the final stage of the localization of process technology development, the headquarters only designs the specificities of the product. All prototype development and process technology development are done at the branch factory. Afterwards, their results will be approved by the HQ and then mass produced at the branch factory. In order for the branch factor to produce the prototype and the engineering capacity to mass produce it, a process and production R&D team need to be set up at the branch factory. A production-driven R&D center is thus created in the overseas factory site in a developing country.

In the China case, the production-driven R&D center often needs a mixture of master/Ph.D employees with mostly bachelor degree engineers. It is often headed by expatriates or Chinese returnees who have working experience in the West, especially the Silicon Valley. Sometimes, Taiwanese R&D project managers, who are experienced in OEM manufacturing in Taiwanese firms are hired to lead the teams as well. Engineering skills are by far the weakest in Chinese firms because of the late start as compared to the NICs.

Cost driven R&D – this kind of center is set up to replace the high-cost R&D center in the home country or other more developed countries. It is a stand alone center with no connections to other facilities. (However, call centers are not considered as R&D centers). The lowest technology required for this kind of center is technology support provided by engineers with at least bachelor degrees. The MNCs' cost driven R&D centers in China mainly focus on software development, mirroring after their Bangalore counterpart. Technology support for global and local clients contributes to the major part of the center. The scale of this type of centers in China is still way behind those in India. However, many local governments and software industrial associations are aiming to complete with Bangalore as the global software development center.

[18] For new product, it is often the best interest for MNCs to keep the ownership advantage by producing it in their own branch factory. Only after the product and production technology become mature and standardize, MNCs might subcontract to the OEM firms to reduce cost.

MNC R&D center in Shanghai a case studies

Table 2: Selected MNCs R&D centers in Shanghai (Year of establishment, Number of engineers)

Motivation / Geography	Technology-driven	Market-Driven	Production-driven	Cost-Driven
Global	-Generic Electric Global R&D Center (2000, 500 researchers)*			-Ericsson R&D center (1998, ??) -Microsoft Global Technical Support Center
Local/Regional	-Motorola Research Center (2000, 50)	-SAP Shanghai Development Center (2000, 70 employees) -HP software solution center (2002, 200)** -HP-Intel Linux solution Center (2003, 50)	-Lucent Technology Optical Network (1999, 150?) -Motorola IC Design Center in Suzhou ***(1999, 150)	-Intel Software Center (1993, 200)

Note: *General Electric (GE) has 20% of resource dedicate to long term basic and applied research (10 years); 70% on medium term (4-5 years) on existing products; and 10% on technical support. However,
**HP Software solution center has 50% export market, and 50% on the local market. So, it should consider as both global and local.
***Motorola IC Design Center in Suzhou belongs to both market and production driven R&D center.

Technology-Driven: Unusual Strategic Decision

Based on the 10 MNC R&D centers located in Shanghai since 1998, we can see that the technology-driven categories of R&D are not common in Shanghai, except for strategic reasons. GE's decision on Shanghai is based on input from other production and sales facilities in China, after many rounds of debates. They acknowledge that Beijing has richer skilled labor resource but argue that Shanghai has a better investment environment. So, it is a very close call. Motorola China Research Center's (MCRC) decision to locate in China is a strategic one. Motorola has all its major investment (both R&D centers and factories) in Beijing and Tianjin. Therefore, they need to strategically set up one major research center (and also 2 Joint Venture factories) in Shanghai to show commitment to the Shanghai government and thus facilitate their market expansion to the south.[19]

[19] Motorola has 16 independent R&D centers in China. Most of them are concentrated in Beijing and Tianjin. Motorola Research Institute, the headquarters that govern the 16 R&D centers in China is located in Beijing.

GE

GE Global Research Center is established in June 2000. It started with 20 researchers, increased to 40 in 2001, 80 in 2002, and 500 in 2003. It plans to have 1200 researchers by 2005. It is probably one of the fastest growing research centers in China. It is currently set in the best known but saturated Caihenjing high-tech park in Western Shanghai. Sometime in 2004, it will move to a brand new research facility in Zhangjiang high-tech park in Pudong, a highly promoted high-tech park in Shanghai. The new facility will have 18000 m^2 of a total 27 research laboratories. The other two GE Global Research Centers are in New York (1900) and Bangalore, India (1996). Both centers have more than 1600 researchers each.

Like the standard role that all GE global research centers play, the Shanghai center divides their research resources into 3 categories. 10% is "ready to serve" and technology support, 70% is multi-generation product and 20% is basic and applied research.[20] As only 10% of their work 'immediately serves' the existing business, most of the research is designated R&D with 4-6 years or even over 10 years date to commercialization. Therefore, it can be classified as a technology-driven R&D center.

Apart from the R&D, the center also acts as a training center for employees, clients and strategic suppliers. In addition, it is also the home of China sourcing teams for numerous GE industrial businesses ranging from Aircraft Engines, to Power Systems and Consumer Products. This sourcing function is only taking place in China, not India. It is also a significant function. What is most surprising is that in 2001, GE's procurement from China is 6 billion, the same amount it gained through the exports of its China factories.

What is special about GE's location decision in Shanghai, as compared to other MNCs especially Motorola is that GE put everything together in one place. The idea is to take advantage of "co-location – sharing of resource and ideas," explained one GE manager. In contrast to GE, Motorola has 16 R&D centers spreading across many Chinese cities. In addition, Motorola also has an important training facility called Motorola University located in its manufacturing complex in Tianjin. Motorola's decision about the dispersed location of R&D centers was mainly guided by the strategic knowledge assets, production needs and market expansion potential of different locations. In fact, the need for market expansion is the primary principle in the location decision of its R&D centers since 1999. Most large MNC R&D centers fall between GE's co-location model and Motorola's strategic model.

[20] According to a R&D manager at GE, "ready to serve" refers to serving the needs of local production facilities and clients. "Multi-generation product development" refers to higher level product/process development that usually takes 4-5 years to commercialize. "Basic and applied research" usually target technology that needs more than 10 years to commercialize.

Most of the GE R&D projects in China are global projects that collaborate with the centers in India and the U.S. Any research team that has the expertise on certain technology domain will organize a global team that consists of team members from 2 other locations. The leading team has "ownership" over the technology and the place of the leading team is called the "center of excellence" for that particular technology. In that sense, any research team can lead a global research team as long as they have the ownership. The research areas carried out at the GE Shanghai center include: Power electronics and controls; Advanced manufacturing, such as digital manufacturing in prototyping and system integration; Imaging technologies such as permanent magnets and Direct-X-ray conversion; Materials such as crystals for medical imaging and transparent ceramics for lighting; Chemical technologies such as conducting polymers and organic coating.

Shanghai GE Global Research Team has a council consisting of 20 senior scientists from the Chinese Academy of Science (CAS). During the process of a collaborative project, they have 2 official meetings and numerous informal meetings to give advice on the research project. The center also carries out joint research projects with universities in the Shanghai city-region. However, the main purpose of locating in Shanghai is really not exclusively about collaborating with the CAS (Shanghai branch) and universities, but to tap into the talent pool in Shanghai or China in general.[21] Chinese engineers are not well trained in engineering skills due to the weakness of Chinese firms' manufacturing capabilities, but Chinese engineers excel in mathematics and pure sciences. Therefore, they often take part in the 'basic' research part of the project. The manager of GE Global Research gives me an example of the division of labor of a global project.

> "This global project is to lower the noise level and improve the efficiency of Heating Air Ventilation of air conditioning systems. It is led by the US team. The US team's main work is mechanical design. The control algorithm and DSP coding are carried out by the Shanghai team, and the Indian team do some of the sub-testing of the project."

As this technology-driven center has more collaboration with other centers than with the local agents, they rely heavily on web-based platforms. They contact each other through daily email and weekly conference calls. All the project management tools are web-based, so the supervisor can just go on line to check the progress of the project.

[21] Because of the special status of Shanghai, most skilled labor from other provinces or from overseas will not resist coming to work in Shanghai.

