Determinants of Cellular Competition in Asia*

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June 2005

ABSTRACT

Using data from the International Telecommunications Union (ITU) Database I explore the market for the provision of cellular services in Asia. This study looks at the diffusion of mobile technologies and mobile tariffs over the last decade. It compares the degree of competition, regulation and its effects in Asia with mobile markets in developed countries. It also analyses a 29 country 10 year panel data set in order to study the determinants of mobile penetration in Asia. The results indicate that competition has played a major role in increasing the diffusion of cell phones. The presence of an independent telecommunication regulator as well as increasing capacity of fixed line telephone exchanges has also positively affected the diffusion of mobile services. The last part of the study takes a brief look at the cellular market in India, where mobile service provision has seen startling growth in the last decade. This growth has made for falling tariffs, increase in the number of firms and technologies and a large subscriber base which is still growing at a significant rate. The structure of competition is explored in some detail for regional markets using monthly data from 1997 to 2004.

JEL Classification: *D4, L1, L2, L5, L9*
Keywords: *Competition, Cellular, Regulation, Telecommunication.*

* I wish to thank Anjan Chatterjee and Devalina Chatterjee for the outstanding research assistance they have provided on this project. I am indebted to Bibek Banerjee for his comments on this draft and the Indian Institute of Management Ahmedabad for providing me with the resources to conduct this research. I retain responsibility for all remaining errors and omissions.

1. Introduction

The market for cellular mobile technologies in Asia has seen explosive growth in the Nineties and the first few years of the millennium. This study documents this growth, explores the organization and firm behaviour in various countries, puts forward and tests certain hypotheses regarding the increase of the subscriber base for cellular technologies and finally focuses on India, which has seen particularly explosive growth in cellular technologies over the last decade.

The main reasons for the growth of mobile telephony in Asia are the opening up of markets to competition, introduction of digital cellular technologies and large untapped markets with limited fixed line penetration. In the early nineties, the emergence of mobile operators as de facto universal service providers (as they are in many countries in Asia) was unexpected. Initially mobile provision was nobody's idea of universal service. It was but a specialty service targeted at a small number of wealthy customers. However as mobile penetration increased, it became clear that there was a strong demand for mobile telephony from all sectors of the population. The introduction of second generation networks reduced costs and a combination of economies of scale (both from the supply side as well as from the demand side) drastically lowered the cost of handsets. As a result, mobile telephony rather than being a high cost premium service became for many customers a relatively low cost method of obtaining a basic telephone connection. Much of the cost advantage of mobile telephony networks stems from the fact that the access (radio frequency) network is shared between subscribers. Once this access network is in place the marginal cost of adding another subscriber is very low, and is primarily the cost of a handset. This contrasts with traditional fixed wire line telephony, where the incremental cost of an additional subscription is significant and often involves adding copper backbone to the existing network. The relatively low startup and marginal costs have thus allowed many less developed countries to adopt digital cellular networks without having any history of cellular technology, and thus leapfrog over generations of technologies.[1]

Mobile operators in Asia have translated this low cost advantage into affordable pre-paid packages (the main growth of mobile telephony has been in the area of prepaid GSM plans) which allow low income users a basic connection to the network. Pre-payment allows operators to lower operational costs and reduce credit risks and also gives subscribers far more control over their expenditure than traditional post paid solutions, thus increasing their attractiveness to low income users.

An important feature of Asian cellular markets that does not find a strong parallel in America and the EU is that existence of more than one competing but compatible wireless standard. Whereas the dominant cellular standard is still GSM, CDMA networks may be found coexisting with GSM in numerous markets in India, China, Indonesia, Malaysia, Hong Kong, Korea and Japan. Furthermore, the leapfrogging nature of cellular technology has also sped up the adoption of third generation (3G) mobile technology, with Japan being the first country in the world to launch a 3G network in 2001. Thailand, Korea, Hong Kong and Singapore are among other countries that have licensed 3G cellular networks for service provision in the early part of the millennium.

2. Competition Policy in the Telecommunications Sector

Since interconnection in the telecom sector is crucial for network and service interoperability - its regulation by the government has traditionally been one of primary importance (Laffont and Tirole, 1991, 1996, 2000; Amstrong, 1997). In the context of interconnectivity, the local loop has always been an important bottleneck.[2] The incumbent local telecommunications operators have usually had a monopoly position in various countries in the provision of local telephone services and have always

[1] Existing cellular standards across the world vary from first generation (1G) technologies such as Advanced Mobile Phone System (AMPS), Nordic Mobile Telephone (NMT), and Total Access Communication System (TACS) to 2G technologies such as Digital AMPS (D-AMPS), Global System for Mobile (GSM), Code Division Multiple Access (CDMA), and Personal Digital Communication (PDC).

[2] This is the part of a telecommunications network that is typically owned and operated by the local telephone switching telephone exchange. Telecommunications service providers like long distance providers and Internet Service Providers (ISPs) need to go through the local loop in order to reach the final customers.

had an incentive to prevent entry of their competitors by setting high access charges for their network[3]. Therefore, the regulation of local loop interconnection prices became the central issue in interconnection regulation. One form of interconnection regulation may be the imposition of low access prices on the incumbent local exchange carriers (ILECs). However, even though cheap access may facilitate market entry, it may dampen incentives for infrastructural investments by both entrants and incumbents (Pelkmans and Young, 1998). Thus, it is critical for regulatory policy to understand how different interconnection access regulation schemes affect investments in this sector. For a more detailed exposition on interconnection prices see Koski and Majumdar (2002) and Noam (2002).

The benefits that telecommunications operators derive from their investments is affected not only by interconnection price regulation, the regulation of retail prices may also play a substantial role in setting incentives or disincentives to firms to undertake investments that increase network coverage or service quality. Price-cap regulation has become a major method used in regulating retail prices in the telecommunications sectors of industrial countries. Majumdar (1997) discusses the effect of incentive regulations such as the price-cap on firm behaviour and efficiency.

In addition to price regulation, there are also various other institutional and regulatory factors that may influence the business environment and investment behaviour in the telecommunications sector. These include the ownership of telecom operators (private vs. government owned), the degree of competition and the type of regulatory agency in the market.

The Telecommunications sector has undergone significant shifts around the world since the mid-1980s. At the beginning of that decade, every country in the world except those in North America had a state owned monopoly telecommunications provider and no other regulatory authority outside of the ministry responsible for overseeing and running that sector. Even in North America, AT&T was a government regulated monopoly in almost all areas of local telephone service provision. By the millennium, 90 countries around the world had at least partially privatized their telecommunications sector, and 95 had built separate regulatory authorities in order to oversee this sector (ITU 1999).

Substantial empirical evidence reveals that privatization or deregulation in this sector can lead to performance improvements. Megginson, et al. (1994) compare pre- and post-privatization financial and operating performance of 61 companies (in 32 industries, including telecommunications) from 18 countries. They find increased sales, profits, investments, and employment following privatization. The early empirical work in this area compares average performance indicators across firms or countries before and after deregulatory reforms. Most of that evidence is from Latin America, a fact that is not surprising, given the region's relatively early start in reforms. In general, these studies find positive effects of reforms (e.g., Kikeri, et al. 1992; Wellenius and Stern, 1992).

Though privatization has yielded significant benefits, allowing entry and competition in the sector tends to yield far greater benefits (Wallsten, 2002). A monopoly provider, whether state-owned or private, experiences fewer incentives to improve service and lower prices than do firms that operate in a more competitive environment. As Ambrose, et al. (1990) argue, "*simply moving a monopoly from the public to the private sphere will not result in competitive behavior*." This wisdom is reflected in results obtained from a broad class of studies, which finds that competition leads to the biggest improvements in the sector (Fink, et al. 2002; Li and Xu 2001; McNary 2001; Petrazzini 1996; Ros 1999; Wallsten 2001).

The detrimental effects of monopoly provision are also exacerbated in network industries, where the presence of network effects, switching costs and supply side economies of scale, may lead to 'lock ins' where a producer with market power charges a premium that customers may be willing to pay given that their cost of moving to a new product or technology may be prohibitively high.[4] 'Locked

[3] When access charges are strictly regulated as in the United States, the incumbent local operators may employ non-price strategies to deter entry of their potential competitors (see Koski and Majumdar, 2000).

