

MARKET STRUCTURE AND PERFORMANCE IN  
CELLULAR TELEPHONY  
-THE EXPERIENCE OF CHINA COMPARED TO OTHER  
COUNTRIES

by

Yonghong Chen  
B.A. in Economics, Renmin University of China, 2005

PROJECT SUBMITTED IN PARTIAL FULFILLMENT OF  
THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF ARTS

In the  
Department  
of  
Economics

© Yonghong Chen 2007

SIMON FRASER UNIVERSITY

2007

All rights reserved. This work may not be  
reproduced in whole or in part, by photocopy  
or other means, without permission of the author.

## APPROVAL

**Name:** Yonghong Chen  
**Degree:** Master of Arts  
**Title of Project:** Market Structure and Performance in Cellular  
Telephony - the Experience of China Compared to  
Other Countries

### Examining Committee:

**Chair:** Douglas Allen  
Professor, Department of Economics

---

**Richard Schwindt**  
Senior Supervisor  
Associate Professor, Department of Economics

---

**Krishna Pendakur**  
Supervisor  
Associate Professor, Department of Economics

---

**Don DeVoretz**  
Internal Examiner  
Professor, Department of Economics

**Date Approved:** Friday, June 22, 2007



SIMON FRASER UNIVERSITY  
LIBRARY

## **Declaration of Partial Copyright Licence**

The author, whose copyright is declared on the title page of this work, has granted to Simon Fraser University the right to lend this thesis, project or extended essay to users of the Simon Fraser University Library, and to make partial or single copies only for such users or in response to a request from the library of any other university, or other educational institution, on its own behalf or for one of its users.

The author has further granted permission to Simon Fraser University to keep or make a digital copy for use in its circulating collection (currently available to the public at the "Institutional Repository" link of the SFU Library website <[www.lib.sfu.ca](http://www.lib.sfu.ca)> at: <<http://ir.lib.sfu.ca/handle/1892/112>>) and, without changing the content, to translate the thesis/project or extended essays, if technically possible, to any medium or format for the purpose of preservation of the digital work.

The author has further agreed that permission for multiple copying of this work for scholarly purposes may be granted by either the author or the Dean of Graduate Studies.

It is understood that copying or publication of this work for financial gain shall not be allowed without the author's written permission.

Permission for public performance, or limited permission for private scholarly use, of any multimedia materials forming part of this work, may have been granted by the author. This information may be found on the separately catalogued multimedia material and in the signed Partial Copyright Licence.

While licensing SFU to permit the above uses, the author retains copyright in the thesis, project or extended essays, including the right to change the work for subsequent purposes, including editing and publishing the work in whole or in part, and licensing other parties, as the author may desire.

The original Partial Copyright Licence attesting to these terms, and signed by this author, may be found in the original bound copy of this work, retained in the Simon Fraser University Archive.

Simon Fraser University Library  
Burnaby, BC, Canada

## **Abstract**

This project explores market structure and performance in cellular telephony. It contrasts China and other countries regarding the effect of market structure on mobile telephony performance and evaluates China's cellular sector performance relative to its declared public policy goals in telecommunications. The results indicate that lower market concentration can increase mobile penetration. The negative relationship of market concentration and price levels as well as the positive relationship of market concentration and labor productivity can be reasonably explained. This study finds evidence to support China's efforts to promote mobile telecommunications by encouraging competition. However, the benefits of increased competition are likely smaller compared to other countries. Regarding China's competition goals in telecommunications, the regulators have made a great effort in encouraging competition in the cellular sector and their efforts are well rewarded. However, they have room to foster an even more competitive market structure in order to reap even greater benefits.

**Keywords:** mobile telecommunications; market structure; Herfindahl Hirschman Index; performance; China

**Subject Terms:** Cellular Telephone Services Industry; Mobile Communication Systems  
Economic Aspects

## **Dedication**

*To my dearest parents, brothers and sisters*

## **Acknowledgements**

I am deeply grateful for all the insightful perspectives and support my supervisors have given me in the research. I owe particular thanks to Professor Schwindt who agreed to supervise me and taught me many things that will continue to inspire me in my future endeavors. I would also like to thank Professor Pendakur for his many penetrating questions that propelled me to question more deeply.

## Table of Contents

<b>Approval</b> .....	<b>ii</b>
<b>Abstract</b> .....	<b>iii</b>
<b>Dedication</b> .....	<b>iv</b>
<b>Acknowledgements</b> .....	<b>v</b>
<b>Table of Contents</b> .....	<b>vi</b>
<b>List of Figures</b> .....	<b>vii</b>
<b>List of Tables</b> .....	<b>vii</b>
<b>1 INTRODUCTION AND OVERVIEW OF CHINA’S ECONOMIC HISTORY</b> .....	<b>1</b>
1.1 Introduction.....	1
1.2 Overview of China’s economic history .....	2
<b>2 EVOLUTION OF THE CHINESE CELLULAR SECTOR AND CHINA’S COMPETITION GOALS IN TELECOMS</b> .....	<b>12</b>
<b>3 LITERATURE REVIEW AND EMPIRICAL ANALYSIS</b> .....	<b>19</b>
3.1 Literature review .....	19
3.2 The model and the data .....	31
3.3 Discussion of the estimation results.....	39
3.3.1 The penetration rate estimation .....	39
3.3.2 The price estimation .....	42
3.3.3 The labor productivity estimation.....	45
<b>4 CONCLUSIONS</b> .....	<b>47</b>
<b>Appendices</b> .....	<b>49</b>
Appendix A: Figures and Tables .....	49
Appendix B: Overview of the relationships of China Mobile Limited and China Unicom Limited with their state-owned indirect shareholders.....	57
<b>Reference List</b> .....	<b>59</b>

## List of Figures

Figure 1: Mobile and fixed-line penetration in China 1978-2005 .....	49
Figure 2: Mobile subscribers per 100 inhabitants of chosen countries 1987-2005 .....	50
Figure 3: HHI indices of the cellular sectors in chosen countries 1999-2005.....	51
Figure 4: Country average of revenue per minute in cellular service 1999-2005 (USD) .....	52

## List of Tables

Table 1: Summary statistics .....	53
Table 2: Panel regression of mobile penetration rate (21 countries, 1999-2005) .....	54
Table 3: Panel regression of cellular service price (24 countries, 1999-2005) .....	55
Table 4: Panel regression of labor productivity (18 countries, 1999-2003).....	56



# 1 INTRODUCTION AND OVERVIEW OF CHINA'S ECONOMIC HISTORY

## 1.1 Introduction

The growth of mobile telecommunications worldwide since the 1990s is no less than exceptional. According to ITU (the International Telecommunication Union) statistics, the number of mobile subscribers worldwide increased by 50 percent annually in the 1990s. With the arrival of the new millennium came a milestone for mobile telecommunications. ITU recorded that in 2002 the number of mobile subscribers worldwide overtook that of fixed lines for the first time in history. Among the fast movers, China has been a star performer. While it did not adopt cellular technology until 1987 with 700 subscribers at the outset, by 2001 it already boasted the world's biggest cellular market in terms of mobile subscribers<sup>1</sup>. Undoubtedly technological advance is an important driving force behind this growth, but regulatory design also plays a critical role by influencing market structure and setting the rules of competition. Although rather conservative in privatizing its major telecom operators compared with its more developed counterparts, China has been actively promoting competition in the cellular sector as well as in other telecom service areas since the early 1990s. Despite its significance, there has been little effort devoted to an empirical investigation of the structure and performance of China's mobile telecommunication sector. Indeed, there are few studies of the relationship between cellular sector performance and market structure. To what extent are

---

<sup>1</sup> MII website January 25 2002 cited Wong and Wong 2003.

performance gains, measured by increases in mobile penetration and labor productivity, and reductions in price levels, attributable to market structure? How has China performed in developing its cellular sector relative to other economies and to its declared public policy goals in telecommunications?

This paper attempts to address these questions with an empirical evaluation of the effect of market structure on the cellular sector's performance. This study contrasts China and other countries in terms of the effect of market structure on mobile telephony performance. The study proceeds as follows. Part I describes the general economic environment in which the mobile telephone industry developed in China. A brief economic history of China for the period 1978-2001 is presented outlining the evolution of state-owned enterprise (SOE) reforms and controls on foreign direct investment (FDI). Part II provides a descriptive analysis of the development of the Chinese telecom industry with emphasis placed on the cellular sector. Part III reviews recent relevant literature and presents the model and estimation results. Part IV summarizes the study's findings.

## **1.2 Overview of China's economic history**

China's efforts to reform its SOEs and to attract foreign direct investment can be roughly broken down into several periods.

**Stage 1 1978-1983** (SOE reform in agriculture & foreign trade; experimental period of attracting FDI)

In 1978, the Third Plenary Session of the Eleventh Central Committee of the Chinese Communist Party (CPP) was held, which was a very important conference in the history

of the CPP and China's economic reform. The Plenum established the 'four modernizations' as the main task of the party. This involved the modernization of agriculture, industry, science and technology, and national defense (Wei and Liu 2001). At this time, while the CPP rejected the utopian goals of the Great Leap Forward (1958-59) and the Cultural Revolution (1966-76), "it remained wedded to a version of socialism that included reliance on state-owned enterprises and some form of central planning" (Yusuf et al. 2006, p.51). Nevertheless, a high degree of consensus had evolved on two matters among the decision makers. First, the lack of incentives for farmers was probably responsible for the weak performance of agriculture, which was evidenced by the fact that per capita availability of food had barely improved over the previous twenty years. Second, the bias of the leftist ideologues against foreign technology and imports was disadvantageous for the country (Yusuf et al. 2006). This consensus might well explain the early emphasis on reforms in agriculture, foreign trade policy and the role of SOEs while the central planning of industry remained largely unaffected. One of the most important reform measures undertaken in this period was the negotiated profit retention approach. This reform scheme allowed firms to retain and spend profits above a negotiated specified planned amount.

This period also witnessed China's experiment in attracting FDI. The leadership realized that in order to achieve the 'four modernizations' goal, it was necessary to open up the economy to the rest of the world to attract capital, technology and managerial expertise. The Ministry of Foreign Economic Relations and Trade was established to take charge of foreign investment, foreign trade and related economic issues. A series of laws and

regulations governing FDI were implemented, which included the Law of the People's Republic of China on Chinese-Foreign Joint Ventures (1979) and the Income Tax Law Concerning Chinese-Foreign Joint Ventures (1980). Additionally, four special economic zones (SEZs) were established as an experiment in opening up the Chinese economy. The experiment was viewed as a compromise between the Chinese leaders' aspirations and their ideology. By limiting FDI to the SEZs, the western capitalist system could be used to benefit China's development goals while Chinese socialism and sovereignty would not be undermined (Breslin 1996 cited Wei and Liu 2001). The SEZs were characterized by three features. The economies of the SEZs relied heavily upon foreign investment. Their economic activity was mainly market-oriented, which was in contrast to the economy in other parts of the country that was controlled by the plan. SEZs enjoyed substantial autonomy in their economic activities and were given the right to approve economic projects subject to certain conditions. This experimental period brought in cumulative values of contracted and realized FDI of \$7,742 million and \$1,802 million respectively (Wei and Liu 2001).