Motorola China Research Center (MCRC)

Motorola China Research Center (MCRC) is established in Shanghai in 2000. Officially, it is the 5th overseas research center of Motorola. The main research foci of MCRC include mid-to-long term research in technologies that link to the China regional standard, the Chinese language and culture, and the support for Motorola's mainstream products in China's Market in the future.[22] Their 4 research teams engage in research projects such as human machine interface technologies, such as embedded Chinese speech recognition, speech generation, Chinese natural language processing, Chinese character recognition and multi-modal communication over China 3G systems.

With 85% of its employees holding Ph.D. degrees, the main focus of this center is basic research. MCRC is actually a latecomer to the research on speech/linguistics and human-machine interactive in China. The pioneers are IBM (1995), Microsoft (1998), Nokia (1998) and Intel (1998). They are all located in Beijing. As a basic research lab, the products of MCRC's research projects are more in the form of publication in journals than direct input into the product.

MCRC and GE are exceptional cases because most of their counterparts (technology-driven R&D centers) locate in Beijing where the network of scientist community is stronger. They choose to invest in Shanghai mainly out of 'non-research' considerations. GE decided to put everything in one basket so it chose Shanghai because of its strength in many areas except rich human resources. Motorola decided to use its Shanghai research center to expand its market to Shanghai and southern China.

Market-driven: mostly software company focus on domestic market

Market-driven R&D centers tends to concentrate in Shanghai. Shanghai has a more vibrant consumer market to test their new product. This especially important for smaller companies that need to rely on the input of vendors and clients for their R&D project.[23] As China enters the

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[22] From the Motorola official website www.motorola.com.cn

[23] Surprisingly, Beijing draws a significant amount of large market-driven R&D centers despite the fact that Beijing remains a political city where you can not even find a 24 hours convenient store (like 7-11) because it has not been approved. The examples of market-oriented R&D centers in Beijing are numerous, such as the P&G R&D center, which focuses on making better soap and toothpaste for Chinese consumers, and the Motorola PCS R&D center, which designs new cellphones for Chinese and global clients. One wonders why a significant amount of new product development (market-driven) of R&D locate in Beijing. The presence of scientists and alumni networks is one reason. In addition, Beijing is still a command and control center where large oligopoly SOEs locates their decision-making headquarters, such as the telecommunication service SOEs. Many critical decisions on the standard of telecommunications are done among local oligopolies, the government agencies and MNCs. These decisions will

WTO, Shanghai emerges as a new regional center for both foreign and local headquarters. More and more MNCs and large local firms choose to locate their market-driven R&D center in Shanghai after 1999. I will illustrate with three examples: the SAP development center (2000), the HP software solution center (2002) and the HP-Intel Linux Solution Center (2003).

SAP is a European[24] business software firm[25] selling expensive business software to 80% of the fortune 500 companies. SAP has two R&D centers in Beijing and Shanghai with 70 researchers. In my last interview in December 2002, the R&D manager indicates that they are planning to freeze their hiring in Beijing while expanding their center in Shanghai mainly because they are "fed up with the bureaucrats in Beijing." Mr. Lim explained:

> "When you bring a problem to the Beijing government, they will give you more problem and ask you to run around different agencies to solve a very trivial problem. On the contrary, Shanghai officials will call you up and are eager to serve you."

He also cited the fact that Shanghai engineers are more fluent in English. Similar to most market-driven centers, SAP's main clients are the MNCs and local firms in China. They have already captured the major large firms (both foreign and local in China). They are now prepared to target smaller and medium sized firms with their new business ERP software. At this moment, the business software market for SME is dominated by the local Chinese firms Ufsoft and Kingdale. To compete in SME market, SAP takes the first steps to localize an SME ERP software that was created in their India labs. Its next step might be to upgrade the Shanghai development center to a Shanghai lab in order to develop more products for their Chinese SME clients. Either way, this type of product innovation (and localization) needs detailed analysis of business conventions, production flows and client preferences. These require deep interactions with clients at all time, especially in terms of after sales service. The center also needs to train their clients to run a successful ERP. It also needs to provide solutions and customer support in the whole process. Thus Shanghai's better English speaking engineers help. This whole upgrading process might take a few years to complete.

The HP software solution center

The HP software solution center was set up in October 2002, a project delay for more than a year due to the HP-Compaq merger. It is one of HP's 5 E-solution divisions in the world. The

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greatly affect the direction of research. For example, it is becoming obvious that the Chinese central government is going to push through their TD-SCDMA standard in 3G wireless communication. Many telecommunication MNCs are rushing to form strategic alliances with local partners to jump-start this research. They are already lagging behind the locals. Therefore, despite the major backdrop of the business atmosphere of Beijing, it still attracts a significant number of market-driven R&D centers.

[24] It originates from German.

[25] Their most popular business software is the ERP for large corporations.

other 4 centers are in India, Japan, England and Germany. It expects to create up to 1500 engineers in the next 5 years. If so, it will be one of the largest software R&D center in Shanghai. Even though it is located in the export zone in Pudong and enjoys incentive for exporting products or services, it focuses half of its research resources on the domestic market. Therefore, it should be considered as a local market-driven R&D center, which in reality, focuses on both local and regional clients.

The HP Shanghai solution center is mainly set up by the Indian R&D management team from the HP India software center. In fact, the Shanghai solution center is a mirror image of the Indian counterpart. The Indian managers design the center and conduct the initial interviews to set up the core team members of the Shanghai center.[26] However, instead of competing with the Indian center for the European and American markets, HP Shanghai will target Japan and Asian markets instead. Therefore, the HP Shanghai center is more 'regional' than 'global.' This strategy echoes most local Chinese software firms that intend to follow the Indian model to become the new software service center. However, they are very aware that they cannot compete with the Indian software subcontracting firms because of scale and expertise. Therefore, the software firms in China (both local and foreign) turn toward the Japanese market, and the Korean market to a less extent, because of language (using double bites, for example), cultural and geographical proximity.

In terms of the local Chinese market, the HP software solution center will focus on four growth sectors: the financial industry, the telecoms, the government and the manufacturing companies.[27] The software solution center will (1) conduct R&D of HP software; (2) build solutions by partnering with local independent software vendors (ISVs) who are familiar with the specific industries in China as well as global ISVs entering the Chinese market; (3) work for HP's enterprise customers to improve their IT infrastructures.[28] As we can see, HP competes with the pioneer IBM on 'on demand' service. It tries to transform itself into a consultant and solutions provider to the enterprises and governments. This type of R&D center will create a fusion of both software engineers and sales people working hand in hand with the customers. Therefore, similar to other software solution centers including SAP, it needs a very market friendly environment to thrive. Shanghai has a big advantage over Beijing in providing pro-business environment. Therefore, they decide logically on Shanghai.

Due to 1) the emerging of Linux-based software in networking platform, and 2) the

[26] Conversation with 3 HP engineers in Pudong, Shanghai Sep. 2002.
[27] "HP Builds ON Foundation in China: New Solution Center is an Outgrowth of Network Building Infrastructure Expansion", 4(12) 2002 HP WORD, http://www.interex.org/hywordnews/hpw112/02news.html.
[28] "HP to Open Shanghai Software Solution Center" by Elaine Er, Business News, http://www.internetnews.com/bus-news/article/0,,3_907921,00.html

commitment of the Chinese government on promoting open-source software,[29] HP and many other MNCs have to increase their R&D on Linux solution projects in their R&D centers in China. Seizing on this opportunity, HP teamed up with Intel in January 2003 to set-up the **Intel-HP Linux Solution Center** in Shanghai. It is a third center of this kind in the world, focusing on the whole Asia-Pacific market. The purpose of the center is to allow customers and partners to conduct proof-of-concept testing, pilots, performance tuning and capacity planning to accelerate the deployment of solutions on the industry standard platform. Due to the special favoritism of the Chinese government over Linux products, small and medium sized Linux based Independent Software Vendors (ISVs) has began to agglomerate in Shanghai. Many of them come from Taiwan and Hong Kong. China will be a new breeding ground for the rapid development of Linux-based software in the near future.