[4] Network effects or externalities in technology market lead to persons deriving utility from a technology when additional users purchase it. This benefit from being connected to other individuals on the network may lead them to purchase technologies that may be sub-optimal with respect to others with a smaller network. Telecommunication markets display strong network externalities. See Katz and Shapiro (1985, 1986, and 1992) and Farrell and Saloner (1985) for detailed exposition on network externalities. Switching costs are economies of scope that arise from the purchase of a compatible product or (especially) a repeat purchase of the same product. This means that the buyer incurs a cost from switching to a different (or non-compatible) product and

in' customers may give rise to imperfect competition *even if there is free entry* to the market, as new firms may not be able to ever build up the installed base of consumers or realize the cost advantages that they require to compete. Again, no anti-competitive behavior is necessary in order to create market inequality in network markets (Economides, 2003). The natural monopoly that occurs due to the large installed base of a dominant firm results in it wielding market power with no explicit strategy of entry deterrence.

Antitrust policy needs to be applied cautiously in network environments as the mere creation of new market entities or the breaking up of existing entities as a part of a 'liberalization' package without a prior restructuring of the industry may give rise to efficiency losses. This however does not mean that privatization and indeed liberalization of network industries is undesirable as a process that transforms these industries from monopolies to private markets. First of all, natural monopoly in an industry (such as switched exchange telephone services) does not necessarily exclude some substitution from other services (such as mobile telephony). In such cases, the privatization of the public utility can help reduce the distortions arising from the soft budget constraints usually associated with state ownership, and strengthen the utility's incentives to increase productive efficiency (Saba, 1998; Sidak and Spulber, 1998). Even where natural monopolies do not have such distinct substitution alternatives, privatization may still have a positive impact on productive efficiency, since exposing the utility to the risk of takeover allows market forces to exert control over the company's performance, or in other words make its ownership structure more contestable in order to increase operational efficiency.

According to Saba (1998) and Economides (2003), increasing utilities' incentives to minimize costs, adopt efficient production technologies, and promote products that are cognizant of the demand in the market may not be enough to guarantee an efficient market outcome. Opening up of markets to competition is often a necessity. The high degree of vertical integration and economies of scale and scope of most public utility industries provide the incumbent operator with the wherewithal to restrict market access by utilizing the market power conferred to it from the demand or the supply side. A well designed privatization process that includes a breakdown of vertical ownership structures that promote network or natural monopoly activities may greatly reduce the network owner's incentive to restrict entry to upstream or downstream markets. This would also do away with the need for close monitoring of natural monopoly activities and simplify the cost structure a great deal.

Sometimes, however, economies from economies of scale or scope may be important enough to not merit divestiture (Economides, 2003). This may be true in certain telecommunications markets, where network externalities and benefits from compatibility are colossal. Thus private ownership may exacerbate this situation by an increase in monopoly rents and divestiture may be undesirable in the sense that it dissipates the benefits arising out of the network by imposing a sub-optimal competitive market structure. Privatization in this situation must accompany the creation of other networks that consumers may substitute without a huge switching cost. Thus, the possibility of providing telecommunications services through a number of technologies that are substitutable (cable, Internet, satellite, wireless in addition to fixed line telephone networks) would make for effective competition at the infrastructure level, expanding the number competitors and actually reaping the benefits of deregulation and privatization. *Put differently, in telecommunication markets, privatization in and of itself may actually harm the growth of provision of services.* It is existence of competition that would ensure that a liberalization package reaps benefits for the consumer.

Compared to fixed line telephony, mobile markets in general have always been subject to more competition. A reason for this may be that historically mobile technologies saw the light of day in the era of market reforms, with the first analog cellular networks going on air in the 1980s. Since service provision is not largely dominated by incumbent operators with state ownership (see section 3) there is less of a tendency on the part of governments deterring entry to protect operators. This has

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values compatibility, i.e. - the ability to take advantage of the same investment between his purchases. Markets for gas and electricity have huge switching costs as for a consumer it is prohibitively expensive to switch once he has invested in a certain technology. Industries have also the presence of supply side economies of scale that allow them to generate large output at very low average costs. The presence of both demand and supply side economies of scale make industries such as electric power extremely prone to a Schumpeterian type of market dominance.

increased the number of providers for cellular services in most markets. A notable case is that of the Middle East and North Africa (MENA) region where in spite of a history of state controlled (or highly regulated private monopoly) infrastructure provision, there has been a significant move towards the boosting of competition in the late nineties and the early part of the millennium (Bezzina, 2003).

2. Worldwide Cellular technology adoption: A brief overview

There are over 1.5 billion cellular phone subscribers in the world today which is about 25 percent of the world's population, according to International Telecommunication Union (ITU, 2005). The growth in mobile phone subscribers today is faster than the growth in fixed telephone subscribers and Internet users. In some developed countries in the EU like Sweden and Iceland cellular diffusion is around 100 percent. Sweden today has a mobile penetration of a 101 percent, i.e. - there are more cellular phone subscriptions than people in the country. Most advanced industrial countries have historically displayed a significant diffusion rate for cellular technologies. According the Organization for Economic Cooperation and Development (OECD) in 2001, mobile penetration in Netherlands, Iceland, Italy, Finland and the UK were 81.3, 82.6, 80.4, 87.1 and 77.1 percent with the overall penetration rate for EU being 74.3 percent. Among the other developed countries the US stood at 45.1 percent, Japan at 58.8, Australia at 57.1 and Germany at 68.3 percent (OECD, 2003) in cell phone penetration. However an important aspect of cellular technology diffusion among advanced industrial countries is that mobile penetration has leveled off in the early part of the millennium with the growth centres for cellular technology shifting to countries such as Russia, China, India, Korea, Malaysia, Indonesia and the Philippines and Taiwan. Driving this mobile growth phenomenon is a rapid increase in the number of subscribers from three of the world's most populous nations - China, India and Russia. By the middle of 2004 developing countries as a whole had overtaken rich nations to account for 56 percent of all mobile subscribers, while accounting for 79 percent of growth in the market since 2000. China reported 310 mn users, about 25 percent of its total population. India saw an increase of 11 mn, reaching a total of 44.5 mn subscribers. In Russia mobile phone subscriber numbers jumped from 36.5 mn in September 2003 to 60 mn by September 2004. Countries in Latin America too have shown impressive growth in cellular technology adoption with cellular penetration rates that are on average higher than most Asian countries. Brazil and Chile with 36.4 and 60 mobile subscriptions out of 100 people, lead the Latin American market in cellular penetration. Of all the economies in Latin America, telecom in Brazil is an explosive growth phase and it is currently the 7th biggest telecommunications market in the world (Nurmi and Vakiparta, 2005).

Asia's pattern of mobile diffusion has highlighted the role of mobile providers as universal service providers. This phenomenon has also been observed in countries of the African continent. In Africa, fixed line services even today are characterized by low penetration and inefficient service provision. The situation in this continent is worse than in other less developed continents like Asia and Latin America. Excluding South Africa, the fixed line penetration was 1.82 per cent in 1999 whereas East Asian and Latin American/Caribbean countries had a penetration of 8.23 and 13.21 percent respectively (Gebreab, 2002). The situation was even worse in sub-Saharan Africa where telecommunications penetration was about 0.64 fixed lines per 100 in the same year. During the 1990s, rapid provision of mobile services by primarily private network providers has caused the cellular penetration rate to overtake the fixed line penetration rate by the end of 2001. The overall penetration rate for cellular service stood at 2.79 per 100 in 2000 and by the end of 2003, stood at an impressive 6.2 per 100 inhabitants, twice the rate of growth of fixed telephony (ITU, 2004). In the Central and Eastern European countries too, mobile technologies have substituted for a lot of consumers, the universal service that would otherwise have to be provided by fixed line telephony. The relatively low penetration of main lines (about half that of the EU), coupled with long waiting lists for connections made Eastern Europe a good market for the growth of cellular technologies which involve less cost intensive network design and spectrum sharing economies of scale. The growth of oligopoly markets for cellular services in the early nineties using digital (GSM) networks saw an increase in the cellular penetration which was more a function of digitalization than an increase in the number of operators (Gruber and Verboven, 2001). In 2002, countries like Bulgaria (33.3 percent up from 0.84 percent in 1997), Romania (23.57 percent up from 0.89 percent in 1997) were displaying impressive mobile penetration rates vis a vis most countries in the developing world.