**Stage 2 1984-1991** (SOE reform in industry, transfer of power, disruption in the late 1980s; FDI: gradual development)

The year 1984 was marked as a watershed year in the reform of the Chinese industrial system. On May 10, 1984, the State Council promulgated the "Provisional regulations concerning the expansion of the autonomy for state-owned industrial enterprises", which deregulated the control over the state-owned industrial enterprises. For instance, enterprises could sell their above-quota production at their discretion and could even sell

2 percent of the planned production quota, and managers had more latitude in determining the wages of their workers under the reforms (Yusuf et al. 2006). Designed to increase autonomy of state-owned industrial enterprises, these regulations provided the managers greater flexibility in their efforts to improve the enterprises' performance within narrowly defined limits (Yusuf et al. 2006). Five months later, the decision to reform the industrial system was further formalized in a document approved at the Third Plenum of the Twelfth Central Committee. These regulations, combined with the SOE law passed in 1988, replaced the "direct control by the state with a relationship that defined the state as an owner" (Yusuf et al. 2006, p.45). With the new legal status, SOE managers had more discretion over the operation of the business, although they still existed within a centrally planned structure.

In 1984, reform of the banking system was also under way. The single "mono-bank" was broken down into a central bank and four large commercial banks. Despite the restructuring, the credit decisions of these commercial banks continued to be heavily influenced by politicians rather than by the profitability of the projects themselves. As will be shown, this problem remained unsolved for a long period of time and led to a significant amount of nonperforming assets in the banking system.

Another critical step taken by the Chinese government was the promotion of the contract responsibility system in 1987. This system adopted performance contracts, which were negotiated between governments and SOE managers and contained specific performance targets for the SOEs. The system introduced a criterion of evaluating the performance of

SOEs and held managers accountable for the performance results. These managers were given autonomy and incentives to achieve better outcomes. The implementation of the system was accompanied by another change. Industrial inputs became available at market prices to enterprises outside the state plan. This situation was similar to what had happened to the grain market where the government set the prices of grain produced within a quota and allowed free market trade in grain produced outside the state plan<sup>2</sup>. Since the complete liberalization of industrial input prices was unacceptable to many powerful groups, notably the managers of large SOEs and was feared by some reformers as a radical step that would lead to chaotic changes in industrial structure and to inflation (Yusuf et al. 2006), the dual-price system was established. This system determined the prices of goods distributed through administrative channels and decontrolled prices of goods produced outside the state plan.

The deregulation of SOEs combined with liberal access to bank loans ultimately led to a sharp increase in inflation. Between 1962 and 1984, inflation stayed around 2 percent whereas by 1988, this figure had skyrocketed to 20.7 percent (Yusuf et al. 2006). At the same time, corruption was rising, involving government officials who took advantage of the dual-price system. These officials abused their political influence and gained enormous profits by obtaining goods at low prices set by the state and reselling them at the market prices.

---

<sup>2</sup> According to Wu and McErlean (2003), two important reforms were initiated in the Chinese grain market between 1983 and 1985. The first was the free trading of grain between non-government economic agents. The second was increased use of negotiated government purchases. The latter was introduced because the prices set by the central government for procurement quotas failed to encourage the additional supplies needed to meet a growing demand for grain from an expanding urban population. With the reform, the additional supplies needed for 'rationed' sales to urban residents were purchased directly from farmers at over-quota prices and negotiated prices (which tended to be significantly higher than quota prices).

The dissatisfaction over these economic and political developments eventually resulted in the Tiananmen Square event in 1989 and the fall of the then Party Secretary.

Subsequently, the new leaders decided to slow down the reform and to put inflation on hold. Inflation was eventually contained in the early 1990s. The popularity of performance contracting with SOEs declined at this time. The system was found to bring few performance gains, due to inadequate performance measures, information asymmetry between SOE managers and the state, as well as an ineffective compensation and punishment system. Meanwhile, the dual-price system was increasingly undermined by a tendency toward market-determined prices.

FDI was generally increasing during this period. The agricultural reform in 1978-83 had achieved dramatic success in raising agricultural output and incomes, and increasing macroeconomic stability. Moreover, the SEZ experiment was regarded as successful in attracting capital, technology and management skills. As a result, reformers decided to further open up the economy. Fourteen coastal port cities were opened up in 1984 and preferential income tax policies were applied to joint ventures and wholly foreign-owned enterprises in these cities. One year later, three open economic zones (OEZs) were added to the roadmap of open regions in China. They included the Yangtze River Delta, the Pearl River Delta and the south Fujian triangle area. As a result of these reforms, the cumulative FDI in 1984-85 was significantly higher than that in the previous five years (Wei and Liu 2001). However, structural problems of FDI were emerging. Areas including energy resources, raw materials and infrastructure received too small a proportion of FDI compared to the inflow into tourism (Wei and Liu 2001). Following

the promulgation of provisions and regulations intended to encourage investment in these areas, the structural problem started to subside. However, it should be noted that the contracted amount of FDI was declining in 1986 following the implementation of these new regulations and tightened monetary and fiscal policies to contain inflation, before it started to rise again in 1987.

**Stage 3 1992-1996** (SOE reform reinvigorated; FDI rapid expansion in 1992-93, adjustment in 1994-96)

Deng Xiaoping's tour of southern China in early 1992 sparked a heated debate over economic reform across the country and accelerated China's progress towards a "socialist market economy", which was established as the official stated goal of the leadership for the very first time (Naughton 1995 cited Yusuf et al. 2006). The reform agenda was comprehensive, ranging from further liberalization of industrial input prices, adoption of a new enterprise accounting system and the value-added tax (VAT) for all enterprises, to granting firms greater flexibility in hiring decisions. The VAT was intended to reduce the government's reliance on enterprise profits as the major source of revenue. Yusuf et al. (2006) are of the view that the introduction of the VAT was not a difficult decision, especially for SOEs, since many of them were actually making losses following price reforms.

A notable development in this period was the stock market boom. Although China had begun to allow stocks and bonds to be traded on the market in 1986, by 1988 the value of enterprise shares issued only amounted to 3.5 billion yuan, of which only 61 percent were



in the hands of the public (Jiandong 1989 cited Yusuf et al. 2006). The boom arrived in 1993 when 9.6 billion yuan worth of shares were issued and sold. By 1997, this figure had climbed to 1,715.4 billion yuan with former SOEs being the main issuers of the shares. Yusuf et al. (2006) maintain that the listing of SOEs was mainly intended to raise capital and to provide the public with an alternative vehicle for investing their savings. However, the issuance of shares did not affect corporate governance. The government along with the CPP assumed complete control of the selection of top management, and the shareholders did not have any influence in this regard.

Inflation was another important aspect of the economic picture. This problem mainly resulted from the relationship between state-owned banks and other state-owned enterprises. “The banks lent mainly to SOEs and did so either at the request of enterprises or at the behest of powerful political patrons of the state enterprises” (Yusuf et al. 2006, p.73). On the one hand, expansion decisions might not be based on whether the project would be profitable, but on such other objectives as management bonuses and employment. On the other, there was little or no effort to determine whether the project for which money was being sought was a good project likely to produce a high rate of return, enabling the enterprise to pay back the loan (Lardy 1998 cited Yusuf et al. 2006). Bank loans were expanding rapidly in the mid-1990s. Money supply rose dramatically too in response to the easing of credit as well as a growing current account surplus. The resulting inflation rate was brought down by Zhu Rongji, the then head of the central bank, through allocation of credit under administrative controls, but the cause of the problem remained.

FDI underwent a rapid expansion from 1992 to 1993 following Deng's tour of southern China. More sectors and areas were opened up to foreign investment. The newly added sectors included retail, finance, tourism, real estate, shipping and resource development. The inflow of foreign investment slowed from 1994 for a number of reasons. First, competition for FDI was increasing, particularly from other Asian economies, Eastern European transitional economies and South America (Jiao 1998 cited Wei and Liu 2001). Second, unfavorable policies regarding importation of machinery, equipment, parts and other materials by foreign firms were expected to be implemented. As a result, the contracted value of FDI from 1994 to 1996 experienced a continuous decline although realized FDI inflows were still rising due to the FDI contracted in previous years.

**Stage 4 1997-2001** (SOE reform efforts strengthened; declining and then increasing FDI)

While the SOE reform resulted in remarkable progress in price deregulation, increased autonomy of enterprises in their input and output decisions as well as more flexible hiring and firing decisions, the SOEs were still a problem in the view of the government leadership. The losses of SOEs amounted to over 3 percent of the state sector gross industrial output in 1996-98 (Yusuf et al. 2006). However, it was not until the 1997-98 Asian financial crisis that the Chinese leaders fully realized the urgency of speeding up the reform of the fragile banking system and its relationship with the SOEs. A significant number of SOE employees were laid off over a five-year period starting in 1997 in an effort to control the bloated payrolls of the state sector (Yusuf et al. 2006). Meanwhile, the country was starting to build a national welfare system to parallel the ongoing SOE reform. Efforts were also made to alleviate the political pressure on commercial banks.

Four asset management companies were established in 1998 to take over a portion of the nonperforming assets of these banks. Yusuf et al. (2006) hold that these asset management companies have had limited success in selling off the assets they took over and the sale from the disposal of the assets generated not more than 10 percent of the book value of these assets.

The solution to the problem of the problematic relationship between banks and other SOEs was less obvious. Due to the political power of many of the SOE leaders, the economic policymakers could not curb the liberal access of these SOEs to the banks' financial sources. Instead, they actively promoted China's accession to the WTO as a method to speed up the reform of SOEs by exposing them directly to foreign competition (Yusuf et al. 2006).

FDI followed a volatile trend in this period. Due to the Asian financial crisis, realized FDI in 1998 remained basically at the 1997 level, and that of 1999 fell by more than 10 percent. By 2000, contracted FDI had increased by over 50 percent from the 1999 level and realized FDI experienced a slight increase, partly in anticipation of China's imminent entry into the WTO in 2001 (Cheng 2005).

## **2 EVOLUTION OF THE CHINESE CELLULAR SECTOR AND CHINA'S COMPETITION GOALS IN TELECOMS**

### **Stage 1 1978-1993 (Introduction of cellular technology in 1987)**

Prior to the economic reform process launched in 1978, China's telecom industry was extremely backward. The telephone penetration rate was only 0.2% in 1978, lower than more than 140 countries according to ITU statistics. As can be imagined, the poorly developed telecom infrastructure seriously frustrated foreign investment and domestic economic development. The Chinese leaders, well aware of the strategic importance of the telecom industry, implemented a series of preferential policies and reform schemes to speed up development of this industry. The preferential policies included the "three 90%*s*" policies: 90% of profit is retained by the local service provider as against 45% for other industries; 90% of foreign exchange earnings are to be retained by the enterprise; 90% of the central government's investment is considered as un-repayable loans (Wu and Zhang 1992 cited Xu 2002). The contract responsibility system, which came into use in 1987, was also implemented in the telecom industry. Since the effectiveness of performance contracts relied upon reasonable performance measures, the former Ministry of Posts and Telecommunications (MPT), the then regulator and monopoly provider of integrated telecom services, adopted an accounting system to improve the structuring of incentive contracts.

The preferential treatment and reform measures led to a rapid growth of the industry. By the time China introduced cellular technology in 1987, the fixed-line penetration rate had risen to 0.35%, a 75% increase relative to 1978 according to ITU statistics. The economic reform instituted in the late 1970s brought about spectacular economic growth that led to a dramatic expansion of economic activity and consequently a substantial increase in the demand for telecom services. Such demand was further fueled by political liberalization that granted the Chinese people much greater freedom to seek employment away from their hometowns. In addition, the arrival of foreign tourists and investors with China's 'open-door' policy and efforts to attract FDI was creating a rapidly growing demand for international telecom services (Wu 2004). All these factors contributed positively to the growth of cellular service in subsequent years.