Production-driven: spread across lower Yangtze River Delta

For a long time, Shanghai has been the heavy industrial complex in China. It has a high concentration state-owned enterprises (SOE). By the 1990s, many the SOEs in traditional sectors such as textiles have almost been wiped out from Shanghai. Some SOEs in import-substitution sectors such as electrical power equipments, machineries, turbine engines, house appliances and automobiles manage to transform into share-holding companies[30] or joint-ventures with MNCs. One example is the Shanghai government's decision on the automobile industry in Shanghai. They merged 30 SOEs into 10, which later formed joint ventures with Volkswagen and General Motors respectively. While trying to close and restructure the inefficient SOEs, the Shanghai government also aggressively pursue the development of its own high-tech industries in telecommunications, Software, PC and biochemical engineering. In the last decade, both domestic and foreign companies rush to the Shanghai city-region to create new industrial agglomerations that have little to do with the existing sectors.

In the mid 1980s, foreign and local private firms that were successful in Southern China began to reinvest in Shanghai. Among them, the most active MNCs come from Taiwanese laptop, PC and peripherals firms, software firms and other electronic firms. They mainly concentrate in Hanzhou, Shuzhou, Wusie and Chuansan. Guansan itself have gathered 5000 Taiwanese small and medium sized firms. At the same time, in the early 1990s, many spin-offs from universities

[29] Microsoft had lost a couple of government contracts to cheaper open source Linux based software in 2001 and 2002.

[30] The Shanghai Technology Stock Exchange has been successful in restructuring many near bankrupt SOEs into share-holding companies with injections of new capital from private parties, other successful SOEs, and increasingly, foreign investors. Many cities have tried to imitate Shanghai's experience with much less success. This is another example of the governing capability of the Shanghai government in managing its economy.

and the Academy of Science in Beijing also moved their manufacturing base to the Shanghai city-region. In less than a decade, a rather impressive industrial cluster on telecommunication, PC and peripherals, automobile, optical fiber have emerged in countless industrial parks in the Yangtze River delta. The OEM Taiwanese firms especially, have successfully built up the engineering capability that the Shanghai city-region is seriously lacking. These extended supplier networks have attracted both upstream (IC design, R&D center) and downstream (IC fab, assembly and packaging) industries to the region.

The transformation of the Yangtze River delta into a new manufacturing platform makes Shanghai a very attractive place for developing upstream activities such as headquarters, logistic centers, financial centers and R&D centers. Many MNC and local research centers were set in Shanghai not only to support their own products, but also to extend their technical support to clients, suppliers, OEM firms and vendors.

Large MNCs that have set their factory in the Shanghai city-region have begun to upgrade Shanghai from merely a cheap production site to a regional headquarters in China and the Asia Pacific region. In this upgrading process, production-driven R&D centers tend to move closer to their manufacturing base in Shanghai for the following reasons: 1) The engineers in the Shanghai plant have accumulated enough experience to absorb and learn more complicated process technology; 2) The needs of shortening product cycled due to intensive competition have make setting up an R&D center a viable choice because it will effectively cut down the communication cost between the experts in home country and the local engineers. 3) The return of experienced Chinese engineers from the West created convenient candidates for R&D directors who can bridge between Western style R&D project management and the Chinese engineering culture. 4) The needs to incorporate the local sales managers in the production process.

I will use two examples to explain the operation of this type of R&D center.

Lucent Technology Optical Network (LTON)

Lucent Technologies[31] is one of the early MNCs to enter the Chinese market. It began with four joint venture factories making optical telecommunication equipment and cable since 1990. These plants are located in Qingdao, Beijing and Shanghai. All of them have the largest manufacturing capacities outside the US.

In 1999, Lucent Technologies made an ambitious move to set up Lucent Technology Optical Network (LTON), a wholly owned R&D center in China. The establishment of LTON is

[31] Lucent Technologies is the manufacturing arm of AT&T before 1996.

accompanied by the construction of a new US$25 million factory for Lucent Technologies of Shanghai (LTOS).[32] In order to design, customize and produce optical network products for clients with different requirements, LTON is set up to optimize the production process and accommodate the expansion of the production line of LTOS. After Sales is also created to serve the clients and provide feedback to LTON and LTOS. In addition, an independent marketing and after-sales service company was also established simultaneously. In that way, Lucent has completed the realignment of the "Innovation-Production-Sales" complex in the same Shanghai city-region. I call this process vertical re-integration (functions) and spatially re-agglomeration (suppliers).[33] Reintegration is a reaction to the intense competition that pushes the efficiency of the production to market process. Re-agglomeration allows LTON to take advantage of suppliers agglomeration in the region – turning Shanghai into a potential Photon Valley.

> "The newly established Lucent Technologies Optical Networks Co., Ltd. (LTON) will become one of the most important branches of Lucent's Optical Networking Group R&D force, engaging in the research and development of latest optical network products so as to meet the needs of China's as well as worldwide networking market need and strengthen Lucent China's potential for further development", said Gerry Wong, Chairman of LTON.[34]

Under the leadership of Gerry Wong and James Hsu – both are Chinese returnees who have been working with Bell labs and the optical networking division of Lucent Technologies in the New Jersey headquarters in the 1980s and 1990s respectively – LTON grew to 300 employees in less than a year and produced the first product release in less than 6 months. This explains how reintegration works to shorten the production to market time.

Motorola IC Design Center in Suzhou

The Motorola IC Design Center in Suzhou, a city 3 hours away from Shanghai, is established

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[32] LTOS is a joint venture partnering Lucent with Shanghai posts & Telecommunications Equipment Co. Ltd, Shanghai Optical Communications Development Co. Ltd. and Shanghai Jiu Shi Corporation. It was the first joint-venture factory set up in 1990 with US$30 million. LTOS is the largest supplier of optical communications and transmission equipment in China. It will be one of the three Global Provisioning Centers of Lucent's Optical Networking Group around the world.

[33] Re-integration means that the R&D, production and sales come together once again after they disintegrated in the early 1990s to relocate production to China to cut cost.

[34] See "Lucent Technologies to expand optical networking presence in China," http://www.lucent.com/press/0700000707.nas.html

in 1999. It focuses on microcontroller design, in which Motorola has the major share in the global market. The center focuses on microcontroller solution and software for the local wireless, consumer electronics and automotive markets. Its number of employees has expanded from 20 in 2000 to 80 in 2003. 20% have Ph.D.s, 60% have Masters and 20% hold bachelor degrees.

The center develops embedded microcontroller product designs for China and Asian customers. In the first year, they are capable of developing 8-bit MCU design, in the second, a 32-bit embedded microprocessor IC technology. According to the director Pern Shaw, the center has designed system-on-chip products that could support personal digital assistants (PDAs) with GPRS (general packet radio services, so called 2.5 GSM network) communications networks. They are also integrating Bluetooth and 802.11b wireless local area network (LAN) technologies in mobile handsets and PDAs. It collaborates with other Motorola IC centers in Singapore and Hong Kong to invent a new smart phone processor that has embedded Bluetooth-on-chip. The new processor was used in the first smart phone model A6188 designed by the PCS R&D center in Beijing, which was produced in Tianjin and hit the market in February 2002. Later in 2002, the smart phone has improved into a color screen model A388 smart phone and sold worldwide.

Motorola is the powerhouse in the 8-bit microcontroller market, which is the technology of choice in China because of the quantity of low-end appliances and consumer devices made in China. The reason for setting up this IC design center in Suzhou is mainly because of the emerging demands of the Chinese OEM firms concentrated in the Shanghai city-region. Chinese OEMs have found their systems often limited by different suppliers' MCUs, so they hope to overcome overdependence on imported MCU. They prefer to implement their system expertise in silicon, so local (including Motorola) chip designers and makers are their new partners.[35] The design center is directly facing the Chinese OEM customers that approach the IC design center with their requirements.