3. Adoption of Cellular Technology in Asia

Figure 1 displays the growth of the subscriber bases for cellular telephony for three broad regions in Asia, Asia-Pacific, Indian Subcontinent and the Middle East (the list of countries used in this study for the different areas is given in table 1). Over the 10 year period used for this study, the growth of the subscriber base in Asia is driven primarily by the Pacific Rim countries among which China, Indonesia, Malaysia and Korea almost doubled their subscriber base in the last five years. Countries of the subcontinent and Middle East grew impressively too but their main growth years were 2003-2005. Compared to the advanced industrial countries in the same time frame, the growth of the subscriber base is significant and reflective of the fact that the demand for cellular subscriptions is nowhere close to saturation. At approximately 350 million subscribers in 2001, the Asian market is a little more than half the size of that of the OECD countries which had just over 600 million subscribers (OECD, 2003). However the growth in the subscriber base for the Asian countries from 2000 to 2001 was approximately 42 percent compared to the much slower 19.1 percent for the OECD countries.

<FIGURE 1 ABOUT HERE>

<TABLE 1 ABOUT HERE>

Figures 2, 3 and 4 show fixed line and mobile telephone penetration in 2002 for countries in the Asia-Pacific, Indian Subcontinent and the Asia Pacific regions respectively.

<FIGURE 2 ABOUT HERE> <FIGURE 3 ABOUT HERE> <FIGURE 4 ABOUT HERE>

By this year in every country except Cambodia and Viet Nam and China in the Asia-Pacific region, mobile penetration had overtaken fixed line penetration by a significant amount. Taiwan led the Asian countries in mobile penetration with the number of subscriptions in the country exceeding its population. In the Middle-East too, all countries except Iran, Syria and Yemen had a higher penetration rate for mobile technologies. The Indian subcontinent represents the only broad region where a majority of countries had a fixed telephony penetration greater than that for mobile services. However today, India and Pakistan have a growth rate of diffusion for mobile phones that outstrip the growth rate for mainline penetration and by the end of this decade we may see more cellular phones than fixed line phones in the subcontinent. China, which may well be the driving force behind generating mobile service demand in Asia, is witnessing a growth in the demand for mobile services (including both voice and data transmission) that significantly exceeds the demand for mainline phones.

4. Level of Regulation and Competition

The cellular mobile industry has always been much less regulated than its fixed line counterpart and indeed most public utility provision. In Asia this more liberal policy environment led to mobile provision at a premium in the nineties by either incumbent operators or by monopoly/duopoly private firms who were charging a rent to consumers with relatively inelastic demand for voice communication services in countries with low mainline penetration. However the relative lack of regulation that prevailed in this industry also meant for more competitive entry as the level of supernormal profits increased. Table 2 shows the number of countries in Asia that had a certain industrial structure (e.g. - monopoly, duopoly, three firms or more than three firms) from 1993-2002. We see that up to 1999, the number of monopolies exceeded the number of oligopolies but from that point on the number of countries with two or more firms increased significantly until in 2002, 11 of the 31 countries surveyed had a monopoly whereas 20 had multiple providers. Figure 5 shows the change in the average peak-rate tariff for a three minute local cell phone call for the different regions in Asia. The graph shows that 2000-2002 was the only phase in the decade when the peak-rate tariff decreased for all three broad regions of Asia. Thus an increase in competition is seen to be directly linked to a falling of prices in this market. It may be mentioned that almost all countries had "liberalized" or "corporatized" their telecom incumbents by the middle of the nineties (except the countries of the Middle East which even in 2002 had a number of monopolies). This however did not make for higher consumer welfare or rapid market growth, which came in the 1999-2002, as a concomitant to higher competition and falling tariffs. It must also be mentioned that for developing countries even though an increase in mobile penetration may be observed with more entry, a significant portion of this increase may be because of unsaturated demand for telecom services, rather

than a response to "better" quality of service per unit of consumer expenditure. Thus some of the rapid growth in the market may be a function of the existence (of sometimes expensive) options brought about by mobile technology where none previously existed.

<FIGURE 5 ABOUT HERE>

<TABLE 2 ABOUT HERE>

In terms of competition, by 2002, Asia compared favourably with the OECD countries with 11 out of 31 countries with four or more operators (compared to 16 out of 30 for OECD) even though the Asian region had about one third the countries surveyed with monopoly (state owned incumbents or private) firms compared to no monopolies in the mobile provision sector of the OECD states.

It is worthwhile to ask the question- if entry is indeed the main engine for growth of this industry, are there any good reasons against liberalization, corporatization and foreign ownership? In the face of growing markets and falling tariffs associated with the increase in the number of providers in Asia (as concomitant to market liberalization), it is difficult to posit arguments that recommend the limiting of capital ownership or entry into telecommunication markets. The econometric analysis in the following sections establishes this fact. However, in the context of developing countries some caveats do need to be exercised regarding the opening up of markets. Specifically with respect to mobile telephony, one salient aspect of its diffusion in emerging economies is its role as universal service provision to the populations of many countries whose governments do not have the fiscal strength to supply basic telephony to a majority of its citizens. Countries like Pakistan, India and Sri Lanka have accordingly seen a liberalized mobile market right from its inception. One function of a market with state owned incumbents is the provision of cross-subsidization whereby long distance and other more premium services are priced at higher than the market rate in order to provide basic telephony to the wider masses. However corporate entities do not have any responsibility of performing any kind of developmental activity and this may be the main loss arising from corporatization of an essential resource like telecom. However many scholars argue that governments are devising means of achieving these universal service objectives without sacrificing competition by creating and promoting universal service funds that can be competitively allocated (Fink et al., 2001). A second concern with unrestricted entry into the market may be that gains from liberalization may be appropriated by foreign entities who are allowed to enter a domestic market. This is a valid fear for most small economies and the only real solution to this (not counting that of a rollback to state owned monopoly) is to establish a credible regime of independent regulation that monitors the behaviour of service providers and steps in when necessary to defuse anticompetitive and myopic actions that may hurt consumers and stem the future growth of the industry. In this context, India, which established an independent monitoring agency TRAI (Telecom Regulatory Authority of India) in 1997, has since seen a significant fall in cellular tariffs along with a growth in the market.[5] This dynamic of falling prices is not true for all countries in Asia. From figure 5 we see a significant fall in peak rate tariffs (1993-2002) only among the Asia-Pacific countries and a marginal decrease in the average peak rate for all 31 countries studied from 1993-2002. I hypothesize that since even as late as 2002 only about one third of the countries had an independent regulatory agency the *mere entry of providers* was not enough to ensure an overall drop in peak rate tariffs. It is clear that more regulation is essential in the mobile sector and that the entry of firms may not necessarily mean more competition (even though entry and competition are often used interchangeably). With inadequate regulation, a fully liberalized market may allow providers to engage in collusion and revenue sharing arrangements. The fact that the presence of an independent regulatory agency in our dataset does not significantly impact the mobile penetration rate (see next section) *may* point to the need to enhance the role of regulatory agencies in this sector.

[5] In fact it is only in 2004, because of the intense competition in the mobile sector, service providers have been given the flexibility to report their tariff plans to TRAI within 7 days from the date of implementation after conducting a self-check with the relevant regulatory principles include tariffs being IUC compliant, non-predatory and non-discriminatory (TRAI, 2004d)

6. Determinants of Cellular Technology Diffusion

In this section I explore the effect of several market related variables on the penetration of mobile services in Asia, using a 29 country 10 year unbalanced panel data set that uses data from the International Telecommunication Union (ITU) Yearbook of Statistics (ITU, 2004) and the ITU Regulatory Database. Given that we have a large number of cross-sectional units (countries) compared to the number of time periods over which these units are observed, it is appropriate to use a linear fixed effects regression (Kennedy, 1998; Greene, 2003), which controls for (unobservable) country related effects by fitting country specific constants in addition to the common regression constant. This technique has been used in several papers that study the effects of regulatory and competition variables on the penetration of fixed line and mobile telephony in different areas of the world. Wallsten (2001) explores the effect of privatization competition and regulation on mainline penetration using 30 African and Latin American countries from 1984-97. Wallsten (2002) uses a fixed effects model to gauge if establishing institutions that promote competition before privatization is important in the penetration of telecommunication services. Ros (1999) uses a fixed effects inter-country model to study the effects of privatization and competition on network expansion and efficiency of mainline phones. In the vein of Wallsten (2001) and Ros (1999), Fink et al (2001) study the effect of different competition variables on mainline penetration in 12 East and South East Asian countries. Boyland and Nicoletti (2000) and Wei et al (2001) too use the fixed effects framework to study the effects of liberalization and regulation on prices, capacity, quality of service and profitability in both the mobile and fixed telephony sector. Gruber (2000), Gruber and Verboven (2001) and Gebreab (2002) explore the effect of different economic variables on the diffusion of cellular telephony in Eastern Europe (Gruber, Gruber and Verboven) and Africa (Gebreab) using linear or non-linear fixed effects regression. From all these studies, the main consistent results that emerge are as follows. First, competition (and competition coupled with independent regulation) leads to higher penetration and better quality of service. Second, privatizing an incumbent in and of itself has limited impact on technology diffusion. Third, the sequence of liberalization may be important, i.e. – a country that chooses to promote competition before privatizing its incumbent service provider may see a significant impact on diffusion, investment, prices and quality of service.