**Stage 2 1994-1999** (Establishment of competition and an independent regulator)

In 1994, the former Ministry of Posts and Telecommunications announced that the heavy investment in telecoms over the previous decade had finally established the infrastructure able to satisfy the basic demand of the economy. While this was a laudable achievement, the Chinese government realized that the rapid growth of the telecom industry had mainly resulted from the preferential policy arrangements and huge public investments (Xu 2002). These practices were becoming a great burden on the constrained government budget and a hindrance to achieving economic efficiency because China Telecom, the incumbent monopolist in integrated service provision, did not face any competition. Meanwhile, the industrial reform initiatives starting from 1984 were clearly steering the Chinese economy toward a market economy with ongoing price liberalization and

increasing enterprise autonomy. Subsequently, the government gradually withdrew the preferential policies and accelerated its efforts to move the telecom industry to a market economy mechanism.

As part of its efforts to introduce orderly competition to the telecommunications sector in China, the State Council approved the establishment of Unicom Group in December 1993 and authorized it to build and operate cellular networks and local and domestic long distance networks (China Unicom Limited Form 20-F 2000, p.8).

Two important events marked 1994 as the year of liberalization in the Chinese telecom history. First, the MPT was formally divided into two bodies, the MPT that assumed overall regulatory control and China Telecom which took charge of all business operations. In the same year, the market witnessed the establishment of two enterprises, Unicom Group and Jitong, which were introduced to compete with the monopolist in different service areas. Specifically, Unicom Group was granted a license to provide fixed local, fixed long-distance and mobile services, although it was viewed as a potential national competitor only in the cellular sector. However, the restructuring of the MPT failed to create an equitable playing field for the fragile new entrant. Even after the reorganization, the MPT remained closely related to China Telecom and failed to act as an independent and transparent regulator<sup>3</sup>. This situation continued until in 1998 the Ministry of the Electronic Industry, one of Unicom Group's major shareholders, merged

---

<sup>3</sup> For instance, Wu (2004) states that this lack of independence was evidenced by Unicom Group's major problems when trying to interconnect with China Telecom.

with the MPT and the State Radio Regulation Commission to form the present Ministry of Information Industry (MII) in charge of telecom regulation. A main objective of the restructuring was to “separate the government’s regulatory function from its business management functions in respect of state-owned enterprises” (China Mobile Limited Form 20-F 2000, p.13). The new administrative system made it possible for Unicom Group to compete with the well-established incumbent on a more equitable basis.

The restructuring of China Telecom in 1999 also had an important bearing on the development of the Chinese telecom industry. This giant was dismembered into three companies based upon service areas. The mobile service division was taken over by China Mobile Communications Corporation (CMCC). The operator of the fixed-line services maintained the name China Telecom, and China Satellite was set up to provide satellite telecom services. The paging division of the former China Telecom was incorporated into Unicom Group to support the still tiny competitor. The dismemberment of China Telecom clearly reflected the regulators’ efforts to further promote competition in the mobile service sector by making the size of the two firms more comparable. As a result of this reorganization, the duopoly of China Mobile Communications Corporation and Unicom Group in the mobile service market was established.

Overall, the period 1994-99 was critical for the development of the cellular sector in China. Not only was a second player introduced, but also an independent regulator was set up to ensure a healthy competitive environment. Moreover, the incorporation of the former China Telecom’s paging division into Unicom Group, a preferential practice,

reflected the regulator's interest in enhancing competition. Thus it follows that the competition goals in this period can be inferred from the sequence of reform schemes. It was clear that the regulators sought to break up the extant monopoly and to encourage competition.

**Stage 3 2000-2006 (Inauguration of the Telecommunication Regulations and China's accession into the WTO)**

The main theme of the second stage was echoed and expressed more explicitly in the Telecommunication Regulations that came into effect on September 25, 2000. These regulations provided the primary regulatory framework for China's telecommunication industry in the interim period prior to the adoption of the Telecommunication Law. They were "intended to develop a transparent and fair regulatory environment to foster orderly competition and encourage development in the telecommunications industry" (China Unicom Limited Form 20-F 2001, p.40). Relevant clauses which are closely related to competition goals in a western context include the following.

Clause 4: The regulation of telecommunications should avoid political intervention of business operations, break monopoly and encourage competition in order to promote development, openness and equity.

Clause 5: Telecommunication operators should provide customers with fast, exact, safe, convenient and reasonably priced telecommunication services.

The accession of China into the World Trade Organization (WTO) had important implications for the development of the cellular sector. As has been addressed above, an



important political consideration behind China's bid for WTO accession was to transform its highly centralized planning economy into a socialist market economy mechanism. By exposing the SOEs in all industries to foreign competition around the globe, the Chinese leaders hoped to speed up the SOE reform toward the goal of building a stronger economy. Regarding the telecom industry, this represented a strategic move in that it terminated historical restrictions on FDI in the public telecom network and invited competition into virtually every telecom service area. According to China's commitment under its WTO service schedules, foreign mobile carriers are permitted to establish joint venture enterprises with Chinese firms in the provision of cellular service. Upon accession, foreign investment was restricted to no more than a 25 percent holding in the joint venture, and business operations were confined to Beijing, Shanghai and Guangzhou. One year after accession, the share of foreign investment could be increased to 35 percent and business operations were confined to 17 specified cities. Three years after accession, the share of foreign investment was restricted to 49 percent and business operations were no longer subject to geographical restrictions (Paul et al. 2001 cited Xu 2002).

A review of the development history of the overall telecom industry and mobile telephony reveals the competition goals of Chinese policymakers regarding the telecom industry. As conveyed in the Telecommunication Regulations, the emphasis is on competition, development, price and quality of service. So what is the outcome of these public policy efforts?

As is shown in figure 1, the growth of the mobile penetration rate in China is indeed spectacular. Mobile penetration exceeded the fixed-line penetration rate in 2003. As early as 2001, China was ranked No. 1 in the world with the largest number of cellular subscribers. However, figure 2 shows that China's achievement is overshadowed by its transitional counterparts including the Czech Republic, Hungary and Poland which did not adopt cellular technology until the early 1990s. For the period from 1999 to 2005, all of these transitional economies experienced a rapid growth of mobile penetration, but China's pace was considerably slower. As is displayed in figure 3, in the same period the Herfindahl Hirschman Index<sup>4</sup> (HHI) for the cellular sector in China averaged 5988, much higher than those of the Czech Republic, Hungary and Poland, which averaged 4090, 4257 and 3415 respectively. Regarding service tariffs in figure 4, the price proxy defined by average revenue per minute (RPM)<sup>5</sup> has exhibited a significant downward trend in China since 1999. Moreover, the absolute service tariff in China was much lower than the developed economies. Overall, China has managed to increase mobile penetration and lower its cellular service tariff notwithstanding an exceptionally high level of market concentration, which is eroding very slowly. How much of the performance gains, in terms of mobile penetration, service tariffs and labor productivity, can be attributed to market structure? An empirical analysis is presented in Part III to evaluate the role of market structure in explaining China's performance in developing its cellular sector relative to other economies and to its declared public policy goals.

---

<sup>4</sup> The HHI is a commonly used indicator of market concentration. It is calculated as the sum of the squares of market shares and therefore ranges in value from 10,000 (a monopoly) to a small number (a very large number of suppliers with very low market shares).

<sup>5</sup> RPM is the weighted average of revenue per minute of mobile carriers based on their market shares in a specific country. According to the research methodology in Merrill Lynch Global Wireless Matrix 2Q04 and 3Q06, revenue per minute is equal to average revenue per user per month (ARPU) divided by average minutes of usage per user per month (MOU) in the voice business of a mobile cellular carrier.

## **3 LITERATURE REVIEW AND EMPIRICAL ANALYSIS**

### **3.1 Literature review**

There are numerous studies of the effect of market structure, defined by telecom policy reform variables including the introduction of competition, privatization and the establishment of an independent telecom regulator, on the performance of basic telecom services, although few of these studies are devoted exclusively to the cellular sector. While there is diversity in the performance measures and control variables chosen, the policy variables typically included in these studies are measures for competition, privatization and regulation. These telecom policy variables mostly take the form of a dummy variable in previous studies, due to the fact that data on the degree of competition, privatization and effective regulation are often limited. Various empirical approaches have been taken to address this issue. Many of these studies employ fixed effects estimation, while some have attempted feasible generalized least squares and random effects specification. There is a general consensus from these studies that competition, establishment of an independent telecom regulator and full privatization can improve performance. However, like other performance studies that evaluate the effect of structure, research in this area is often criticized for ignoring possible endogeneity of the policy variables. Several recent studies have employed different techniques, most of which involve the use of instrumental variables, to deal with this problem.

This paper studies the relationship between market structure and performance for the cellular sector, a topic that has been little explored in an environment of spectacular growth of mobile telecommunications. Furthermore, it contrasts China with a group of approximately 24 countries, mostly developed OECD economies, in terms of how different market structures lead to diverging performance outcomes.

The relevant literature reviewed in this paper adopts a similar model specification:

$$y_{it} = \alpha + \beta X_{it} + \gamma C_{it} + \delta t + \theta_i + \varepsilon_{it}$$

where:

$y_{it}$  are various telecom performance measures such as teledensity, per capita number of mainlines, labor productivity, investment and service pricing.

$X_{it}$  are telecom policy variables and typically include dummy variables of competition, privatization and regulation. The definitions of these dummies are very similar across these studies. For example, a competition dummy takes on 1 if there is competition for a specific service field and 0 if the field is serviced by a monopoly. The existence of a separate regulatory agency gives the regulation dummy a value of 1 and 0 otherwise. Privatization is a dummy that takes on 1 if at least 50 percent of the assets of the main provider of basic telecom services are privately held.

$C_{it}$  are a set of control variables. Among them GDP per capita, population and population density are the most often included ones.  $t$  is a time trend intended to control for such

factors as technological change and service improvement.  $\theta_i$  is the time-invariant country-specific effect and  $\varepsilon_{it}$  is the idiosyncratic error term.

Li and Xu (2004) investigate the impacts of privatization and competition on employment, investment, output, service pricing, network expansion in both the fixed-line and the mobile market segments, labor productivity, and total factor productivity (TFP) in the telecom sector. Their baseline regression analysis estimates a fixed effects treatment response equation with a panel data set of 177 countries for the period from 1990 to 2001. They incorporate full privatization, partial privatization and competition as the telecom policy variables. The competition variable is defined to be 0 when a national monopoly exists in the whole telecom sector, 1 when there is competition in either the fixed-line or the cellular segment, and 2 when there is competition in both segments. The control variables are a series of country economic indicators including population, share of urban population, GDP per capita and the consumer price index. The results indicate that full privatization brings about significant performance gains while partial privatization shows no significant impact. The increase in competitive pressure contributes substantially to growth in the industry by raising both factor inputs and total factor productivity. To deal with possible endogeneity of the privatization and competition variables, they use specific political economy variables as instrumental variables and find the results are not qualitatively different from those in the baseline regressions. It should be noted that their definition of the competition variable dictates that it is not possible to disentangle the direct effect competition in each segment has on performance in that segment as pointed out by Fink et al. (2003).

This study is comparable to Li and Xu (2004) in several ways. First, it also applies fixed effects estimation to the baseline regression and takes account of possible time-series autocorrelation within each country with robust standard errors. Second, a competition variable is constructed with the HHI index, which is more informative of the actual degree of competition than the competition dummy in Li and Xu (2004). Moreover, endogeneity of their competition variable is likely because the decision to allow competition is made by officials based on their observation of the performance in the field and expected outcome of increased competition. Such reasoning, however, does not apply to the HHI index which is the direct outcome of competition. Third, this study provides improvement over Li and Xu (2004) in the sense that it shows the direct effect competition in a particular telecom sector has on the performance of that sector.