The important resource that the IC center enjoys is the Motorola Technology Library that is shared by Motorola design centers worldwide. It stores well documented functional modules. The design engineers can make a new design based on customer's requirement by using advanced design automation tools. Then the new design will be validated by product and quality control engineers. In order to develop new design and methodology such as Bluetooth and other

[35] Even though helping a local OEM design a controller chip for a refrigerator may not be a very challenging job, it does bring revenue to Motorola. MCUs are the main products manufactured at the Tianjin fab, which uses a 0.25-micron process. The works by the IC design centers (Suzhou IC design center (1999) and Tianjing IC design center (2003)) will help to increase the production of the under capacity MOS 17 – Tianjin IC fab. Before the Tianjin MOS17 fab begin production in 2002, the microcontroller design of the Suzhou center was produced at Motorola's IC fab in Austin, Texas, with some outsourcing of production to fabs in Taiwan and South Korea.
"Local production plants cement commitment to potentially vast market – Motorola earmarks $2B for MCU fab in China," by Sunray Liu, Electronic Engineering Times, Feb 7, 2000: 32.

microcontroller applications, the center also collaborates with regional universities. For example, it works with the National Wireless Communication Lab located at the South East University in Suzhou to setup product development tools and software development environment for China's 3G system and handsets in 2003.[36]

In short, Motorola locates its IC design center in Suzhou to get close to its Chinese OEM clients clustered in the Shanghai city-region. In this sense, it is a market-driven R&D center. At the same time, the result of IC design is produced at its own IC fab in Tianjin. Therefore, it is also a production-driven type of R&D center.

Cost-Driven – very common in Shanghai

The world technical support type of innovation is less sensitive to special talents, unlike the previous three categories. This is because their service involves less technical difficulties. In contrast to the technology-driven type of R&D, which concentrate in Beijing, the cost-driven type of R&D is almost absent in Beijing.[37] In contrast, it is very concentrated in Shanghai, mainly because of Shanghai's pro-business atmosphere that is in sharp contrast to the bureaucratic atmosphere in Beijing. More importantly, cost-reduction centers usually do not require a university-scientific environment to operate. They require a large quantity of engineers with average qualifications, which Shanghai provides cost effectively. Moreover, most directors of technical support centers acknowledge that Shanghai engineers are more proficient in English.[38] In addition, Shanghai, has relatively better and cheaper living conditions than Beijing. This attracts Chinese returnees[39] as well. Slowly, Shanghai has emerged as an alternative to Bangalore in becoming a global technical support center. However, with its developed manufacturing base, Shanghai can attract a wider spectrum of both hardware and software firms to set up global and regional technical support centers. In contrast, Bangalore is more narrowly focused on software expertise. Therefore its possibility to expand into hardware based technical support service is limited.

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[36] From the official website: http://www.motorola.com.cn/semiconductors/spschina/suzhou.asp

[37] When I say absent in Beijing I do not mean the MNC R&D centers in Beijing do not take advantage of low cost engineers in Beijing. I want to emphasize that their primary motive is not cost reduction, even though cost-reduction is always an essential advantage of any MNC R&D center in China. For example, the primary motive of Motorola Software Center in Beijing is to serve the other 13 R&D centers and manufacturing activities all over China. In 2003, it began to compete with HP and IBM for software service in the Chinese market. In other words, it has evolved from 'production-driven' (serving other Motorola's units) to market driven (serving companies outside Motorola) R&D.

[38] English level 6 and computer skill level 4 is a minimum requirement for non-Shanghai resident to apply for Shanghai residency (Shanghai unique city-based green card). This might provide incentive for migrant skilled labor to improve their English abilities in order to obtain a Shanghai green card.

[39] For example, Shanghai government provide very low housing loan for qualified skilled labor to buy a home in Shanghai.

Intel Shanghai Software Labs

Intel software lab was established in Shanghai since 1993. The role of this software lab is to help maintain Intel's monopoly in the Chinese market by supporting the vendors to work on the 'Intel architecture platform," and not its competitor platform like AMD. It has expanded to 200 engineers. The strategy of providing solutions to the vendors, who are encouraged to develop their own software or hardware on Intel platform, has become a common tactic employed by many hardware-turn-consumer MNCs.[40] Until today, there are many research groups within the software center. Among the groups, the Linux software group is the largest and fastest growing research team. By 2002 summer, it has 30 engineers. Due to the global prospect of Linux, and especially in China, in which Linux is taken seriously as an alternative to Microsoft, this group is growing rapidly, and it has great potential to eventually replace the 150 Linux experts in their parent lab in the U.S. If that happens, the Linux group will grow to 200 engineers. The primary reason for the migration of this research group to China is mainly because of the cheap software engineers in China. In addition, the Linux community in China is also expanding faster[41] with strong government backing for "open source" alternatives to the overpriced Microsoft "closed system."

Ericsson R&D center

The Ericsson R&D center was setup in Shanghai in 1998. The primary goal of this center is to provide software development and technical support for their telecommunication clients in Europe. As most European clients are still using narrow band GSP telecommunication infrastructures set up over 2 decades ago, they cannot be easily upgraded to broadband. Therefore, the whole technical support team was relocated to Shanghai in order to save cost.

Microsoft's Global Technical Support center

Microsoft Global Technical Support center was established in 1999. It serves all the customers in the world. This center started as the technical center for Chinese clients. It was renamed the Asian technical center and eventually renamed as the global center. This is not just a

[40] Eriksson has launched the Ericsson Open Labs campaign in China as a means to provide a platform to serve their vendors. They provide solutions and services to the vendors who will develop their products on Ericsson technological platform.

[41] Taiwanese Linux firms are also gradually migrating to China recently. They will add addition pools of expertise to the Chinese soil. As usual, Taiwanese IT firms prefer Shanghai to set up their company.

naming strategy, but a reflection of the success of the upgrading of this center in a very short period of time. The director is a Chinese returnee who has worked at the Microsoft headquarters in Redmond for 6 years. Due to his charismatic leadership in transforming the Shanghai technical center, he has been appointed as the Microsoft Managing Director in China.

Some might question the language capability of Chinese engineers in serving global customers. Microsoft Technical Support finds a way to overcome this problem via team work. One person who is fluent in English will respond directly to customers after their team has come up with a solution to their customer's problem. In this way, most technical support engineers do not need to engage in direct conversation with the customers.

Part II: Shanghai's innovation system in relations to MNC R&D centers

The decentralization of economic power has given Chinese city governments autonomy to engage in land development, residential policy, sectoral and industrial policy to shape their own innovation system. While many city governments have no better strategy but to create cheaper or heavily subsidized industrial parks to attract investment, major coastal cities such as Shanghai, Shenzhen, Beijing and Guangzhou are more equipped with think tanks and strategists that often take full advantage of various tools in shaping their knowledge economy. For the purpose of this paper, I will not go into detail of all the major policies that shape Shanghai's innovation system. Instead, I will use a simple schema of demand and supply to highlight those crucial city-based knowledge assets that enable the MNC R&D centers to grow in the Shanghai city-region.

Figure 1 shows the position of MNC R&D centers in relation to Shanghai's innovation system. At the center of the diagram are two kinds of MNC R&D centers. The first kind is the production-driven type that has tight relations with their factories. The second kind is the other three types of R&D centers that locate in the city, with little or no relation to their corporate branch factories. Lucent Technology Optical Network (LTON, a process R&D center) and its factory are both located in the Shanghai Caihejing science park. The rest of the centers are independent R&D centers that has nothing to do with manufacturing. For example, Intel Software Lab in the Shanghai city is independent and not related to the Intel CPU packaging factory in Pudong. Below is a brief description of the knowledge assets that are relevant to the centers.

1. The skilled labor supply of the city is most crucial to the centers. The supply of skilled labor comes from various sources: Graduate from major universities and the Chinese Academy of Science (Shanghai Branch), migrant skilled labor from other regions, overseas Chinese returnees, and those recruited from other firms in the industrial complex.