This paper fills a need in the literature for a comprehensive study on the diffusion of cellular technology in Asia.[6] It uses a 29 country 10 year panel to study the effects of several variables pertaining to existing infrastructure, unmet demand, competition and regulation on the diffusion of mobile service provision. It also splits the sample into the three broad areas in Asia (the Indian Subcontinent, Asia-Pacific and the Middle East) to check the robustness of the original model on these three subsets of the data.

The econometric model I use takes the form given in equation 1, where *LNMOBSUB100* is the natural log of the number of mobile subscribers per 100 of population in the country. The subscripts *i* and *t* represent the country and the point of time respectively.[7]

$$LNMOSUB100_{i,t} = \alpha + COUNTRY_i + LNGDP_{i,t} + LNLINE_{i,t} + LNPAY_{i,t} + INCUMB_{i,t} + REGULAT_{i,t} + ENTRY_{i,t} + TIME_{i,t} + \varepsilon_{i,t} \quad (1)$$

Here, the *COUNTRY* variable represents the effect of other unobservable factors that might be specific to a country, which we wish to control for, but have no interest in exploring. The discrete time trend

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[6] Fink et al (2001) use 12 countries in Asia in their regression analysis, but their preliminary estimation is not very conclusive and very surprisingly obtains the result that the level of competition (proxied by the total number of cellular operators) does not significantly affect the mobile penetration rate. This result may be on account of a small number of countries being used in their study.

[7] The econometric specification here is the linear fixed effects regression model. Generally for panel data models of this type, estimates from OLS estimation may not be minimum variance due to the presence of heteroscedasticity. Thus equations 1 and 2 have been re-estimated using a Weighted Least Squares procedure (not reported in this paper) that yields results robust to those reported here. For a more detailed econometric analysis of the same data set, diagnostic tests and robustness checks, a longer version of this paper may be requested from the author at sujoy@iimahd.ernet.in

variable *TIME* captures the effect of new technologies, consumer awareness of cellular technologies, etc that may positively influence cellular penetration but may not be reflected in the other infrastructural, competition and regulatory variables. The *LNGDP* (the natural log of the per capita GDP) variable is a measure of the purchasing power of a nation and is hypothesized to positively influence the *LNMOBSUB100* variable. The *LNLINE* variable is the natural logarithm of the line capacity of public switching exchanges. This variable is hypothesized to positively impact the diffusion of mobile services as a bulk of the calls that originate on mobile phones are routed through the PSTN. The natural logarithm of the total number of payphones in the country *LNPAY* is a proxy for unmet demand for telephony services and is postulated to positively influence the diffusion of mobile phones. The *INCUMB* variable indicates whether an incumbent (currently state owned or partially privatized with majority government stake) operator is present in the mobile services market. The presence of an incumbent operator may negatively affect the diffusion of cellular technology as it may have considerable power in certain markets to control access and interconnection.[8] The presence or absence of an independent regulatory agency is captured by the *REGULAT* variable. The presence of an independent regulatory agency is hypothesized to positively influence the penetration of mobile technology. The *ENTRY* variable indicates whether or not the mobile sector is liberalized to accommodate the entry of firms. Another variable, *LNUMFIRM* or the natural logarithm of the number of cellular providers is also used but not in the same regression with *ENTRY* as the two variables are strongly correlated. Both these are hypothesized to positively influence mobile penetration. The regressions with *LNUMFIRM* do not include the *ENTRY* variable and may be given as,

$$LNMOSUB100_{i,t} = \alpha + COUNTRY_i + LNGDP_{i,t} + LNLINE_{i,t} + LNPAY_{i,t} + INCUMB_{i,t} + REGULAT_{i,t} + LNUMFIRM_{i,t} + TIME_{i,t} + \varepsilon_{i,t} \quad (2)$$

The precise definitions of the variables used are given in table 3.

<TABLE 3 ABOUT HERE>

Notice that unlike Wallsten (2002) I have not really distinguished between privatization and competition. This sort of sequence may be largely true for fixed line telephony, where very often the incumbent (who is an important provider of fixed telephone services in almost all countries) has often been privatized well before competitive entry is allowed. There are no countries in Asia (in the time period considered) where a (more than 50 percent divested) public sector company (companies) has (have) continued to provide monopoly (or oligopoly) services in a regime that prevented entry into the market. For some countries such as China, Laos or a few Middle Eastern countries, the incumbent (with a majority government stake or complete government control) has continued to provide services for the full period considered. For others such as India, privatization with respect to the mobile sector coincided with the allowing of competitive entry into the market. Thus the pertinent variable with respect to liberalization for the mobile cellular industry is *ENTRY*. I have also not attempted to look at the order sequence of independent regulation before or after privatization because for all countries in the data set, establishment of a private regulatory authority occurred after privatization.

6.1 Results

Table 4 displays the results from the full panel of 31 countries.[9] We see that GDP per capita positively and significantly impacts the mobile penetration rate. This is consistent with Wallsten (2002).[10] The line capacity of fixed telephone exchanges *LNLINE* too positively affects the growth of the number of cellular subscribers. This is intuitively obvious in the light of strong network effects that operate in the market for telephony services. The number of payphones positively affects the

[8] The variable is also used by Gebreab (2002) who models the diffusion of cellular services in Africa. It is used very parsimoniously in the sense that even if some stake in the incumbent is sold to private investors the company is still considered an incumbent until majority stake and (thus strategic control) is no longer with the government. This definition has also influenced my decision to not deem a market as "privatized" if a minority stake in a former state owned enterprise is sold to private investors.

[9] In total the data set has 33 countries, but data pertaining to 31 of them is usable for this regression. The reason for dropping Lebanon and Yemen is that they were missing a number of covariates.

[10] The results are not strictly comparable as Wallsten (2002) uses the total number of subscribers as the dependent variable as opposed to the percentage diffusion variable used by me.

diffusion of cellular services. This too is intuitively clear as payphones primarily meet the communication needs of people who do not have a main line phone. The presence of an independent regulator does not affect the growth of the mobile subscriber base significantly. This is consistent with Gebreab's (2002) study of the African mobile markets and Fink et al.'s (2001) study of 12 Asian countries. Both the *ENTRY* and *LNUMFIRM* variables positively and significantly affect the mobile penetration rate per 100 in the population. This is consistent not just with other studies on the diffusion of cellular technology but studies that investigate the diffusion of fixed line services. The *TIME* variable (which proxies primarily technological changes in the provision of cellular services) shows a positive relationship with the dependent variable.

<TABLE 4 ABOUT HERE>

We split our full set of data into three parts (corresponding to the Indian Subcontinent, Asia-Pacific and Middle East regions) and re-run our basic model. Unfortunately I often cannot use all our dummies (*ENTRY*, *REGULAT* AND *INCUMB*) in the same equation due to singularities that occur with the design matrix. However, the model fits are impressive and the coefficients have values that are robust for most part with the original regression in table 2 with a few interesting deviations. In the subcontinent (table 5) we find that the presence of the incumbent negatively (and significantly at the 10 % level) affects the mobile penetration rate. This result is consistent with Gebreab (2002) and may be due to the presence of countries like Myanmar and Nepal which have a monopoly incumbent and a low mobile penetration rate.

<TABLE 5 ABOUT HERE>

The Asia Pacific region has the bulk of the observations of the first (full) regression and perfectly reflects the results in table 6. Notice that I could not use *ENTRY* and *INCUMB* in the Asia-Pacific region because of singularity problems.