Fink et al. (2003) analyze the effects of privatization, competition and regulation on the fixed-line sector's performance measured by teledensity and labor productivity. Teledensity is defined as the number of landline telephones in use for every 100 individuals living within a country, and labor productivity is defined to be mainlines per telecom employee. They employ feasible generalized least squares on a panel data set of 86 developing countries over the period 1985-99. Their policy measures are a privatization dummy that takes the value 1 if an incumbent has been partially or fully privatized, a competition dummy and a regulation dummy variable that equals 1 if a separate regulatory agency exists. GDP per capita and population are the control variables. The results suggest that complete liberalization, which is characterized by privatized incumbents, additional competitors and a separate regulator, leads to higher

teledensity and labor productivity. While both privatization and competition contribute to performance, the latter is found to reinforce the former. To take account of the effect of the development of mobile telephony on fixed-line teledensity and productivity, they include the fitted value from a first stage regression of the natural log of (1+mobile penetration rate) on a time trend, country fixed effects, natural logs of per capita GDP and population, and a dummy variable representing competition in the mobile segment. However, the competition dummy variable for the mobile segment is likely to be correlated with the error term in the regressions of fixed-line performance variables. Therefore, it does not serve as a valid instrumental variable.

Several aspects of this study are related to Fink et al. (2003). First, this study also accounts for the existence of potential heteroskedasticity. The heteroskedasticity correction makes the estimation far more efficient than an ordinary fixed effects panel estimation (Baltagi 1995 cited Fink et al. 2003). Second, the performance variables chosen are similar. This paper uses the mobile penetration rate, an equivalent of teledensity in the fixed-line sector. It also attempts to measure labor productivity, defined as the number of cellular subscribers per mobile industry employee. Third, this paper uses the same definition for the regulation variable but a more informative competition variable.

Wallsten (2001) explores how privatization, competition and regulation affect telecom performance including the per capita number of mainlines, payphones and network connection capacity as well as the price of a three-minute local call. The main approach is a fixed effects regression on a panel data set of 30 African and Latin American countries

from 1984 to 1997. The privatization and the regulation variables are defined in the same way as in Fink et al. (2003). The degree of competition is constructed as the number of mobile operators not owned by the incumbent telecom operator. The control variables include per capita income, share of urban population, population, exports as a share of GDP, a dummy indicating whether the country passed telecom reform legislation and several other indicators. Wallsten concludes that competition provides positive improvement in performance measures including the per capita number of mainlines, payphones and network connection capacity as well as the price of a three-minute local call. In addition, he takes the position that privatization alone generates few benefits, but when combined with the establishment of an independent regulator it can result in performance improvement. To account for possible endogeneity of competition, privatization and regulation, Wallsten includes country fixed effects to control for a country-specific propensity to reform and year fixed effects to control for general trends of changes in telecom service. However, there can be some time-varying and country-varying unobserved factors which show up in the idiosyncratic error term and affect competition, privatization and regulation. Without the use of instrumental variables, his approach is not likely to resolve potential endogeneity.

A number of features link this paper to Wallsten's research. Both studies use fixed effects estimation. The competition variable based on the HHI is an improvement over that of Wallsten. As argued by Fink et al. (2003), Wallsten's competition variable is an inadequate measure of competition considering the fact that many countries have introduced competition in mobile services while maintaining a monopoly in fixed-line



services. Furthermore, the use of RPM as a price proxy overcomes some of the drawbacks of the rate of a three-minute fixed telephone local call (peak rate) used by Wallsten. He rightly acknowledges that the price data based on the rate of a three-minute local call are difficult to analyze for several reasons. For example, the rate of a three-minute fixed telephone local call (peak rate) is defined as the cost of a peak rate three-minute call within the same exchange area using the subscriber's own terminal (ITU Indicators Definition 2007). However, the size of a local exchange area may differ dramatically, which may reduce the comparability of the data across countries. Also, as Wallsten points out, the fixed-line service provided to households is often subsidized, which makes the price information unreliable.

The equivalent in cellular service of the price of a three-minute fixed-line telephone local call is the price of a mobile cellular three-minute local call, defined as the rate of a three-minute peak or off peak call from a mobile cellular telephone to a mobile cellular subscriber of the same network (ITU Indicators Definition 2007). Although it is unclear to what extent cellular service tariffs will be distorted by cross-subsidization practices, the data on cellular service tariffs published by ITU do suffer from comparability problems. The size of a network may be very different across countries and this will likely affect the tariffs. In fact, as a product differentiation strategy, operators with national coverage can charge a higher price than operators with smaller coverage. In contrast, RPM does not impose such restrictions in the calculation of tariffs. Moreover, it is more informative of the actual cost of cellular service because it takes into account not only the cost of a local call, but also the costs of a long-distance call and value-added

services. However, the effectiveness of RPM as a price indicator relies crucially on a relatively stable structure of an average consumer's consumption of different products in cellular service. This may not be satisfied due to differing income elasticities of demand for different cellular service products and due to the introduction of new service features for certain products. For example, if long-distance calling can be shown to be more income elastic than local calling, then consumption of long-distance calls will rise more rapidly than that of local calls with the increase of income. Because cellular telecoms generally price long distance calls higher than local calls, the change in mix will lead to a higher RPM notwithstanding the fact that the price of each service remains the same. Also, in a case where the long-distance call tariff and the local call tariff are stable and the former is higher than the latter, if consumption of long-distance calling for an average consumer increases substantially due to some new service features while the consumption of local calling remains the same, the RPM will be biased upward and serve as a poor approximation of price over time. Since introduction of new service features is very common in a cellular sector, it is important to be aware of the disadvantage of RPM in adjusting for structural changes in consumption.

Ros (1999) examines the effects of competition and privatization on network expansion and efficiency. The fixed effects estimation procedure he employs in his study of 110 countries from 1986 to 1995 is followed by many other researchers. Network expansion is measured by the number of mainlines per 100 inhabitants and efficiency is the number of mainlines per employee. The competition dummy indicates if a country permits competition in its local, long distance or international service. Privatization is a dummy

that takes on 1 if at least 50 percent of the assets of the main provider of basic telecom services are privately held. Control variables encompass GDP per capita lagged 1 year, investment per line lagged 1 year and prices (price of a three-minute local call, residential and business initial connection and monthly recurring charges). He finds that privatization is associated with significantly more mainlines per 100 inhabitants and more mainlines per employee. By contrast, competition has a positive effect on network expansion and efficiency although the effect is significant only in the case of efficiency. Ros deals with possible endogeneity of the competition and privatization dummies with an instrumental variable technique that involves the use of a logit model.

The relationship between Ros's work and this study can be summarized as follows. First, the performance measures in this study include the mobile penetration rate and the number of cellular subscribers per employee, similar to the performance indicators used by Ros (1999) and Fink et al. (2003). Second, the competition variable based on the HHI is a better indicator of the degree of actual competition. By contrast, Ros defines the telecom regime to be competitive as long as any one of the local, long distance, or international segments is competitive. Fink et al. (2003) point out that Ros's competition variable might not reflect competition in the local fixed-line segment, the most relevant influence on mainline penetration. Third, the treatment of price data is different. Price is included as an independent variable in his estimation of mainline penetration and number of mainlines per employee. It can be argued that the dependent variables can also affect prices, leading to endogeneity problems which Ros does not account for. In my view, it is more reasonable to use price as a performance indicator, achieved through the interaction

of competition, regulation and a series of country economic characteristics. Following Wallsten (2001), this study treats price as one of the dependent variables.

In sum there are four distinguishing features of this study. First, it focuses on the relationship between market structure and performance in the cellular sector and contrasts China with a group of countries, mostly advanced OECD economies. So far there has been little empirical investigation of the competition status and performance of the Chinese cellular market in the context of a comparative study. This paper should add to understanding in this regard.

Second, the definition of the competition variable, and the treatment of the effects of regulation and privatization are different. The HHI index is used as the competition variable and an indicator of market structure. This represents an improvement over previous telecom performance empirical studies, which typically use a competition dummy that does not provide continuous and precise information on the intensity of competition. However, caution should be taken in the interpretation of the HHI as a measure of market structure. According to the International Competition Network (ICN) report on merger guidelines, to calculate market share presupposes the definition of a market and the identification of the firms participating in it; it is therefore necessary to define the market and make sure these calculations correspond as closely as possible to market realities. A precise definition of a geographic market would seem particularly relevant for a cellular sector often featuring a few large firms that do not compete in the same region. A relevant geographic market is typically defined as the area in which the

firms concerned are involved in the supply of products or services and in which the conditions of competition are relatively homogeneous. In a case where only some firms operate a network with national coverage while the others compete only in regional markets, market share data in terms of subscriber base in the national market are not based on the relevant geographic market. As a result, the HHI index is likely to underestimate the competitiveness of regional markets. Since the HHI index used in this study is calculated from market shares of total subscribers for cellular operators on a national basis, its merit as a market structure measure should be weighed against its disadvantage.

A regulation dummy is constructed in the same way as in previous studies. However, it is included in the regression of mobile penetration rate only where the regulation variable has slightly more variation. In the samples for the price and productivity estimations to be addressed below, almost all of the included countries had already established an autonomous telecom regulator prior to 1999, the first year of the sample time period. As a result the regulation variable is excluded from these two regressions. Privatization does not show up explicitly in the baseline regression due to lack of data. If it produces a time-invariant effect on telecom performance, then it will be captured in the country specific effects. If its effect varies with time, it is likely to affect performance through its impact on the competition status measured by the HHI index. For example, a privatized firm is likely to have much more diversified capital resources that can be used to invest in technology and to enhance productive efficiency. The strengthened competitive

advantage will earn the firm a greater market share and market concentration, as measured by the HHI index, varies accordingly.

Third, this paper uses average revenue per minute as an indicator of cellular service tariffs, which is likely to be a better price indicator than the price of a mobile cellular three-minute local call published by ITU, the equivalent of the fixed-line service price indicator Wallsten (2001) uses in his paper. The ITU cellular tariff data may offer poor inter-country comparability based on its definition and do not reflect the true consumer cost of cellular service containing many product offerings. Furthermore, the supplementary notes of the ITU in its definitions of telecom service tariffs caution that because most countries now have some form of competition in at least one market segment, there may not be a standard tariff. These notes also suggest that it is preferable to report tariffs in national currency. While not without its disadvantage, RPM enhances comparability of tariff data across countries and takes into account the weighted cost of different cellular service products.

Fourth, basing the competition variable on the HHI avoids an endogeneity problem encountered in other studies. The competition variable in earlier studies is usually defined as a dummy that equals 1 if a country permits competition in a certain telecom service field and 0 otherwise. Since the decision to allow competition is made by officials based on their observation of telecom performance and expected outcome of increased competition, the competition variable defined this way may suffer from endogeneity. In contrast, because the HHI index represents the outcome of competition rather than a

policy decision, the endogeneity argument does not apply. Regarding the regulation variable, it is included only in the regression of mobile penetration where all countries had had an autonomous telecom regulator before 1999 except two which did so in 2000, the second year into the sample period. This means out of the 147 observations of the regulation variable in the sample, only 2 of them take on the value 0. Due to the little variation of this variable, endogeneity is not likely to be a serious problem if it does exist. Therefore, this paper does not account for endogeneity.

### **3.2 The model and the data**

This part provides an empirical evaluation of the effect of market concentration on the cellular sector's performance. The emphasis is placed on the performance of the Chinese mobile telecom industry relative to other economies and its public policy goals in telecoms. Three performance measures are chosen: mobile penetration rate, price and labor productivity. The mobile penetration rate measures network expansion in the cellular sector, the equivalent of teledensity for the fixed-line sector which is usually included as a telecom performance measure in previous studies. Labor productivity in terms of the number of cellular subscribers per mobile industry employee, is similar to the labor productivity measure used by Ros (1999) and Fink et al. (2003), who define it as the number of mainlines per employee. Price is treated as a performance measure following Wallsten (2001). It is proxied by the average revenue per minute of mobile carriers weighted by their market shares in a specific country.