2. Their relation with universities is very crucial to MNC R&D centers. This often happen in the form of 1) joint-research labs 2) joint research programs; 3) subcontracted research projects; 4) student intern programs; 5) faculties and students recruited to work in the MNC R&D centers. 6) University departments help in MNC employee training or joint-training program.

3. The IT manufacturing cluster in the region is strongly supported by the pro-business Shanghai government through incentives, and industrial and sectoral policies. For example, the Shanghai government pioneered in designing the Shanghai Technology Stock Exchange in 1999. It helps the near-bankrupt SOEs to restructure on one hand, and helps local startups, individual and spin-offs from university to look for potential investors on the other. This industrial cluster in return, attracts production and market-driven R&D centers to the region. Many stand alone design centers, such as IC design, optical network design and embedded software firms emerge because they can easily subcontract their design to the OEM firms in the region.

4. The increase in investment in service sectors from both foreign and local capital has improved the producer service sector of Shanghai, especially in financial sector. Investment banking and venture capital have mushroomed in Shanghai to provide badly needed capital for the local firms. The abundance of insurance, consultant, accountant and business law firms all help to make Shanghai a pro-business city in China. Even though these producer services do not affect the R&D directly, they make Shanghai an attractive place in general for all kinds of investment. GE's decision to locate its jumbo research center in Shanghai has everything to do with this overall pro-business environment of Shanghai.

5. Large local R&D centers are also encouraged to move their HQs and R&D centers to Shanghai. In one case, Shanghai provides a whole piece of land for free just to ask one large telecommunication equipment firm to move their R&D center and manufacturing facilities to Shanghai. The Shanghai government also provides matching R&D grants to support R&D investment of the firms registered with the city. It also provides free patent application to encourage patent filing for local R&D labs. Increasingly, we see some strategic alliance and joint research carried out between large local firms and MNCs. Most of these joint-research labs occur in Beijing, much more than Shanghai. The more common joint research labs in Shanghai are formed by two MNCs, such as the HP-Intel Linux Labs in Shanghai (2003).

6. Infrastructure building –Shanghai is most successful in building its infrastructure, which includes both IT infrastructure and physical infrastructure. One of the key factors behind this rapid growth is the strategic use of public land. In a socialist urban system, all the land belongs to the government, a condition that never exist in any capitalist city. When Shanghai successfully lobbied a special permission to lease their public owned land for a rent, it fuel expansion of real

estate development since 1992. With the inherited top-down planning model[42] and the influx of hot money from overseas Chinese, Shanghai has undergone unprecendented urban renewal since 1992. Using BOT and other planning tools, Shanghai achieved its infrastructure improvement in less than a decade. This improvement makes Shanghai stand out from other coastal cities as a livable city. This is a major attraction for MNC R&D centers. The unusual change has transformed Shanghai into a modern city in less than a decade.

[42] During its urban renewal project, the Shanghai government can clear out large pieces of old residential areas in less than 3 months by relocating the residents to the fringes of the city. Many committed suicide in resistance because of this top-down and undemocratic process.

FIGURE 1: MNC R&D CENTERS IN SHANGHAI'S INNOVATION SYSTEM

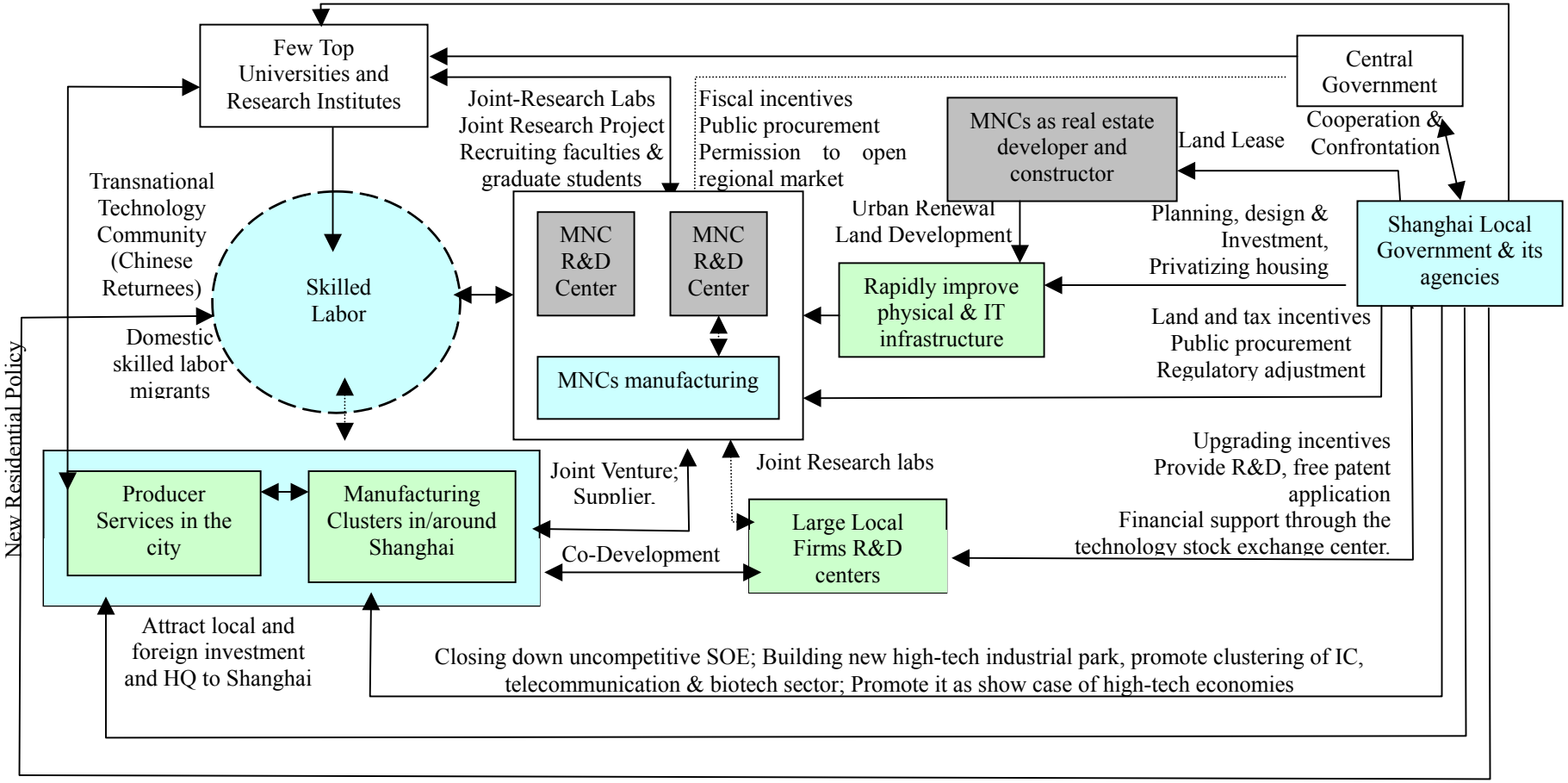

Table 3: The demand and Supply of MNC R&D centers in Shanghai

Motivation / Demand & Supply	I Technology-driven	II Market-Driven	III Production-driven	IV Cost-Driven
Demand	1. Skilled Labor with Ph.D./ Master degree who is committed to basic/applied research. 2. Close to good public research labs for collaboration on basic research. 3. Good infrastructure	1. Skilled Labor with market skills 2. Pro-business government service 3. Proximity to the key clients who can make crucial decisions. 4. For strategic alliance or joint research with other firms. 5. Urban Services 6. Good Infrastructure	1. Skilled labor with production skills 2. Agglomeration of network of suppliers (OEM firms and vendors) 3. Pro-business government service 4. Good Infrastructure	1. Abundant cheap labor with bachelor degrees and English proficiency 2.Good infrastructure
Supply	SKILL 2,3,5 GOV 1 INF	SKILL 3,4,6 SECTOR 2 GOV 1,2,3 INF SERVICES	SKILL 2,3,5, SECTOR 1,2,3,4 GOV 1,2 INF	SKILL 1,3,4 SECTOR 4 GOV 1 INF

SKILL: Increase the supply of skilled labor in the city-region

1. Expansion of the Engineering Schools – in the last decades, Shanghai engineering school has expanded 2-3 times. The faculties are evaluated on international standards (publication), and more faculties are hired to keep generating enough cheap engineers. Graduate programs are also expanded tremendously.