<TABLE 6 ABOUT HERE>

For the Middle Eastern countries, only the *LNGDP*, *LNLINE* and *TIME* variables are significant. These results are consistent with the results from our main regression in table 2.

<TABLE 7 ABOUT HERE>

7. The case of India

This section looks into the structure of the Indian Mobile Phone industry from the period 1997 to 2004 and categorizes the pattern of diffusion of cellular technology both in the rural and urban sectors of the country. It also looks at the major providers of cell phone service, examines the degree of competition in the market and its effect on cell phone subscription tariffs over the seven year time series. It investigates the introduction of a new technology in cellular service provision (Wireless in Local Loop or WiLL) in 2001 that competes for customers with the existing GSM (Global System for Mobile Communications) service and studies the effects of this technology duopoly on the industry at large.[11]

In August 1995, Modi Telstra launched the first cellular network in Kolkata. By October 2004, the installed base of mobile phone users in India stood at 41.66 million with annual growth rates of over 100 per cent from the 2nd quarter of 2003 onwards. The gross subscriber base of fixed line and mobile telephone users was 88.47 million resulting in an overall tele-density of 8.24 per cent in October 2004 (TRAI, 2004). Out of this, fixed line telephones accounted for 43.96 million, and thus the number of mobile subscribers in India had crossed the number of fixed line telephones in India. Figure 6 depicts the number of subscribers for both fixed line telephones as well as cellular telephones over the decade 1995 – 2004.[12]

<FIGURE 6 ABOUT HERE>

Fixed line telephones have grown over this period at an average of 30 per cent a year. Cellular subscriptions grew at an impressive 24 percent per year. From 1999 adoption of cellular phones grew

[11] WiLL technology is a "limited mobility" technology that is related to the Code Division Multiple Access (CDMA) technology that is the dominant cellular provision format in the USA.

[12] The source data for this chart are the International Telecommunication Union Yearbook of Statistics, 1993-2002 (ITU, 2004) and Telecom Regulatory Authority of India (TRAI 2003, 2004a, 2004b).

at a staggering 453 per cent a year. Today, there are 54 GSM 900 networks and nine major providers that span the metropolitan cities and the non-metro "circles." The installed base for WiLL (mobile) service was approximately 7.5 million in March 2004, with four main players (TRAI, 2004b, TRAI, 2004c). The next two sections examine the diffusion of cellular services in India contrasted with the experience in other countries in Asia.

7.1 Cellular technology adoption in India- a brief history

The rapid rise of mobile telephony in India occurred as a result of the opening up of the Indian market to private investment in general and foreign direct and institutional investment that came in the wake of the New Economic Policy (NEP) of July 1991. This set of reforms introduced sweeping changes in the external sector as well the deregulation of several erstwhile public sector domains, one of which was telecommunications.[13] In the early nineties, tele-density in India was a little over 1 per cent (ITU, 2004). As increasing the telephone coverage was a high priority due to its effect on human development parameters in a country (UNDP, 2001), the Government of India (GOI) liberalized the telecommunications sector in 1994. This liberalization in the form of the National Telecom Policy 1994 (NTP 94) embodied a shift insofar as access to telecommunications technologies were no more seen to be a privilege to be enjoyed by the wealthy but rather as a necessity for the economic and political advancement of the country's population (TRAI, 2004a). The universal service obligation in NTP 94 spurred the government to explore options other than to extend its fixed line telephone networks. Furthermore, NTP 94 also sought to increase the level of competition in the sector, which at that point had three incumbents in fixed telephony services and no mobile service providers.[14]

Accordingly as a strategy to increase India's telephone coverage in 1994, GOI invited bids from and issued licenses to eight separate mobile telephone service providers in the four major metropolitan cities of India. Initially the market was designed to be a regulated duopoly with two providers for each metropolitan area. All of these providers used the GSM technology, which is the leading cellular technology accounting for approximately 74 per cent of the current global digital phone market according to the EMC World Cellular Database (EMC, 2004). The market was extended in 1995 to include 20 telecom circles that roughly corresponded to the states of India. These were categorized into A, B and C type circles with the A circles forecast as having better business potential than B circles which in turn were felt to be more potentially profitable than the C circles. Table 8 lists the states that fall in each category or circle. The Telecom Regulatory Association of India (TRAI) was set up in 1997 to be an independent agency that provided oversight for not just mobile service but the entire telecom sector.[15]

<TABLE 8 ABOUT HERE>

The initial response of the private sector and foreign direct investors was very promising as India provided companies with a low tele-density, high demand economy and a growing middle class. According to the Department of telecommunications (DoT), the FDI inflow into the telecom sector increased over 800 times in the period between August 1993 and March 1998. Roughly half of the total investments in telecom were made to the cellular industry. This wave of foreign investment brought in Singapore Telecom (stakeholder in Bharti Televentures which operates in India under the brand name AirTel) and Hutchison Whampoa Telecom (who provide services under the brand name

[13] For a detailed summary of the reforms introduced by the Government of India (GOI) known as the New Economic Policy in July 1991 see Acharya (2002).

[14] The three incumbents were DoT, Mahanagar Telephone Nigam Ltd. (MTNL) and Videsh Sanchar Nigam Ltd. (VSNL). Out of these public sector providers, DoT operated in all parts of the country except New Delhi and Mumbai, while VSNL provided international connectivity (Singh et al., 1999). It may be notes that BSNL, a current provider of both fixed and mobile phone services is the corporate entity created by the DoT since October 2000 to provide telecommunications services under NTP 99. A rationale for operating in this manner was that it would make public sector service provision more efficient (and provide a level playing field among the private operators and the incumbent) to have a corporation providing the services rather than a department of the government. Currently DoT is responsible for policy making, provision of licenses and the propagation and administration of MOUs that generate private investment in telecom equipment and services

[15] Some of the specific functions of TRAI include interfacing with the government to ensure transparency in the bidding process for licenses, monitoring the level of compliance with license conditions for companies, fixing tariffs and service targets for telecom services in conjunction with companies, settling disputes between service providers and protecting the consumer through monitoring of the quality of service (Gupta, 2002).

Hutch). However, this initial exuberance gave way to a faltering market for cellular services in 1997-98, where low retained earnings on the part of a number of cellular licensees led to several licenses being terminated by the DoT and a certain amount of merger/acquisitive activities. For a detailed list of service providers and their evolution in the Indian cellular market see table 9.

<TABLE 9 ABOUT HERE>

What were the main reasons for the slowdown the industry from 1997-99? *First*, telecom regulation was performed as with most liberalization reforms in developing countries, more with a view towards privatization as a pancea for all ills, rather than the more balanced approach of setting up independent monitoring agencies (TRAI was set up only in 1997, whereas reforms were introduced as early as 1992) and enforcing effective competition before opening up the economy to private sector participation and foreign investment. This form of liberalization has been performed by other developing countries and puts the interests of corporate entities, international organizations like the World Bank or IMF and policies that yield significant short run revenue over long term consumer welfare. Not surprisingly, this hurried process of privatization has often led to an intertemporal lowering of technology penetration. This phenomenon is well documented by Wallsten (2001) in a study that looks at telecom deregulation in Africa and Latin America.[16] In the case of the Indian mobile industry, deregulation should have been preceded by a policy of tariff rebalancing coupled with a strong regulatory environment.[17] *Second*, when TRAI was set up in 1997, there was considerable ambiguity regarding the scope and extent of its powers, that led to a significant amount of service related legal disputes between it and cellular licensees and an associated slowdown in the level of FDI that came into the industry from 1997-99 (COAI, 2004). The deterioration in the quality of service offered by certain cellular providers was also a function of the high license fees paid by some operators, which given the low installed base of the technology at the time, led to high operating costs, exorbitant tariffs (to the tune of almost Rs 17 as peak-rate). High costs led to the termination of licenses for cellular operators Digicel Airlink and Koshika for non-payment of license fees. *Third*, there was a certain amount of false optimism on the part of some operators who overestimated the scope of the Indian market and paid huge premiums in order to secure licenses only to find a smaller market than they had estimated coupled with a forbidding cost structure. The near collapse of the industry in 1999 caused the Government to undertake a review of the existing telecom policy and TRAI's role in it. Out of this review, the National Telecom Policy 1999 (NTP 99) was announced in March 1999. This was followed by the amendment of the TRAI Act in early 2000.