The main variable of interest is the HHI index, the indicator of market structure and competition. An interaction term of the HHI index and a dummy named China is also

included in the regressions of mobile penetration and price. This dummy is given the value of 1 if the country is China and 0 if otherwise. The purpose of the interaction term is to quantify the difference between China and the other countries regarding the effect of market structure on performance. Control variables include the number of years after the liberalization of a country's cellular sector, whether a country has established a telecom regulatory authority that is autonomous in its decision making in a specific year, population and GDP per capita.

Boylaud and Nicoletti (2000) include the prospect of liberalization, measured by the number of years remaining before liberalization of each market in their study of cellular sector performance. They find that the prospect of liberalization has a positive effect on productivity. Moreover, they suggest that the liberalization variable might be catching other factors that have an important bearing on the performance of incumbents over the sample period and are only partially accounted for in the regression. They further argue that in many countries the liberalization commitment has been matched by a process of regulatory and industrial adjustment involving corporatization, privatization, and changes in pricing practices (with the introduction of price caps and price rebalancing). Therefore, the study here uses a liberalization variable, defined as the time that has passed after liberalization<sup>6</sup>, to capture the effect of the liberalization process on cellular sector performance. While many previous studies have treated the regulation variable as a variable of interest, it is included in this study only as a control for important regulatory changes. As has been argued above, if endogeneity can be shown to arise from the

---

<sup>6</sup> Except for Argentina and Brazil, all the countries in the three samples had liberalized their cellular sectors prior to 1999, the first year of the sample period.



inclusion of the regulation variable, it will be a minor problem. GDP per capita is included by most relevant studies as a control for country economic characteristics and it is found to be significant in most of these studies<sup>7</sup>.

In the regression of mobile penetration rate, China is included along with 20 OECD countries for the data period 1999-2005. The sample of the regression of cellular service price in the same data period comprises not only China and major OECD economies, but also India, Russia, South Africa and several countries in Latin America. As for the productivity regression, all 18 countries included are OECD member states and the data period is 1999-2003. China is not included in this estimation due to lack of data on the number of mobile employees.

The baseline model to be estimated is:

$$y_{it} = \beta_0 + \beta_1 HHI_{it} + \beta_2 Libera_{it} + \beta_3 Re\ gu_{it} + \beta_4 GDP_{it} + \beta_5 t + \beta_6 Popu_{it} + \theta_i + \varepsilon_{it}$$

Definitions of the variables are as follows:

$y_{it}$  refers to the three performance measures: mobile penetration rate, price and labor productivity.

$HHI_{it}$  is the sum of the squares of market shares of cellular service providers in a specific country used to indicate the degree of market concentration. It is computed based on whole percents and ranges in value from 10,000 to a very small number. Market

---

<sup>7</sup> See Fink et al. (2003) and Ros (1999) for instance.

concentration influences the output and price choices of competitors and therefore the performance measures used in this study.

$Libera_{it}$  is defined as the number of years after the liberalization of a country's cellular sector. It is expected that the earlier a country liberalizes its cellular mobile market, the more benefits will result when operators have to compete for market share by reducing cost and upgrading their services early on. Moreover, it is likely that early liberalization serves to facilitate privatization of telecom operators and cultivate an effective regulator who has to adapt to a constantly changing competitive environment in the market. Therefore, this variable will likely affect the performance measures.

$Regu_{it}$  is a dummy variable that equals 1 if a country has established a telecom regulatory authority which is autonomous in its decision making in a specific year and 0 otherwise. An independent telecom regulator is expected to make decisions to promote healthy competition in the market and therefore contributes to mobile penetration and productivity growth as well as a price structure in line with cost. As a result, it is included in the regression analysis to indicate a country's propensity to undertake pro-competitive regulatory reforms.

$GDP_{it}$  is GDP per capita measured in USD in the penetration and productivity regressions and it is measured in local currency in the price regression. Since GDP per capita is expected to affect the demand and supply of cellular service and thus the performance measures, it is included in the baseline model as a control variable.

$Popu_{it}$  is the population of a country in a specific year. As an important macroeconomic indicator, it is expected to impact the demand and supply of cellular service.

$t$  is a time trend included to capture the effects of technological change and service upgrade.

$\theta_i$  is a country-specific effect meant to control for time-invariant factors that influence cellular sector performance but do not show up in the regression explicitly as these factors are either unobservable or difficult to quantify.

$\varepsilon_{it}$  is the idiosyncratic error term.

The main data sources are ITU World Telecommunication Indicators 2006, ITU official website, Merrill Lynch Global Wireless Matrix 2Q04 and 3Q06, OECD Telecommunications Database 2005, various issues of F-20 forms of China Mobile Limited and China Unicom Limited. Moreover, information on the year of liberalization of cellular markets is obtained from several BuddeComm reports on mobile communications markets and Boylaud and Nicoletti (2000). Specifically, the market share data are mainly obtained from Merrill Lynch Global Wireless Matrix 2Q04 and 3Q06 except for China whose market share data in the Merrill Lynch research reports

represent a very crude estimate of the actual market structure. China Mobile Limited<sup>8</sup> and China Unicom Limited, the two listed cellular operators, are indirectly held by state-owned China Mobile Communication Corporation and Unicom Group respectively<sup>9</sup>. The two listed operators aggressively sought expansion through acquisitions of mobile telecommunication operations, which were conducted by their indirect controlling shareholder's regional subsidiaries, after their initial public offerings (IPO). The geographical coverage of each cellular operator was therefore constantly changing with the acquisitions, making it difficult to find out the exact market share in terms of subscriber base on a national basis. For instance, when issuing an IPO in 1997, China Mobile Limited's initial mobile telecommunication operations only included those in Guangdong and Zhejiang provinces. Now it operates in all of the thirty-one provinces, autonomous regions and directly-administered municipalities in Mainland China. In contrast, China Unicom Limited started with nine provinces and three municipalities in the year of its IPO and currently operates in thirty provinces, autonomous regions and directly-administered municipalities. Due to the differing geographic coverage, the market share data reported by both do not add up to 1 in a specific year. However, since both adopted the strategy of acquiring the assets of mobile telecom operations in the more developed regions before reaching out to the historically less developed areas, the measurement problem is alleviated to a great extent. For example, the market share data reported by China Mobile Limited for the years 2001-03 are 72.4%, 67% and 64.8%. For

---

<sup>8</sup> According to China Mobile Limited Form 20-F 2005, the company was incorporated under the laws of Hong Kong on September 3, 1997 as a limited liability company under the name "China Telecom (Hong Kong) Limited". It changed its name to "China Mobile (Hong Kong) Limited" on June 28, 2000 and to "China Mobile Limited" on May 29, 2006.

<sup>9</sup> A brief overview of the relationships of the two listed companies with their indirect state-owned shareholders is presented in Appendix B.

China Unicom Limited, the corresponding figures are 28.5%, 33.1% and 34.6%<sup>10</sup>. To calculate the HHI index, I use the market share data of China Unicom Limited directly and subtract the corresponding figure in a specific year from 1 to find out the market share data of China Mobile Limited.

Following Boylaud and Nicoletti (2000), I employ both fixed effects and random effects regressions on a baseline model consistent with that in the literature reviewed. These two estimations differ mainly in their treatments of the unobserved individual effects  $\theta_i$ . The fixed effects model allows  $\theta_i$  to be correlated with the included variables and models  $\theta_i$  as a parameter in the model. The fixed effects approach always gives consistent results, but it may not be the most efficient model to estimate. As a dummy variable approach, it is costly in terms of degrees of freedom lost.

If it can be assumed that the individual effects are uncorrelated with the other regressors, “then it might be appropriate to model the individual specific constant terms as randomly distributed across cross-sectional units” (Greene 2002, p.293), which is the random effects approach. “The payoff to this form is that it greatly reduces the number of parameters to be estimated” (Greene 2002, p.294) and produces more efficient results, but at the cost of possible inconsistent estimates if the assumption turns out to be inappropriate.

---

<sup>10</sup> These figures are reported in various issues of F-20 forms of China Mobile Limited and China Unicom Limited.

In order to choose from the two approaches, the Hausman test is used in all the regressions. The test is based on the idea that under the hypothesis of no correlation between individual effects and the included variables, both ordinary least squares (OLS) in the least squares dummy variable (LSDV) model and generalized least squares (GLS) are consistent, but OLS is inefficient, whereas under the alternative, OLS is consistent but GLS is not (Greene 2002). “Therefore, under the null hypothesis, the two estimates should not differ systematically” (Greene 2002, p.301). Based on the test, if the null hypothesis is rejected, it is appropriate to use the fixed effects approach for consistency.

However, according to the Stata statistical software reference manual (2003), there may be a "small sample" problem with the Hausman test. Hausman's test is based on estimating the variance of the difference of the estimators by the difference of the variances of the two estimators. Under the assumptions underlying the consistent and efficient estimators, the difference of the variances of the two estimators is a consistent estimator of the variance of the difference of the estimators, but it is not necessarily positive definite "in finite samples". If this is the case, the Hausman test is undefined. Furthermore, the reference manual indicates that this is not a rare event. I encounter this problem in the regressions of the three performance measures. Therefore, the reported results of the Hausman tests are not credible and should not serve as the basis for the choice between the random effects and fixed effects treatments. Rather, the random effects approach should be chosen when it can be assumed that the individual effects are uncorrelated with the other regressors. If this assumption is not credible, the choice should be the fixed effects estimation.

This paper also accounts for potential within-country heteroskedasticity and reports heteroskedastic-robust standard errors for the fixed effects regression. Such a correction for potential heteroskedasticity is unnecessary for the random effects regression. As a GLS approach, it can produce efficient results.

### **3.3 Discussion of the estimation results**

#### **3.3.1 The penetration rate estimation**

Table 2 presents both the fixed effects and random effects estimations for a panel of 21 countries in 1999-2005. The OECD member countries include the more developed economies such as Finland, Sweden, the UK and the US as well as transitional economies including the Czech Republic, Hungary and Poland. It should be noted that China has the lowest GDP per capita and mobile penetration rate in the sample and the gap between China and the included transitional economies is large.

It is found that the HHI has a statistically significant negative impact on the mobile penetration rate in all three regressions. This lends strong support to the benefit of competition in the promotion of mobile service. If the mobile carriers have to compete very hard in order to retain the existing customers and expand the customer base, they are more likely to make good efforts to enhance the quality of service and to make the service more affordable than if they are in a highly concentrated environment. Demand for mobile service, reflected by the mobile penetration rate, increases in response to the enhanced service.

Caution should be taken in the interpretation of the coefficient on the interaction term, which is positive and significant. The results indicate that high market concentration in China does not have as strong a negative effect on mobile penetration compared with the other countries in the sample. If the fixed effects model is supported, then there is also a negative relationship between mobile penetration and market concentration in China based on the magnitudes of the coefficients on the HHI and the interaction term. If the random effects model is more appropriate, the results indicate that high market concentration contributes to mobile penetration in China. Information on the correlation coefficient between the HHI index and mobile penetration may be helpful here. For the whole sample it is -0.27097, and for China alone it is -0.84247. If the assumptions of the fixed effects model are credible, creating a more competitive environment is meaningful for China in promoting cellular service, which has one of the most highly concentrated cellular sectors in the world.