2. Reform of university and public research labs to train more Masters and Ph.D. students that are more sensitive to market-oriented research. Examples includes: The university authority or the CAS Shanghai branch encourage joint research labs with both local and foreign firms. Encourage market-oriented research. Encourage labs to fund themselves by doing marketable research so they can make money by licensing, spin-off companies from labs, compete for research project form large corporate…etc.

3. Attract the return of experienced Chinese returnees (including overseas Chinese in Hong Kong, Taiwan, Southeast Asia and Western countries) with many benefits such as buying house with deep discounts, green cards, loan for starting businesses, special industrial zoning for Chinese returnees only.

4. New Residential law (Shanghai green card) to attract skilled labor (at least with a bachelor degree) from other regions in China by granting Shanghai green cards.

5. Most large MNCs set up their own training facilities. Example, Motorola University in Tianjin. Some of them subcontract the employee training to universities. University departments in need of funding are more than happy to do the training for the companies. Many MNCs send their higher level managers and senior engineers back to their mother company in the home country for training.

6. Many MBAs and EMBAs mushroom in Shanghai, often run by famous management schools in the West. It has become the most lucrative FDI since the mid 1990s. Many MNCs also set up their own MBA courses (either with or without degrees) to train their own employees, government officials, vendors, suppliers and general public.

SECTOR: Sectoral Policy – IT sector

1. IC fabrication plants: the Shanghai government is very active in attracting IC fabrication plants to Shanghai. It has so far attracted 4 IC plants that have capabilities to do 8 inch IC with 0.35 micro technology.

2. IC design: With IC fabrications in place, Shanghai is also attracting may IC design houses from abroad, especially from the U.S. and Taiwan. Local house appliance, consumer electronics and PC firms that start their IC design firms are also locating to
Shanghai.

3. PC and peripherals: Taiwanese PC and peripherals clusters have basically rebuilt themselves in Suzhou, Hangzhou, Kunshan, Wusi, all key cities that receive Taiwanese investment in the Shanghai city-region.

4. Independent Software Vendors: Content providers, application software for telecommunications and Linux-based software vendors are coming to Shanghai. Taiwanese software firms that are good in embedded software and Linux are also finding their way to Shanghai.

GOV: Role of Government

1. Incentives for the FDI
2. Government Service for MNCs
3. Government purchases from MNCs

SERVICES: Open up the service sector for foreign investment has increased the spectrum of urban service in the Shanghai city-region.

INFRASTRUCTURE: Rapid improvement of physical and IT infrastructure as a result of aggressive government policies with 'efficient' top-down planning processes. The Shanghai government encouraged this by utilizing the real estate capital from overseas Chinese from Hong Kong, Taiwan and Southeast Asia.

Elaboration on the increasing supply of skilled labor

Let me elaborate some of the key policies above on labor supply in Shanghai. Without enough skilled labor to feed both local and foreign R&D centers, Shanghai will not be able to compete with Beijing for MNC R&D investments.

Shanghai's green card

To attract skilled labor from outside Shanghai, the Shanghai government took the lead in 1998 to loosen up the harsh residential regulations in China, which forbade internal migration to large cities. Shanghai began allowing university graduates from elsewhere to obtain Shanghai residential status rather easily. Cities today both create (via university reform) and attract (via loosening up migration restrictions for skilled labor) the new high-tech human capital that is most critical to the R&D demands of both MNCs and local firms.

The increase in mobility of university graduates is actually a very recent phenomenon. Choosing between "getting a residential status in Shanghai or getting a higher paid job in Shenzhen" is a common debate among graduates in top universities, as shown in their BBS chat rooms. Firms in Shenzhen and other cities outside Shanghai have to pay much more to attract the talents to come to their city. Hence, large MNCs, which are considered privileged stepping stones to Shanghai residency has attracted plenty of skilled labor with the intent to stay in the city. Large local companies can also attract talents not by their high salary, but by their willingness to help their employees obtain a 'city-based green card.'[43] This is very similar to foreign engineers working in the Silicon Valley in order to obtain the U.S. green card. The desire for city-based green-cards in big cities is actually a newly available option, and has become a hot trend in China.

[43] The Shanghai government often privilege large companies, so they are more willing to facilitate the green card application for employees from large local and foreign firms.

This is a very unique phenomenon in post-socialist countries where residential control is eroding but is still pretty much ingrained in established forms of statecraft.

University reform – foster industry-university linkage and expanding engineering schools

Shanghai, as an old manufacturing city, has been accumulating its skilled labor force in existing traditionally strong sectors. However, both foreign and local companies are relocating into new sectors in Shanghai, including both high-tech and design-intensive sectors, such as notebook, PC peripherals, electronics components, IC manufacturing, telecommunication, biotechnology, fashion design, IC design and so forth. To accommodate these booming sectors, the Shanghai government, the universities and training institutions are aggressively addressing the shortage of labor in all these new sectors. Shanghai's strategy of shaping the supply of its skilled labor market is different from Beijing. It does not possess the enormous academic resources as compared to the capital city. In order to carve out a niche for itself, Shanghai must seriously reform its universities. The first strategy is to transform Shanghai's universities into entrepreneurial universities. One reason for this trend is the fact that research funding from the state government has been severely cut. Therefore, each university department is forced into the market in search of industrial funding to support their centers and programs. Thus, the urge to look for industrial funding has indirectly fostered better industrial-academic linkage. The second strategy is to change the curriculum by consolidating different departments into a targeted department and to gear towards equipping students and faculties with more market-oriented skills. The third strategy is to 'localize the national universities' located in Shanghai. The Shanghai government provides funds for under funded national universities in Shanghai in exchange for the co-ownership of the university. After having a say in the university management, the Shanghai government sets a quota to increase the entrance of local Shanghai high-school graduates up to 40%. This is a very well targeted investment because local students are perceived as more 'loyal' to Shanghai, and will therefore, stay behind after graduation and retain Shanghai's human resource investments locally. The fourth strategy is to set up new departments or new branch departments near the important high-tech science parks.

Transnational Technology Committees

Local skilled labor alone is not sufficient to build a vibrant knowledge economy. After learning from the successful experience of the Hsingchu Science Park in Taiwan, Chinese technocrats are trying to mimic the Hsingchu model. The Hsingchu Park is based heavily on the

returnees from the Silicon Valley, who brought home technology, management skills, culture and venture capital. Thus, the local governments are all very aggressively engageing in talent hunting, targeting those Chinese experts in top positions of large firms in the West, and encourage them to come back at any cost. This group of people is what I will call the 'transnational Chinese technology community' or simply Chinese returnees. They are critical to the development of the knowledge economy of any Chinese city. They are often returnees from the Silicon Valley who act as critical agents in the coordination among various agents: MNCs, city-governments, local firms, universities and skilled workers. Moreover, many of them have families living in the West. They are often commuting between Silicon Valley and China, making frequent critical knowledge exchange between the two regions. Therefore, I prefer to call them 'transnational,' emphasizing their constant negotiation between two cultures. This is more accurate than the Chinese official term "overseas returnees," which can be misunderstood as those who decide to permanently return to China. Instead, most of them have foreign citizenship, and are forced to give up Chinese citizenship, as dual citizenship is not allowed in China. It is quite unlikely that they would give up their foreign citizenship. Thus, their status tends to remain transnational. The Shanghai government has been quite successful in attracting the return of these transnational Chinese experts.