7.2 India's cellular experience compared to other developing countries in Asia

Compared to other countries in Asia, India shows low percentage diffusion rate. Figures 7 and 8 show India's subscriber base and subscriber base per 100 of population respectively. Compared to China with a subscriber base of over 250 million in 2002 and Taiwan and Israel with penetration rates of 106 and 95 percent respectively, India has shown slower growth in the 1993-2002 period. Even today, with a subscriber base of close to 40 million (December 2004), India lags behind China, Korea and Taiwan (in both absolute as well percentage penetration) and is comparable to countries like Indonesia, Malaysia and Philippines. It is however ahead of other countries in the Indian subcontinent and a number of the Middle Eastern states.

<FIGURE 7 ABOUT HERE> <FIGURE 8 ABOUT HERE>

[16] In Wallsten (2001) fixed line phone penetration is negatively related to the presence of a privatized incumbent, while competition and privatization with an independent regulator increase main line penetration. The idea that *an environment that does not emphasize competition may well find no benefits emanating from making the transition from state to private ownership* confirms earlier studies in the literature like Peltzman (1971), Caves and Christiansen (1981), Caves (1990), Ahuja and Majumdar (1998) and caution proselytizers of privatization that privatizing enterprises in weak institutional environments with little or no competition may give rise to firm behaviour that is detrimental to societal welfare.

[17] Tariff rebalancing is a strategic measure often adopted by a telecommunications regulator or a government to widen access to communications services by the creation of a pricing structure that provides incentives to firms to invest on backbone infrastructure particularly to the rural areas.

What is interesting about India's cellular growth is that the main thrust has been observed in the 2000-2004 time period. Between December 2002 and September 2004, the number of GSM cellular subscribers in India grew by 250 percent, which represents a monthly average growth in the subscriber base of over 20 percent. Figure 9 shows this staggering growth in the 2002-2004 period.

<FIGURE 9 ABOUT HERE>

The main reasons for the improvement in growth for the industry were to do with regulatory refinements brought about by NTP 99. According to the new policies, direct interconnectivity between licensed mobile service providers and any other type of service provider in their area of operation (including sharing of infrastructure and access for long distance services) was permitted. The providers were also free to provide in their service areas of operation, all types of mobile services including voice and non-voice messages, data services and payphones utilizing any type of network equipment that met the relevant International Telecommunication Union (ITU)/Telecommunication Engineering Center (TEC) standards (TRAI, 1999). This same act also provided for the availability of optimal bandwidth not just for the existing operator in each service area but additional bandwidth to enable entry for new operators. Figures 9 and 10 illustrate the growth of the subscriber base for GSM cellular users in the metropolitan cities as well as for the non-metropolitan environments of small towns and villages. In pure numbers, the non-metro subscribers exceeded the metro subscribers, but in terms of penetration, the large metropolitan cities with 18 out of a 100 population with subscriptions far outstripped the small towns and rural areas with a penetration of a little over 2 percent for GSM mobile phones.[18]

<FIGURE 10 ABOUT HERE>

Thus the main thrust of cellular growth in India has been from the most urbanized environments in the country. This differential in diffusion rates between the metros and the rest of the country is also a testament to the high levels of dualism and inequity that have always plagued the Indian economy. For a significant number of rural towns and villages, a cellular phone is not a technology alternative but a basic need, as laying fixed line backbone in backwoods rural communities would require capital injections that the Central or State Government may not be able to provide. In the NTP 99, the government made a commitment to provide fixed line telephones on demand in towns and rural areas by 2002 and targeted a rural tele-density of 4 percent by 2005.[19] However this target is far from being achieved and so in 2005 the Indian Cabinet ministry approved a move to make the Universal Service Fund statutory. This provision is absolutely necessary as urban markets for cellular services in India may well reach saturation over the next twenty years creating a drag on the growth of this industry.

Figure 11 shows the monthly evolution of (GSM) cellular markets for the four main metropolitan cities in India for the period March 1997 to October 2004. The two largest cities, Delhi and Mumbai showed a higher growth of the subscriber base over the entire period. Figure 12 presents the number of subscribers added each month from March 1997 to October 2004. Notice that Chennai actually saw a fall in the number of GSM subscribers from October 2003 to January 2004. This fall is probably related to the growth of the WiLL limited mobility services from the end of 2003.

<FIGURE 11 ABOUT HERE> <FIGURE 12 ABOUT HERE>

WiLL technology, that uses fixed lines with a "last mile" connection being mobile, was first introduced in India in 2002 by MTNL and Reliance Infocomm. This technology by using externalities arising from the fixed infrastructure has been able to provide consumers with cheaper tariffs and thus has been beneficial in the provision of universal service in the Indian Economy. Though the provision of WiLL mobile services had commenced as early as 2002 it was only late 2003 that WiLL operators (BSNL, Tata Teleservices, Reliance and MTNL) managed to overcome regulatory hurdles and increase their subscriber bases.[20] The WiLL subscriber base was under 1 million until March 2003 but

[18] In terms of population, the four largest metropolitan cities Mumbai, Delhi, Kolkata and Chennai have a total of just over 46 million people or approximately 5 percent of the Indian population. The rest of the population of India is distributed over smaller towns and villages.

[19] In March 2002, the urban tele-density was 4.4 percent and the rural tele-density was approximately 1 percent.

[20] In August 2003, India's Telecom Dispute Settlement Appellate Tribunal (TDSAT) ruled that WiLL provision was perfectly legal and was in the best interests of the telecom sector and consumers. This regulatory battle was

has seen rapid growth ever since. By the end of 2003 it had climbed to about 6 million, which was a little less than half the size of the GSM mobile market.

At the heart of the various regulatory battles like the one over WiLL mobile services (see footnote 19) is the lack of a unified license in Indian cellular service provision. Currently cellular licenses in India are service specific and circle specific and a player engaged in the provision of one service in a circle (say fixed line) has to obtain a license to enter the mobile or internet/data communication segment in the same or different circle. Unified pan-Indian license agreements whereby an operator can provide a broad spectrum of services may actually provide more de-facto competition in the market.

7.3 Characterizing firm behaviour in the Indian cellular Industry: competition and pricing

Figures 13, 14, 15 and 16 illustrate the evolution of the (GSM cellular) market in the four main metropolitan cities of India from March 1997 to October 2004. The markets in all four of these cities were a regulated duopoly with two private (non-state owned) providers until a third operator joined the market about halfway through the time series. In all four markets the two main players are Bharti Televentures and Hutchison Telephone or AirTel and Hutch as they are popularly known. A third operator entered the markets in Mumbai and Delhi in March 2001. For Kolkata and Chennai entry of a third licensed operator occurred in January 2002 and June 2002 respectively. This was followed by the addition of a fourth operator in late 2002 for Mumbai and Delhi, and in early 2003 for Chennai. Entry into these markets was accommodated by the incumbents with the market share for AirTel and Hutch falling for the rest of the time series and those of the incumbents continuing to rise over the next couple of years.

<FIGURE 13 ABOUT HERE> <FIGURE 14 ABOUT HERE>

<FIGURE 15 ABOUT HERE> <FIGURE 16 ABOUT HERE>

Tariffs have fallen as a result of more vigourous competition for GSM providers over the last decade. Figures 17 and 18 show the prices over successive quarters for both WiLL providers as well as GSM providers. Figure 17 calculates a minimum average effective charge per minute for users of both cellular technologies based on usage pattern of 250 minutes per month. This is seen to be falling continuously in the period 2000-4004. WiLL providers on average had a lower minimum charge per minute in recent years allowing limited mobility providers to somewhat erode the market share of GSM operators.

<FIGURE 17 ABOUT HERE > <FIGURE 18 ABOUT HERE>

The pattern of competition in this market with oligopoly providers and two competing and compatible technologies is an interesting paradigm in industrial organization as it is different from the traditional models of competition with network externalities as proposed by Katz and Shapiro (1985, 1986,1992) and Farrel and Saloner (1985). These studies modeled competing *incompatible* technologies like VHS and Beta as well computer programmes and operating systems. In such a situation, various strategic moves could be initiated by firms that involved a captive or "locked in" installed base. In this case however, though the market has network externalities, consumers are not locked in (in markets where both these technologies are available). They are free to switch mobile plans interchangeably between GSM and WiLL providers. This has intensified competition and over time eroded profits for both incumbents and entrants. Net profits of four listed telecommunications service providers (VSNL, MTNL, Bharti Televentures and Tata Teleservices) declined as much as 47 per cent in 2002-03. The Cellular Operators Association of India (COAI) put accumulated losses of its members (GSM cellular service providers) at Rs 71 billion (US$1.42 billion) (Pinto 2003).