In the random effects model, since the liberalization variable and the time trend are highly correlated and both included, a significant coefficient can be estimated for only one of them. The liberalization variable is excluded from the fixed effects estimations. It is linear in the time trend and the country fixed effects; therefore it cannot be identified separately from them.

The regulation variable has a positive and statistically significant coefficient in the random effects regression and the fixed effects estimation without accounting for potential within-country heteroskedasticity. When interpreting its coefficient, it should be



noted that as there is little variation in the regulation variable which is included only to control for the effect of important regulatory change. In fact, all the countries had had an independent telecom regulator in place prior to 1999 with the exception of the Czech Republic and Poland where such a regulator was introduced in 2000.

The coefficient of GDP per capita shows an unexpected negative sign in all three regressions. The correlation coefficient of GDP per capita and mobile penetration is 0.47 for this sample, which is mainly composed of the more developed OECD economies. With an average annual GDP per capita of 22,912 USD and a penetration rate of 69%, the sample potentially suffers from selection bias.

The time trend is found to significantly increase mobile penetration in all three estimations. This indicates that factors including technological and service innovation as well as more affordable handsets, which are expected to be accounted for by this variable, do play an important role in cellular network expansions.

Interestingly, population is estimated to be significantly negatively associated with mobile penetration. Population is a very important macroeconomic indicator and it has direct implications for the supply and demand of telecom services. Although a bigger population might represent a greater demand, it is likely that a country with a bigger population is also one with a more dispersed population across a vast land. In such a case, the cost of setting up cellular networks with national coverage will be much higher and mobile penetration growth could be negatively affected.

To account for the presence of arbitrary heteroskedasticity, a fixed effects model with robust standard errors is also estimated. The results do not systematically differ from those of the fixed effects model without considering heteroskedasticity except that the interaction term becomes more significant and the regulation variable becomes insignificant.

### **3.3.2 The price estimation**

As defined above, the price of mobile service is proxied by the average revenue per minute in a specific country. Revenue per minute is calculated based on data of average revenue per user per month (ARPU) and average minutes of usage per user per month (MOU) in the voice business of mobile cellular carriers. Dividing ARPU by MOU gives revenue per minute.

The countries included in this sample of 24 countries are much more diversified than the previous sample. Inclusion of such emerging telecom markets as India, Russia, South Africa, Brazil and Argentina are expected to lessen the potential selection bias the previous sample may suffer from. Considering the volatile exchange rate relative to USD in certain countries, RPM is not converted to USD but instead is measured in local currency to show the pricing pattern. Correspondingly GDP per capita is also measured in local currency.

For all three estimations, the HHI is highly significant but its coefficient shows an unexpected negative sign. The negative sign might be counterintuitive but can be reasonably explained. First, the RPM might not capture all aspects of competition in the

cellular service markets. Product differentiation serves as a good example. Firms do not always resort to price competition for a bigger market share. They can, in many cases, compete effectively with product differentiation techniques. Building mobile telecom networks with differing coverage is one of them. According to Gruber (2005, p.178), “if firms have ability to differentiate their product by coverage, this may have important implications for market structure”. In other words, operators with national coverage can charge a higher price than operators with smaller coverage; therefore price competition can be relaxed by building networks of differing coverage (Gruber 2005). Moreover, firms can also lock in customers with incompatible standards, SIM card and phone numbers<sup>11</sup>. This might explain the coexistence of a competitive market structure and a high RPM. Second, the credibility of RPM as a price measure might need to be taken with caution. As has been addressed above, the quality of RPM as a price indicator relies crucially on a relatively stable structure of an average consumer’s consumption of different cellular service products. With differing income elasticities of cellular service products and rapid technological innovations in the sector, this condition might not be satisfied. Moreover, cellular service often comes with a variety of options including prepaid service and monthly accounts with or without contractual agreements. Service providers often offer promotion packages involving subsidizing the purchase of handsets. In addition, there are different rates charged for use in the daytime, at night, as well as in the weekends and weekdays. Considering the complexities of these fee schedules, RPM might only be able to give a crude estimate of the actual price level.

---

<sup>11</sup> The SIM lock makes a handset usable only with a given SIM card issued by a specific service provider. As to the phone number lock-in, since each firm owns a series of dialing codes, changing the firm requires the customer to change the telephone number at the same time, which commonly involves an extra cost. See Gruber (2005) for a detailed discussion.

The coefficient on the interaction term is positive and it is significant only in the random effects model. Again, information on the correlation coefficient of RPM and the HHI might be helpful in the interpretation of this result. For the whole sample, the correlation coefficient is 0.052 whereas for China it is 0.894. This implies that compared with other countries in the group, a high market concentration in China is less likely to decrease the price level of cellular service proxied by RPM.

GDP per capita is estimated with a positive and significant coefficient. This is consistent with the notion that telecom service is a normal good. When consumers on average are getting wealthier, demand for this service will go up and an upward pressure on price will result.

The time trend is estimated to decrease the service price and this effect is significant in the fixed effects regressions. A bigger population is also shown to have a negative impact on cellular service price. A possible explanation is that populous countries might roll out their cellular networks in densely populated regions first, enabling them to cut down on network expansion costs and to lower service tariffs. For instance, the two Chinese cellular operators both launched their businesses in the developed coastal areas before they reached into backward provinces in western China.

The fixed effects estimation with robust standard errors slightly improves the significance of the fixed effects model, although the results are not qualitatively different.

### **3.3.3 The labor productivity estimation**

Based on data availability, this sample includes only 18 countries for the data period 1999-2003.

The HHI has a positive coefficient and it is significant in all the three regressions. The positive sign of its coefficient is worth careful inspection. Labor productivity, which is defined as the number of mobile subscribers per employee, is dictated by investment in human capital and physical capital. Workers equipped with advanced skills and up-to-date technology are likely to handle their customers more efficiently and each employee can be responsible for a greater number of subscribers. A highly concentrated market dominated by a small number of operators will behave poorly in terms of labor productivity only when the industry is underinvested. However, empirical evidence suggests that high market concentration is associated with high profit margins. This might imply that the dominant operators are better able to pay investment bills. Moreover, to maximize profit, these firms have the motivation to enhance labor productivity and cut down on labor cost. Therefore, if high concentration is positively correlated with capital investment it stands to reason that it will also be positively associated with labor productivity, although it is potentially negatively correlated with capital productivity if the increase in capital investment outweighs the increase in subscribers.

GDP per capita is estimated with a statistically significant negative sign. Two arguments might explain the sign. First, since the countries included are mainly the more developed OECD countries with the Czech Republic and Hungary being the only two transitional economies, the sample could suffer from selection bias. Second, while this result seems

to suggest that richer countries have a less productive cellular sector, it should be noted that the productivity measure itself is not perfect in that it does not account for the quality of cellular service provided. It is possible that wealthier countries have a better customer service system in the sector. For example, they might have more staff in call centers ready to address customer concerns and improve customer experience. If the number of staff rises more rapidly than the number of subscribers, such a quality component might serve to decrease the measure.

The time trend shows the correct sign and is also significant. This implies those factors that are not easily quantified such as advancing technology, growing variety of mobile service and more affordable handsets can contribute to productivity by improving mobile staff's efficiency and bringing in more customers.

The regulation variable is excluded as there is little variation in the variable across the countries over the sample period. In fact, the Czech Republic is the only country in the sample which established an autonomous telecom regulator within the sample period and it did so in the year 2000. The liberalization variable is not included in the fixed effects estimations because it is linear in the time trend and country fixed effects. The population variable is estimated with a negative coefficient in fixed effects regressions and the effect is significant only in the case of the fixed effects treatment with robust standard errors. By contrast, its coefficient is positive in the random effects regression.

## 4 CONCLUSIONS

Overall, the empirical results indicate that competition, as reflected by the HHI measure of concentration, can increase mobile penetration. The negative relationship between market concentration and price levels, as measured by average revenue per minute is, on the surface, counterintuitive. However, there are several plausible explanations for this finding. First, it might be that in cellular markets increased competition is reflected in dimensions other than price such as expanded coverage, more reliable service, or more enhanced service (e.g., text messaging, ring-tones and the like). Second, given the complex mix of priced and un-priced components of the product bundle (e.g., the offering of “free” or subsidized handsets, music downloads and hardware accessories), RPM may fail to properly capture the complex pricing scheme typical of cellular service. Finally, the positive relationship of market concentration and labor productivity might be accounted for by the motivation of profit-maximizing firms and the enhanced ability of these firms to fund investment with higher profit margins.

The results from adding the interaction term to the regressions of mobile penetration and price are less clear-cut. The time trend, expected to capture the effects of technological change and service upgrade, demonstrates a significantly positive effect on mobile penetration and productivity growth. Moreover, it is found to significantly decrease the cellular service price in the fixed effects estimations. Regarding the regulation variable, it is shown to bring about significant improvement in mobile penetration, lending support

to the argument for benefits associated with the establishment of an autonomous telecom regulator.

With regard to the effect of market structure on the mobile penetration in China, the empirical results indicate that if the assumptions of the fixed effects model can be justified, it will lend credence to China's efforts to promote development in mobile telecommunications by encouraging competition in the field. However, the benefits of increased competition are likely smaller compared to other countries which might be accounted for by China's unique duopoly cellular market of two virtual SOEs. Therefore I expect that future research in this line will yield fruitful results using data on the degree of privatization of cellular operators across countries.

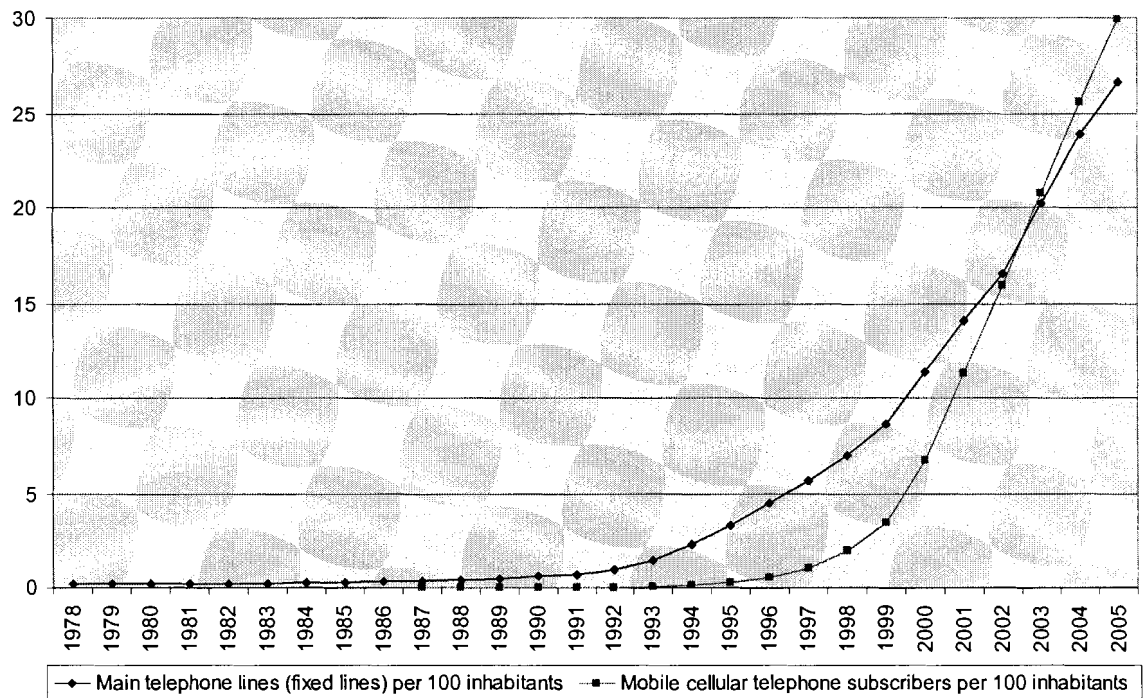
As to China's competition goals in telecommunications, I am of the view that the regulators have made a great effort in breaking the extant monopoly and encouraging competition in the cellular sector and their efforts are well rewarded. However, they have room to foster an even more competitive market structure in order to reap even greater benefits.