There are many policies that target these people directly. For example, 1) the Shanghai government provides housing subsidies for these returnees by exempting all sales tax for house purchase in Shanghai. This policy gave a tremendous boost to the concentration of skilled labor who rush to buy their first house in Shanghai. Many Beijing people actually bought a house in Shanghai even though they might not stay in Shanghai in the future. 2) The Shanghai government also builds science parks and returnees' parks that provide seed money and land subsidies for local start-ups.

III. The Technology Spillover effects of MNC R&D centers

From Joint-venture to MNCs R&D center: a new mechanism of technology transfer?

In the past, management scholars and economic geographers argued that Shanghai had relatively successful technology transfer compared to other cities because it knew how to bargain with the MNCs. Bargaining on behalf of the Shanghai SOEs, Shanghai officials often got the upper hand by playing one MNC against the other in order to close a more favorable JV contract with the higher bidder. This favorable JV deal allow local partners of JV firms to assert more pressure on technology transfer and enforce local content requirement. For example, the

joint-venture between Shanghai SOEs with Volkswagen and GM was relatively successful in creating a cluster of auto-part suppliers in Shanghai. Recently, a new car town is planned to further enhance and support the growth of the automobile cluster in the Western part of Shanghai. An Automobile University, a joint effort of Tongzi University and Volkswagen will become the innovation and training center of this automobile city.

The main reason that joint-venture works in favor of the Chinese partner is mainly because of the majority ownership of the local partners. Not all joint-ventures are collaborating efficiently since the expectation and management philosophy of foreign partners and local partners are often different. For example, foreign partners are more eager to get the production efficiency up, while local partners are pushing toward newer product models irrespective of their absorption capability. Despite the constant battle within the joint-venture company, it is nevertheless a major mechanism of technology transfer in the 1990s.

However, JV has been heavily challenged in the late 1990s, and will probably lose its strength as a major bearer of technology transfer after China joins the WTO. After China joins the WTO, foreign firms are no longer obliged to form joint-ventures with Chinese firms in order to enter the Chinese market. Even before the WTO, many foreign partners have begun to take over the JV plants. Foreign business consultants, such as Mckinsey, has been urging foreign partners to take control of the management of JVs if they want to start making profit. Only by taking charge of the management can they eliminate the distrustful and inconsistent business culture under two leaderships. The most effective way is to increase their share over to 50% ownership through expansion. Targeting the capital constraint on the Chinese partners, foreign partners can readily argue their ownership share and take over the management of the JV factories. Therefore, the heyday when local partners of JVs can assert significant pressure on technology transfer is gone.

In the post-WTO era, MNCs would still choose to form joint-ventures with Chinese firms, but this time, they can choose their own local partners instead of bowing to the government's pressure. They tend to choose large and successful non-SOE private firms as new joint-venture partners 1) to diverse the risk of investment; 2) to exploit the marketing channels developed by local firms over the years. This market network often penetrates deeply into the most remote area of China.

Will the arrival of MNC R&D centers in the late 1990s to Shanghai create an alternative way of technology transfer to replace the declining role of JVs? The situation is unclear. In fact, the arrival of wholly owned R&D centers come as a surprise to Shanghai. They have yet to formulate a clear position on how to react to this new form of R&D investment because it does not fit any criteria of existing preferential policy. Tax holidays are not relevant because R&D centers by nature do not generate tax revenue because, unlike factories, they do not produce sellable

products.[44] They are also usually small, with a range of 50 to 500 employee, compared to FDI in manufacturing.

At the moment, the Shanghai government finds the wholly MNC owned R&D centers at least useful to their high-tech propaganda. The number of MNC R&D centers become a new set of statistics to demonstrate the competitive edge of Shanghai.[45] The Shanghai government uses this statistics to pressure those MNCs still hesitating to transfer their R&D centers to Shanghai, even though the officials are unsure about the real effects of this new trend.

Technology spillover of MNC R&D center to the local

Technology spillover from the MNCs to the local economy is often regarded as desirable positive externalities of FDI in any given city-region. Technology spillover has an 'informal' conotation as it is often the 'unintended consequence' of MNCs activities. As it is too early to systematically assess the full effect of technology spillovers, I will show a few case studies on how informal technology spillover occurs between MNC R&D centers and local agents –university and firms.

Technology spillover in the form of joint-research lab(JRL)

One of the characteristics of the MNC R&D operation in Shanghai (or China in general) is to set up multiple joint-research labs (JRL) in top universities of a given city-region. Many of these joint-research labs have hardly any trace of "joint-research" because the main purpose is to build positive public image on the campus. Without conducting any research, this kind of MNCs often donate equipment and research funding[46] in order to put their company name in front of a famous research labs. Sometimes you can see a couple of billboards side by side at the entrance of a university research lab. This image building gesture of MNCs usually does not produce any possible technology spillover to the university. However, some MNC R&D centers do run their joint-research labs seriously.

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[44] Some might argue that they produce license-ready technology. However, most R&D centers are still serving their mother company more than selling their technology to other companies. In the long run, selling technology and know-how might happen. For example, the Motorola software R&D centers in Beijing, inspired by IBM 'on-demand' service, has transformed itself into a software center that also serve clients outside Motorola. However, this is an exception rather than the rule at the moment.

[45] Government statistics do not keep track of R&D centers as they usually do not register as such. Therefore, the actual number of R&D centers is often inaccurate. Every city will boast that their number is more than the others, especially between Beijing and Shanghai.

[46] Funding can be a one time lump sum or an annual funding of usually not more than 1 million RMP per year.

Below are two examples of MNC joint-research labs in two universities in the Shanghai city-region.

Bell Labs joint-research labs in Jiaotong University

Bell Labs – the research arm of Lucent Technologies – has set up their first research lab with Shanghai Jiantong University in 1997. According to the director of the Bell Labs joint-research lab in Jiaotong University:

> "With around 1 million RMP research grant, we can support 4-5 faculties and more than 20 Masters and Ph.D. students. Without this joint-research lab, we will never even start a research team on phonetics [part of the speech research]. We are doing pretty well considering that we started from scratch."

As a latecomer into basic research on speech, Jiaotong University has slowly made an inroad to this brand new research field. Now, they are catching up with four established public labs in Beijing that have been working on this domain for more than 20 years. Even though this research team in JRL is still relatively small, it has successfully created a 'community' of researchers in and outside the JRL. [47]

The Motorola Microcontroller Unit (MCU) Joint Research Lab

I want to show you another example of Motorola's joint research lab to demonstrate a more complex picture of how Motorola used MCU JRL to promote their MCU product, create a lock-in effect while producing positive technology spillover effects in the process.

Motorola has many Microcontroller Unit (MCU) labs with major universities in many Chinese cities since 1995. For each MCU JRL, Motorola do not merely donate equipment, but also involve in designing the training program for the lab. As a result, the joint labs produce a lock-in effect for Motorola MCU application. In the long-run, the research labs will act as the agents of the diffusion of Motorola MCU technology and its products into the future customers – faculties, students and clients of the labs.

Let me give a good example of how this 'lock-in' effect actually works. At the Suzhou Motorola MCU JRL, faculties use the JRL to provide services for companies. Students are therefore, exposed to real case applications in their training, instead of simply working on lab

[47] Not all joint-research labs undergo substantial joint-research. Many MNC joint-research labs act more like a public relations entity on campus. They only donate equipments and research funding but do not involve in the everyday operation of the labs. Their contribution is really in money, and hardly any effect of 'technology spillover.'

experiments. In one client project, an electronic device company approaches the lab for a solution to design an advanced intellective Cold Water Meter IC Card. Their goal is to design an IC card that can detect the residential usage of cold water automatically, so that the Water Company does not need to send workers to read the water meters every other month. A researcher at the Motorola MCU JRL chooses Motorola MC68HC08 MCU as the solution to design a chip for their customer. It is not a coincidence that the Motorola MCU JRL finds that the 'Motorola MCU is the best solution' for their client. In the process of working with the client on this 'real' project with Motorola solutions, the Motorola MCU lab serves both as a training program for the faculties and students and also as a vehicle for the diffusion (if not lock in) of Motorola MCU technology and its solutions. According to research directors of JRLs,

> "Engineers often choose platforms they know well, especially those systems they learned in college. … So foreign companies always regard their university programs [as] prior investment in China" explained Limin He – professor at the University of Aeronautics and Astronautics of Beijing.[48]

Moreover, this JRL also held design contests. For example, Motorola and China Computer Academy jointly hosted design contests since 1994 for Motorola microcontrollers design. They asked contestants to design products around a processor with fast on chip flash memory and Internet access functions. The contest drew more than 1,500 applications in 2000, along with 300 detailed proposals. These efforts are all geared towards 'locking in' the future user with Motorola MCU, hence securing the Motorola MCU market in the long run.