The entry deterrence taxonomy of Fudenberg and Tirole (1983) lists various strategies that may be adopted by incumbents to deter or accommodate entry depending on whether investment makes an incumbent tough or soft and if the firms in the market are strategic substitutes or compliments.[21] In the

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as a result of GSM cellular operators asserting that fixed service providers (like Reliance and BSNL) were using their fixed services advantage to eat into the market share of GSM cellular players.

[21] If increasing a strategic variable by one player makes the other reduce the same variable, we say that the two strategies are substitutes (e. g. - Cournot competition in quantities, where if one firm increases its output, the

mobile services sector, investment in advertising or infrastructure by an incumbent may indeed make him soft by providing spillover benefits to its rivals. These benefits may include both demand and supply side economies of scale. In such a situation, if there is price competition, the incumbent would do best by being a 'fat cat' (over invest) if he wanted to accommodate entry or adopt a 'lean and hungry look' (under invest to keep his operations small) if he meant to deter entry. Investment figures from the Indian cellular industry seem to indicate that the investments of the two largest players (Bharti and Hutch) in both advertising as well as infrastructure have been increasing steadily over the last decade.

8. Conclusions

The market for cellular services in Asia has seen growth in the last fifteen years that is hard to parallel in any other industry. An important reason for the rapid diffusion of cellular products appears to be the universal service provided by mobile firms in countries with low tele-density. The healthy economic growth seen in several countries in Asia is an important factor in the diffusion of cellular services as is the level of competition. In the case of India profiled in the last section, an interesting paradigm is observed (and paralleled by some other countries in Asia) of mobile provision by primarily private providers who are engaged in significant competition in numerous oligopoly markets. This intense competition has caused a lowering of tariffs and the ARPU (Average revenue per user) and very importantly the erosion of profit for almost all the providers in the market. The competition has been furthermore intense due to the co-existence of two competing and compatible technologies (GSM and CDMA).

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other reacts by reducing its output). If on the other hand, increase or decrease in a strategic variable causes the rival to do the same, we the two strategies are compliments
(e. g - Bertrand competition, where if one firms decreases its price, the other reacts by decreasing its price too.

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Table 1: countries used in the panel data analysis

Asia-Pacific	Indian Subcontinent	Middle East
Brunei		
Cambodia		
China		Bahrain
Hong Kong		Iran
Indonesia	Bangladesh	Israel
Japan	India	Jordan
Korea	Maldives	Kuwait
P.D.R Laos	Nepal	Oman
Macau	Pakistan	Qatar
Malaysia	Sri Lanka	Saudi Arabia
Philippines	Myanmar	Syria
Singapore		UAE
Taiwan		
Thailand		
Vietnam		

Table 2: Competition and Regulation in mobile markets in Asia (1993-2002)

Year	Number of countries	Number of countries with independent regulator	Number of countries with liberalized entry	Number of Monopolies	Number of Duopolies	Number of countries with 3 operators	Number of countries with 4 or more operators
1993	24	3	12	17	3	3	1
1994	26	4	12	19	2	3	2
1995	28	6	15	18	3	2	5
1996	29	6	16	17	4	3	5
1997	30	8	18	16	5	2	7
1998	30	8	19	15	3	4	8
1999	32	9	19	17	2	5	8
2000	32	9	19	15	3	6	8
2001	32	9	20	12	5	5	10
2002	31	11	20	11	5	4	11

Source: ITU Regulatory Database.

Table 3: Variables used in panel data regressions and their definitions

VARIABLE	DEFINITION
LNMOSUB100	Natural logarithm of the number of mobile subscribers in the country per 100 inhabitants
LNGDP	Natural logarithm of the GDP (in US$) per capita
LNLINE	Natural logarithm of the number of fixed lines operating in the country
LNPAY	Natural logarithm of the number of payphones in operation in the country
INCUMB	= 0 if there is no SOE or partially privatized ex-SOE (majority stake still controlled by government) in the mobile market = 1 if there is at least one SOE or partially privatized enterprise in the mobile market
REGULAT	= 0 if there is no independent regulator = 1 if there is an independent regulator
ENTRY	= 1 if free entry of firms is allowed in the year = 0 if entry is restricted to the market in the year
LNUMFIRM	Natural logarithm of the number of mobile providers
TIME	Discrete time trend variable

Table 4: Determinants of Mobile Diffusion in Asia

Dependent Variable = LNMOSUB100		
Variable	**Model 1‡**	**Model 2‡**
LNGDP	0.47***	0.47***
	(0.09)	(0.09)
LNLINE	0.51***	0.53***
	(0.11)	(0.12)
LNPAY	0.31***	0.28***
	(0.09)	(0.09)
INCUMB	0.10	0.01
	(0.27)	(0.27)
REGULAT	0.14	0.12
	(0.18)	(0.19)
ENTRY	0.72***	
	(0.19)	
LNUMFIRM		0.30***
		(0.10)
TIME	0.34***	0.34***
	(0.02)	(0.02)
Number of Observations	295	295
Number of countries	31	31
Multiple R-squared	0.97	0.97
Adjusted R-squared	0.96	0.96

‡ The 28 country specific fixed effects and the intercept have not been listed
*** denotes 1 % level of significance, ** denotes 5 % level of significance and * denotes 10% level of significance
Standard Errors are given in parentheses

Table 5: Determinants of Mobile Diffusion in the Indian Subcontinent

Dependent Variable = LNMOSUB100	
Variable	**Model 1‡**
LNGDP	0.37**
	(0.14)
LNLINE	1.19
	(0.82)
LNPAY	0.73
	(0.47)
INCUMB	-0.98*
	(0.59)
REGULAT	-0.74
	(0.46)
LNUMFIRM	1.04
	(0.79)
TIME	0.32*
	(0.16)
Number of Observations	53
Number of countries	7
Multiple R-squared	0.93
Adjusted R-squared	0.89

‡ The 6 country specific fixed effects and the regression intercept have not been listed
*** denotes 1 % level of significance, ** denotes 5 % level of significance and * denotes 10% level of significance
Standard Errors are given in parentheses

Table 6: Determinants of Mobile Diffusion in the Asia-Pacific Region

Dependent Variable = LNMOSUB100		
Variable	**Model 1‡**	**Model 2‡**
LNGDP	0.94***	0.85***
	(0.17)	(0.18)
LNLINE	0.48***	0.53***
	(0.09)	(0.09)
LNPAY	0.20**	0.17**
	(0.08)	(0.08)
ENTRY	0.92***	
	(0.13)	
LNUMFIRM		0.50***
		(0.08)
TIME	0.32***	0.29***
	(0.02)	(0.02)
Number of Observations	149	149
Number of countries	13	13
Multiple R-squared	0.98	0.98
Adjusted R-squared	0.98	0.97

‡ The 12 country specific fixed effects and the intercept have not been listed
*** denotes 1 % level of significance, ** denotes 5 % level of significance and * denotes 10% level of significance
Standard Errors are given in parentheses

Table 7: Determinants of Mobile Diffusion in the Middle East

Dependent Variable = LNMOSUB100	
Variable	**Model 1‡**
LNGDP	0.64*
	(0.33)
LNLINE	2.37***
	(0.72)
LNPAY	0.12
	(0.21)
LNUMFIRM	0.66
	(0.40)
REGULAT	0.28
	(0.37)
TIME	0.24***
	(0.05)
Number of Observations	93
Number of countries	9
Multiple R-squared	0.96
Adjusted R-squared	0.95

‡ The 8 country specific fixed effects and the intercept have not been listed
*** denotes 1 % level of significance, ** denotes 5 % level of significance and * denotes 10% level of significance
Standard Errors are given in parentheses

Table 8: Telecom Circles in India

A Category Circle	B Category Circle	C Category Circle
Maharashtra	Kerala	Himachal Pradesh
Gujarat	Punjab	Bihar
Andhra Pradesh	Haryana	Orissa
Karnataka	Uttar Pradesh(West)	Assam
Tamil Nadu	Uttar Pradesh(East)	North East States
	Rajasthan	
	Madhya Pradesh	Andaman and Nicobar Islands
	West Bengal	
		Jammu and Kashmir