# Appendices

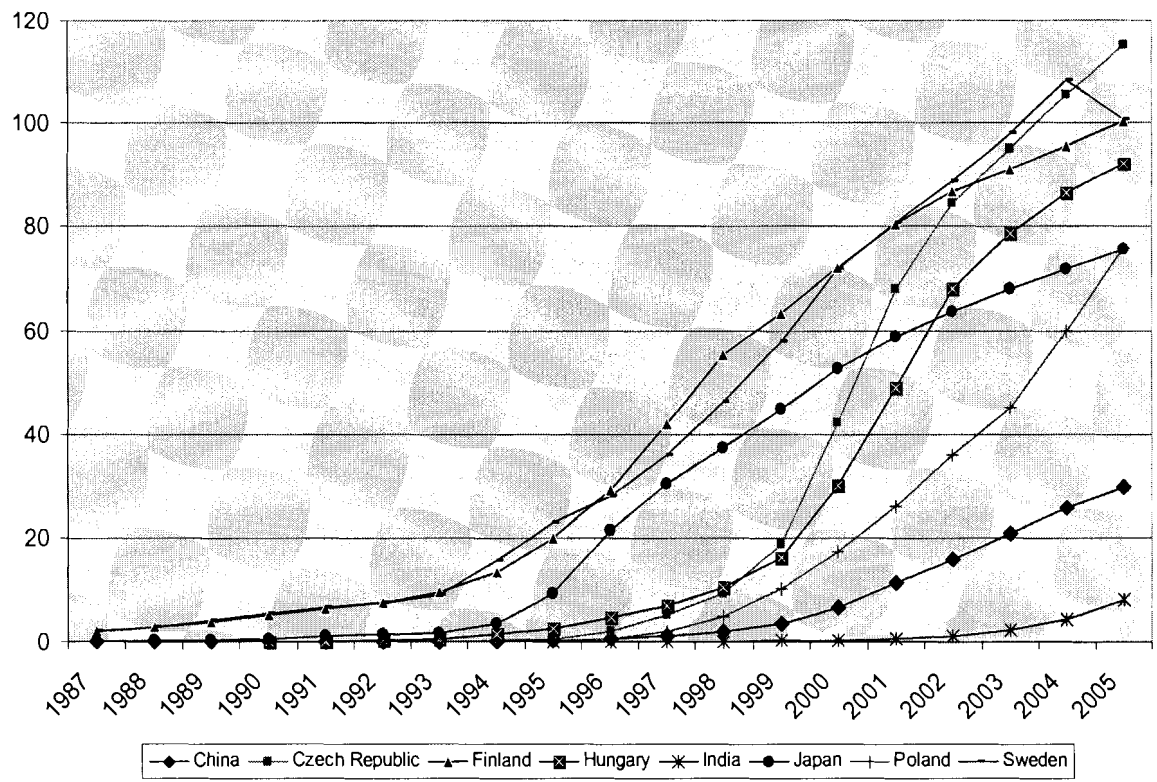
## Appendix A: Figures and Tables

Figure 1: Mobile and fixed-line penetration in China 1978-2005



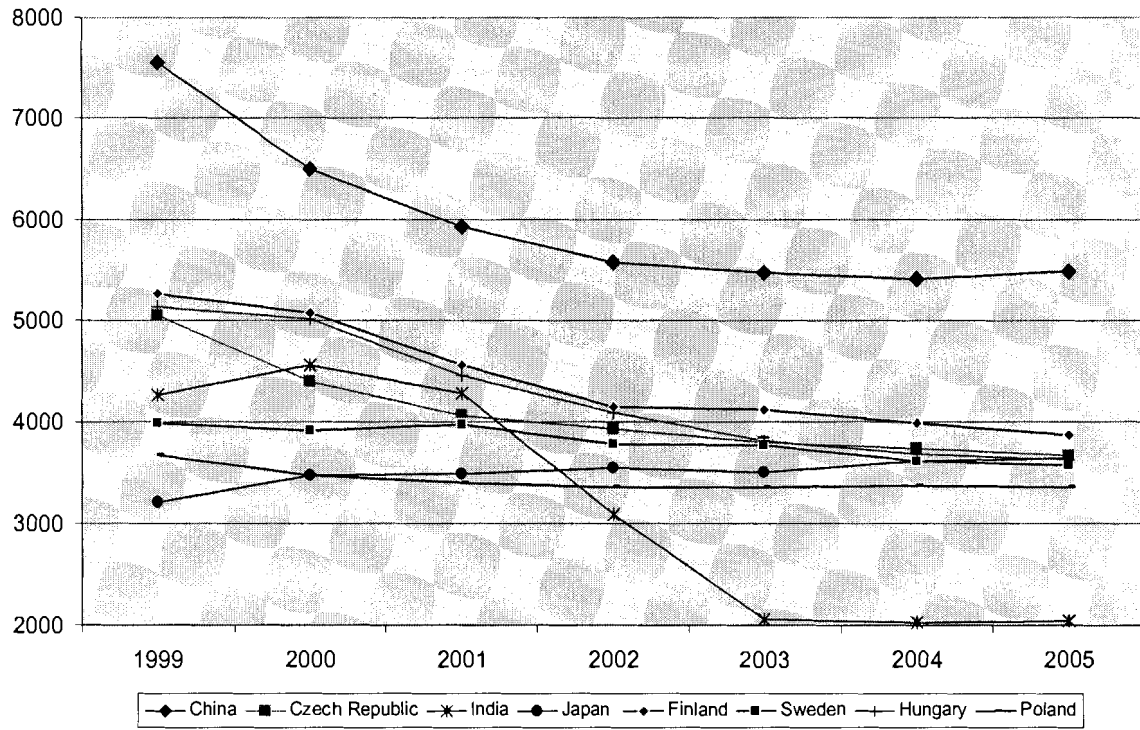
Source: ITU World Telecommunication Indicators 2006

**Figure 2: Mobile subscribers per 100 inhabitants of chosen countries 1987-2005**



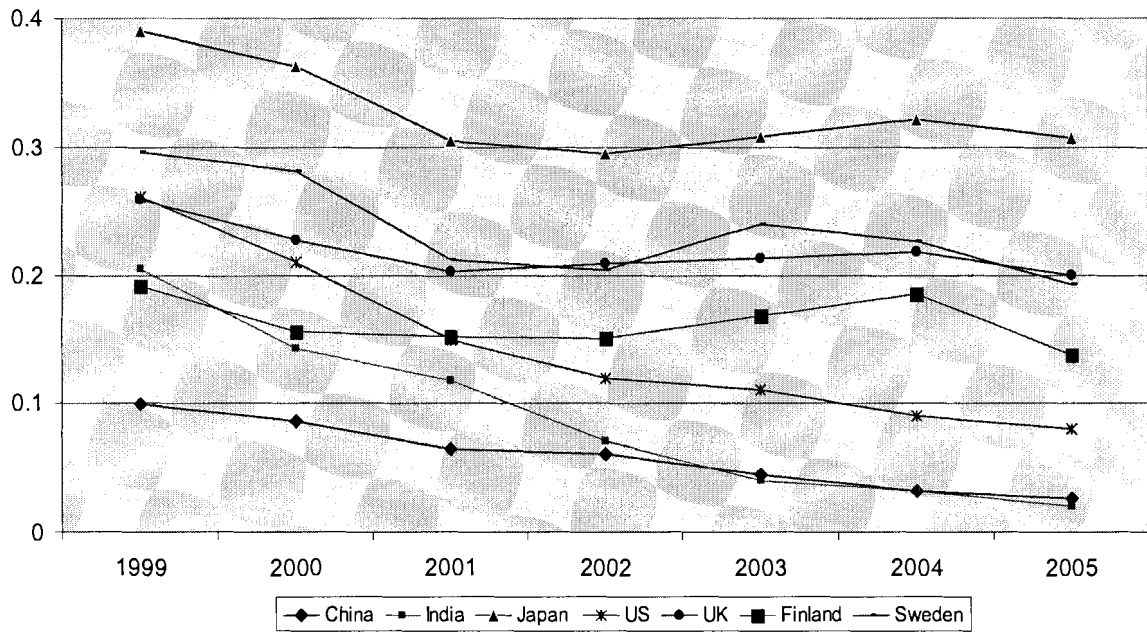
Source: ITU World Telecommunication Indicators 2006

**Figure 3: HHI indices of the cellular sectors in chosen countries 1999-2005**



Source: Merrill Lynch Global Wireless Matrix 2Q04 and 3Q06

Figure 4: Country average of revenue per minute in cellular service 1999-2005 (USD)



Source: Merrill Lynch Global Wireless Matrix 2Q04 and 3Q06

**Table 1: Summary statistics**

<b>Regression of mobile penetration rate (21 countries, 1999-2005)</b>					
Variable	Obs	Mean	Std. Dev.	Min	Max
penetration rate	147	69.05	25.20	3.43	124.28
hhi	147	3781.87	969.86	1630.42	7563.28
libera	147	10.33	4.34	3.00	22.00
regulation dummy	147	0.99	0.12	0.00	1.00
gdpcap (USD)	147	22911.90	12647.39	869.09	63955.00
year	147	2002.00	2.01	1999.00	2005.00
population	147	105000000	273000000	4478497	1320000000
<b>Regression of cellular service price (24 countries, 1999-2005)</b>					
Variable	Obs	Mean	Std. Dev.	Min	Max
RPM	168	26.47	69.39	0.06	408.61
hhi	168	3671.56	1007.05	1630.42	7563.28
gdpcap	168	1235503.00	3139018.00	1853.78	16700000.00
year	168	2002.00	2.01	1999.00	2005.00
libera	168	9.58	4.84	-3.00	22.00
population	168	151000000	318000000	4478497	1320000000
<b>Regression of labor productivity (18 countries, 1999-2003)</b>					
Variable	Obs	Mean	Std. Dev.	Min	Max
productivity	90	1647.69	919.17	403.44	4346.88
hhi	90	3812.92	881.08	1630.42	5968.00
gdpcap (USD)	90	22690.93	10150.57	4612.58	48674.18
year	90	2001.00	1.42	1999.00	2003.00
population	90	44400000	67200000	4478497	291000000

Data Source: ITU World Telecommunication Indicators 2006, ITU official website, Merrill Lynch Global Wireless Matrix 2Q04 and 3Q06, OECD Telecommunications Database 2005, various issues of F-20 forms of China Mobile Limited and China Unicom Limited, BuddeComm reports, Boylaud and Nicoletti (2000).

**Table 2: Panel regression of mobile penetration rate (21 countries, 1999-2005)**

	<b>Random effects</b>	<b>Fixed effects</b>	<b>FE robust</b>
<b>HHI</b>	-.0084886*** (0.000)	-.010826*** (0.000)	-.010826*** (0.000)
<b>HHICHINA</b>	.0172222*** (0.000)	.0099569* (0.092)	.0099569*** (0.000)
<b>Libera</b>	.8926895 (0.22)	Not included	Not included
<b>Regu</b>	15.59035*** (0.002)	12.00215** (0.012)	12.00215 (0.169)
<b>Gdpcap</b>	-.0002836** (0.034)	-.0005644*** (0.000)	-.0005644** (0.013)
<b>Year</b>	7.527525*** (0.000)	8.924689*** (0.000)	8.924689*** (0.000)
<b>Population</b>	-.000000119*** (0.000)	-.000000546** (0.02)	-.000000546*** (0.000)
<b>Constant</b>	-14979.52*** (0.000)	-17701.67*** (0.000)	
<b>R square</b>	0.6673	0.9166	0.9166
<b>Hausman test</b>	chi2 = 18.06	Prob > chi2 = 0.0012	

1. P values are reported under coefficient estimates.
2. FE robust refers to the fixed effects estimation with robust standard errors.
3. \*\*\* Significant at the 1 percent level, \*\*significant at the 5 percent level, \*significant at the 10 percent level.