However, universities do not simply lose out. With funding, training program and donated equipments from Motorola, many under-funded labs are revitalized and their graduate program expanded. The JRLs do not only train the student with Motorola MCU design, but also expose them to more advanced technology and new idea on market-oriented research.

MNC JRLs also create demonstration effects. Many large local firms are now competing with MNCs to set up joint research labs with top universities. However, they have a harder time competing with the MNCs for a spot in top university research labs because these 'spoiled' universities are already preoccupied with the Fortune 500 companies that are eager to pour money into the campus. Therefore, the local Chinese firms (also Taiwan and Hong Kong MNCs) choose to form JRLs with second tier universities outside the major metropolitan regions. Many

[48] Cited from the article "Local production plans cement commitment to potentially vast market – Motorola earmarks $2B for MCU fab in China", *Electronic Engineering Times*. Feb 7, 2000: 32. My interview with other directors of joint research labs in Shanghai and Beijing also confirm these findings.

of these successful large local firms have a nationalist mission too: that is, to promote national champions that can compete with these MNCs on the world market. Therefore, some of them have much more intense collaboration with second-tier universities, In the long run, it will benefit both the universities and the firms.

Spillover in the form of spin-off

Labor mobility from foreign to domestic firms is often the most effective way of technology transfer. This effect is usually weak in the contest where you have weak local firms competing with the MNCs for the talents. It is not true any more in China. As many Chinese local firms have risen to compete with MNCs on both domestic and foreign markets, they often offer higher salaries to lure the engineers from the MNCs. In one example, a research director of an MNC R&D center brought the whole team of researchers back to the Chinese Academy of Science. They were met with heroic welcome and granted a brand new research with handsome research grants. The main reason to leave is because they wanted to set their research agenda free of corporate agenda. The other effective way of technology spillover is the spin-offs from MNC R&D centers. Below is an example of a spin-off from a MNC R&D center in Shanghai.

Photonic Bridge – Spin off of Lucent Technology Optical Network (LTON) R&D center

Since 2000, Lucent Technologies in China has been affected by the financial devastation of its parent company- Lucent Technologies, severely crippled by diminishing sales and lack of new products.[49] Lucent blames it on global recession in the telecommunication market. This caused bankruptcy among its clients (operators), who can no longer pay for the purchases they made. Industrial analysis blame Lucent for being spoiled by Wall Street and for recklessly providing handsome loans to clients to purchase its products, a common practice in the industry during that boom time. As a result, Lucent China is struggling between increasing sales, scaling back operations and disposing of its assets to reduce the parent's debt, which have turned out to be very difficulty on both ends. As a result, Lucent Technologies sold its major factories in China to its competitors.[50]

[49] Lucent Technology loose all most all its market to Nortel because the later had came up with a better and faster product.

[50] Two largest manufacturers of optic fiber cable and networks (one in Beijing and one in Shanghai) were sold to Corning in 2001, the largest US fiber optic company. The following year (2002), its largest optical network equipment factory (LTOS, the factory we discuss above) in Shanghai was also sold to Jabil Circuit. In return, Jabil Circuit agrees to continue to supply Lucent with the products needed for the Chinese market.

The frustration has caused 70 people from LTON to leave and open a new spin-off company called Photonic Bridge in 2001. This new company is led by 7 Chinese overseas returnees including Garry Wong and James Hsu, the founder of LTON. Many of them are senior researchers and engineers working in Bell Labs New Jersey for many years before they came to set up LTON in Shanghai in 1999. [51] They left LTON because of the uncertainties caused by the financial crisis, but most importantly, because they are unhappy with the hierarchical decision making structure inherited in big companies like Lucent, where they cannot freely reform LTON in major ways.

Photonic Bridge is a non-manufacturing based design house that outsources its design to optical equipment OEM plants clustered in the Shanghai city-region. Even though Photonic Bridge still claims to be a global firm with headquarters in the U.S. (mostly as a strategy to get venture capital from Silicon Valley), it is basically a local firm that focuses exclusively on the Chinese market. This might be an extreme case of spin-off. However, examples of individual senior researchers leaving MNC R&D centers to join local companies is numerous, and it will continue to occur over the years.

IV. Conclusion

This paper aims at analyzing a new stage of localization of R&D in developing cities, in this case, Shanghai. This analysis has significant implications not only for a redefinition of the theories of globalization of innovation. It also demonstrates a possible way for latecomer cities in developing countries to actively intervene in this tango with the wolves.

Here is a summary of why MNCs choose Shanghai for its R&D investment.

1) Shanghai has been aggressive in attracting international and domestic skilled labor to their city. Rapid expansion of engineering departments in universities and the new Shanghai residential policy (city-based green card) has successfully attracted skilled professionals from other regions and also internationally. The abundant engineers with better language proficiency make Shanghai an alternative to Bangalore for ***cost-driven*** technology-support centers.

2) Shanghai is often the pioneer market for MNCs to test their products in China. Due to the intensified competition imposed by both foreign and local firms in the domestic Chinese market, MNCs began localizing and upgrading their ***market-driven*** R&D centers in Shanghai since 1999.

3) In the last decade, there was rapid build-up of IT industrial clusters in the Shanghai

[51] "China Optics Firms Thing Big – Photonic Bridges Sees a Niche in a Developing Market Shunned by Wary Western Firms – 'They Don't' Value or Respect Innovation' The Asian Wall Street Journal 2001/02/16.

city-region by MNCs, especially Taiwanese OEM firms and their suppliers. This has encouraged MNCs to upgrade or relocate their ***production-driven*** R&D centers to this region to take advantage of the supplier network and to shorten their production to market timing.

4) Even without the dense scientific and alumni network like Beijing, Shanghai manages to attract a few ***technology-driven*** R&D centers. The reason are mainly because of the general pro-business environment, service-oriented city government, and better and lower living cost (compared to Beijing) that are very attractive to local and foreign engineers. As the most valuable asset of any R&D centers is people, it is not surprising that a more democratic MNC R&D center will vote to locate this type of R&D center in Shanghai.

The technology spillover effects of wholly MNC owned R&D investment are different from the traditional joint-venture strategy, in which local partners can assert pressure on foreign partners for more technology transfer. In its new form, technology spill-over usually takes place in informal ways. Let me summarize the possible ways in which informal technology spillover takes place.

Labor mobility – As local Chinese firms have risen rapidly to compete with MNCs for market and human resource, some of them offer higher pay to lure the researchers form MNCs R&D centers to their own R&D centers. Sometimes, individual researchers who is impatient with the lack of progress of certain research might take the project to local firms, so that it can be developed into a product faster.

MNC-University Joint Research Labs – Most MNCs compete to form joint-research labs with famous university. While most of them are only public relations gimmicks, some MNCs do conduct joint-research and training programs with universities. In the later case, long term secure funding and collaboration exposes faculties and students to the latest market-oriented research. Nevertheless, it has a danger lock in effect. Certain labs might get locked into a narrow technology spectrum confined by the MNC sponsor.

Spin offs – there are some examples of research teams leaving MNC R&D centers to form their own design houses. The dense supplier networks embedded in the Shanghai city-region provide an opportunity for these design houses to survive. They can easily subcontract their design to the OEM firms coming mainly from Taiwan.

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