**Table 3: Panel regression of cellular service price (24 countries, 1999-2005)**

	<b>Random effects</b>	<b>Fixed effects</b>	<b>FE robust</b>
<b>HHI</b>	-.0144028*** (0.000)	-.0177928*** (0.000)	-.0177928*** (0.000)
<b>HHICHINA</b>	.0106945* (0.08)	.0050437 (0.469)	.0050437 (0.114)
<b>Libera</b>	.044301 (0.987)	Not included	Not included
<b>Gdpcap</b>	.0000128*** (0.000)	.0000124*** (0.000)	.0000124*** (0.002)
<b>Year</b>	-1.95799 (0.481)	-1.7824*** (0.002)	-1.7824*** (0.000)
<b>Population</b>	-.0000000532 (0.172)	-.000000427*** (0.006)	-.000000427*** (0.000)
<b>Constant</b>	3988.415 (0.472)	3708.149*** (0.002)	
<b>R square</b>	0.3730	0.4288	0.4288
<b>Hausman test</b>	chi2 = 10.21	Prob > chi2 = 0.0169	

1. P values are reported under coefficient estimates.
2. FE robust refers to the fixed effects estimation with robust standard errors.
3. \*\*\* Significant at the 1 percent level, \*\*significant at the 5 percent level, \*significant at the 10 percent level.

**Table 4: Panel regression of labor productivity (18 countries, 1999-2003)**

	<b>Random effects</b>	<b>Fixed effects</b>	<b>FE robust</b>
<b>HHI</b>	.239296*** (0.009)	.2577174*** (0.010)	.2577174** (0.032)
<b>Libera</b>	12.8141 (0.873)	Not included	Not included
<b>Gdpcap</b>	-.0284949** (0.021)	-.0297983** (0.038)	-.0297983** (0.011)
<b>Year</b>	210.7178*** (0.009)	235.1646*** (0.000)	235.1646*** (0.000)
<b>Population</b>	.00000358 (0.416)	-.0000231 (0.434)	-.0000231** (0.046)
<b>Constant</b>	-420540.1*** (0.009)	-468197.9*** (0.000)	
<b>R square</b>	0.1410	0.5363	0.5363
<b>Hausman test</b>	chi2 = 0.34	Prob > chi2 = 0.9524	

1. P values are reported under coefficient estimates.
2. FE robust refers to the fixed effects estimation with robust standard errors.
3. \*\*\* Significant at the 1 percent level, \*\*significant at the 5 percent level, \*significant at the 10 percent level.



## **Appendix B: Overview of the relationships of China Mobile Limited and China Unicom Limited with their state-owned indirect shareholders**

### **China Mobile Limited and China Mobile Communication Corporation (CMCC)**

According to China Mobile Limited Form 20-F (2005, p.19), as part of the restructuring of the telecommunication industry, the telecommunication operations previously controlled by the former Ministry of Posts and Telecommunications were separated along four business lines: fixed-line telecommunications, mobile telecommunications, paging and satellite telecommunications. CMCC was established in July 1999 as a state-owned company to hold and operate the mobile telecommunication business nationwide resulting from the separation. As part of this separation, in July 1999 CMCC obtained the approximately 57% holding of voting shares and economic interest in China Mobile (Hong Kong) Group Limited, China Mobile Limited's indirect controlling shareholder, previously held by Telco Communications (Group) Limited, an entity 100% controlled by the former Ministry of Posts and Telecommunications. In addition, in May 2000, the remaining 43% interest in China Mobile (Hong Kong) Group Limited previously held by the Directorate General of Telecommunications was transferred to CMCC. As a result, CMCC became the owner of all voting shares and economic interest in China Mobile (Hong Kong) Group Limited and thus all of the PRC government's interest in China Mobile Limited. In addition, following the completion of the acquisition of the ten regional mobile telecommunication companies and other telecommunication assets by China Mobile Limited in July 2004, CMCC ceased to operate mobile telecommunication businesses in Mainland China other than through China Mobile Limited. As of May 31,

2006, CMCC indirectly owned approximately 74.9% of China Mobile Limited's outstanding shares.

### **China Unicom Limited and Unicom Group**

According to China Unicom Limited Annual Report (2006, p.3), as of December 31, 2006, Unicom Group indirectly and effectively held 52.60% of shares in China Unicom Limited through China Unicom (BVI) Limited and China United Telecommunications Corporation Limited. The public investors of the A Share market in Shanghai indirectly and effectively held 24.09% of shares in China Unicom Limited. The remaining 23.31% of shares in China Unicom Limited were held by public investors in Hong Kong and New York.

## Reference List

- BOYLAUD, O. and NICOLETTI, G., 2000. *Regulation, market structure and performance in telecommunications*. Paris: OECD Publishing, OECD Economics Department Working Papers No. 237 doi:10.1787/601531871521.
- BUDDECOMM, 2005. *Africa mobile communications market*. Bucketty: BuddeComm.
- BUDDECOMM, 2005. *Latin American mobile communications and mobile data markets*. Bucketty: BuddeComm.
- BUDDECOMM, 2005. *South Asia mobile communications and mobile data markets*. Bucketty: BuddeComm.
- CHENG, L., 2005. China's experience with foreign direct investment: lessons for developing economies. In: H.S. KEHAL, ed. *Foreign investment in rapidly growing countries*. New York: Palgrave Macmillan, 46-63.
- CHINA MOBILE LIMITED, 1999. *Form 20-F*. Washington D.C.: Securities and Exchange Commission.
- CHINA MOBILE LIMITED, 2000. *Form 20-F*. Washington D.C.: Securities and Exchange Commission.
- CHINA MOBILE LIMITED, 2001. *Form 20-F*. Washington D.C.: Securities and Exchange Commission.
- CHINA MOBILE LIMITED, 2002. *Form 20-F*. Washington D.C.: Securities and Exchange Commission.
- CHINA MOBILE LIMITED, 2003. *Form 20-F*. Washington D.C.: Securities and Exchange Commission.
- CHINA MOBILE LIMITED, 2004. *Form 20-F*. Washington D.C.: Securities and Exchange Commission.
- CHINA MOBILE LIMITED, 2005. *Form 20-F*. Washington D.C.: Securities and Exchange Commission.
- CHINA UNICOM LIMITED, 2000. *Form 20-F*. Washington D.C.: Securities and Exchange Commission.
- CHINA UNICOM LIMITED, 2001. *Form 20-F*. Washington D.C.: Securities and Exchange Commission.

- CHINA UNICOM LIMITED, 2002. *Form 20-F*. Washington D.C.: Securities and Exchange Commission.
- CHINA UNICOM LIMITED, 2003. *Form 20-F*. Washington D.C.: Securities and Exchange Commission.
- CHINA UNICOM LIMITED, 2004. *Form 20-F*. Washington D.C.: Securities and Exchange Commission.
- CHINA UNICOM LIMITED, 2005. *Form 20-F*. Washington D.C.: Securities and Exchange Commission.
- CHINA UNICOM LIMITED, 2006. *Annual report*. Hong Kong: China Unicom Limited.
- FINK, C., MATTOO, A. and RATHINDRAN, R., 2003. An assessment of telecommunications reform in developing countries. *Information economics and policy*, 15 (2003), 443–466.
- GREENE, W., 2002. *Econometric analysis*. 5<sup>th</sup> ed. New Jersey: Pearson, 287-303.
- GRUBER, H., 2005. *The economics of mobile telecommunications*. Cambridge: Cambridge University Press, 171-222.
- INTERNATIONAL COMPETITION NETWORK, 2004. *Merger guidelines-chapter 2* [online]. ICN. Available from: [http://www.internationalcompetitionnetwork.org/media/library/conference\\_2nd\\_merida\\_2003/amg\\_chap2\\_mktdefn.pdf](http://www.internationalcompetitionnetwork.org/media/library/conference_2nd_merida_2003/amg_chap2_mktdefn.pdf) [Accessed 24 May 2007].
- INTERNATIONAL TELECOMMUNICATION UNION, 2006. *ITU world telecommunication indicators 2006*. Geneva: ITU.
- INTERNATIONAL TELECOMMUNICATION UNION, 2007. *Countries with a separate regulator* [online]. Geneva, ITU. Available from: <http://www.itu.int/ITU-D/ICTEYE/Regulators/Regulators.aspx#> [Accessed 2 March 2007].
- INTERNATIONAL TELECOMMUNICATION UNION, 2007. *Definitions of world telecommunication/ ICT indicators* [online]. Geneva, ITU. Available from: <http://www.itu.int/ITU-D/ict/handbook.html> [Accessed 12 March 2007].
- LI, W. and XU, L., 2004. The impact of privatization and competition in the telecommunications sector around the world. *Journal of law and economics*, vol. XLVII, 395-430.
- MEGGINSON, W., 2005. *The financial economics of privatization*. Oxford: Oxford University Press, 271-309.
- MERRILL LYNCH, 2004. *Global wireless matrix 2Q04*. Toronto: Merrill Lynch.
- MERRILL LYNCH, 2007. *Global wireless matrix 3Q06*. Toronto: Merrill Lynch.
- MUELLER, M. and TAN, Z., 1997. *China in the information age: telecommunications and the dilemmas of reform*. Westport: Praeger, 45-64.

- ROS, A., 1999. Does ownership or competition matter? The effects of telecommunications reform on network expansion and efficiency. *Journal of regulatory economics*, 15 (1999), 65–92.
- SOURCEOECD, 2005. *Telecommunications database vol 2005 release 01*. Paris: Organisation for Economic Co-operation and Development.
- STATA CORP, 2003. *Stata statistical software: release 8.0 reference G-M*. College Station: Stata Corporation, 51-58.
- WALLSTEN, S., 2001. An econometric analysis of telecom competition, privatization, and regulation in Africa and Latin America. *Journal of industrial economics*, 49 (2001), 1-19.
- WEI, Y. and LIU, X., 2001. *Foreign direct investment in China*. Northampton: Edward Elgar, 8-20.
- WONG, J. and WONG, C., 2003. China's telecommunications industry. *In: S. YAO and X. LIU, ed. Sustaining China's economic growth in the twenty-first century*. London: RoutledgeCurzon, 77-95.
- WU, Y., 2004. China: growth and reform in telecommunications. *In: A. BROWN, M. HOSSAIN and D. NGUYEN, ed. Telecommunications reform in the Asia-Pacific region*. Cheltenham, UK: Edward Elgar, 217-232.
- WU, Z. and MCERLEAN, S., 2003. Chinese grain market efficiency in the post-reform period. *In: S. YAO and X. LIU, ed. Sustaining China's economic growth in the twenty-first century*. London: RoutledgeCurzon, 133-149.
- XU, Y., 2002. China's accession to the WTO and its implications for foreign direct investment in Chinese telecommunications. *Communications and strategies*, no.45, 17-47.
- YUSUF, S., NABESHIMA, K. and PERKINS, D., 2006. *Under new ownership: privatizing China's state-owned enterprises*. Palo Alto: Stanford University Press, 45-113.