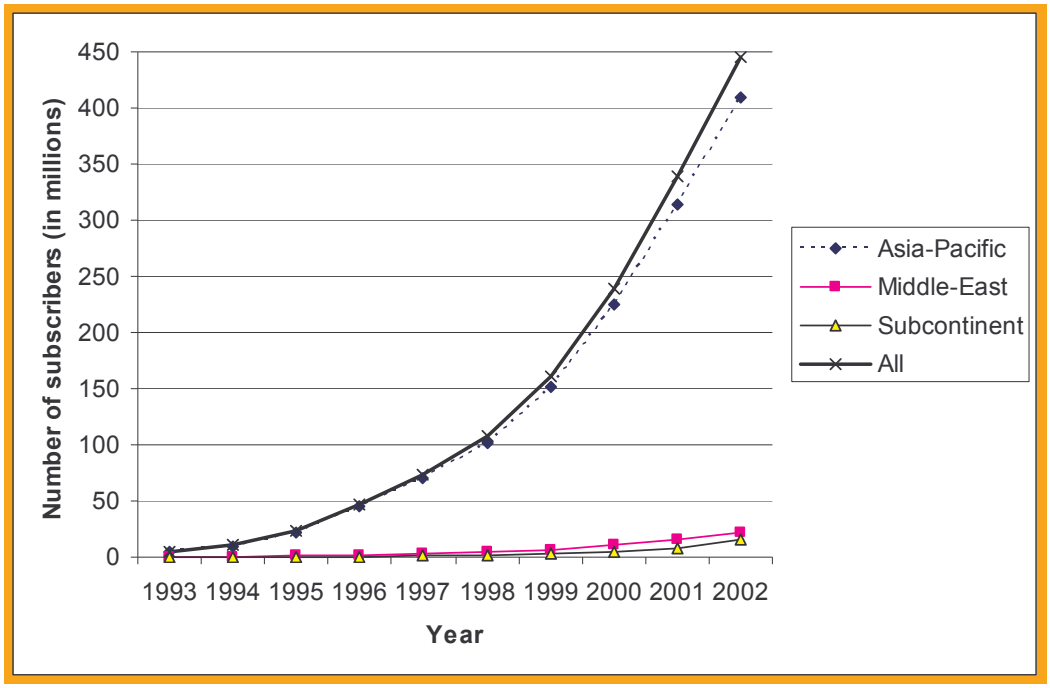
Source: COAI

Table 9: Entry of Cellular providers and technologies by year: India

Year	Provider	Technology	Remarks
1994	Usha Martin	GSM	
	Skycell	GSM	Bharti since 2001
	Modi Telstra	GSM	Spice since 2001
1995	RPG Cellular	GSM	Aircel since 2004
	Hutchison Telecom	GSM	
	Bharti Tele-ventures	GSM	
1996	Aircel Digilink	GSM	Hutchison Essar Group
	BPL Cellular	GSM	
	Idea Cellular	GSM	
1997	Escotel	GSM	Idea Cellular since 2004
	Hexacom	GSM	
	Koshika	GSM	Usha Group Company license terminated 1999
	Spice Telecom	GSM	Modi Group Company
	Tata Cellular	GSM	Idea Cellular since 2002
	JTM Evergrowth	GSM	Bharti since 1999
	Reliance Infocomm	GSM	Also started CDMA service in 2001
1999	Aircel	GSM	Sterling Group Company
2001	BSNL	GSM	Former SOE now partially privatized
	BTA Cellcom	GSM	Idea Cellular since 2004
	MTNL	GSM	Former SOE now partially privatized
2002	Reliance India Mobile	CDMA	Also GSM operator in some regional markets
	MTNL	CDMA	Also GSM operator in some markets
2003	Tata Indicomm	CDMA	Also GSM operator in some regional markets
2005	BSNL	CDMA	Also GSM operator

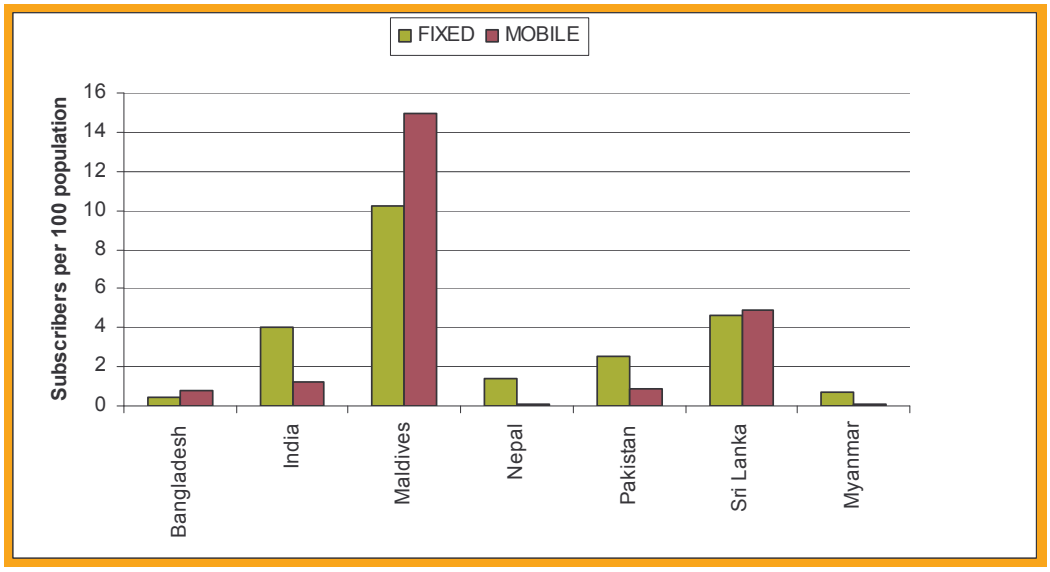
Source: Cellular Operators Association of India (COAI)

Figure 1: Number of subscribers- Asia



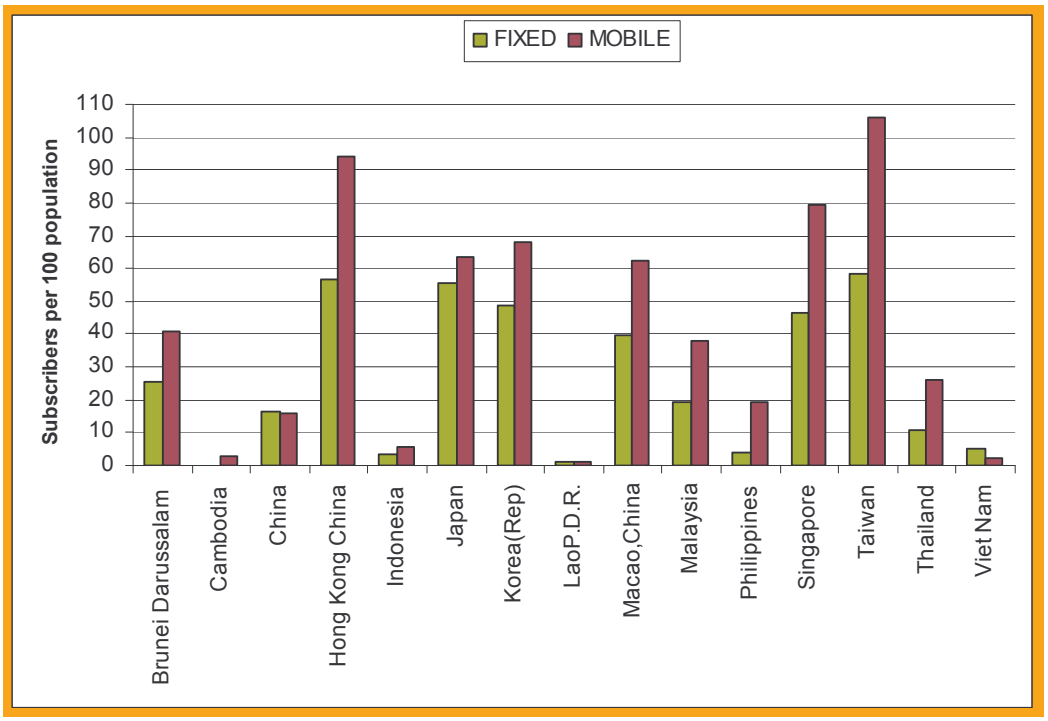
Source: ITU Yearbook of Statistics (2004)

Figure 2: Fixed Line and Mobile penetration (2002) - Indian Subcontinent



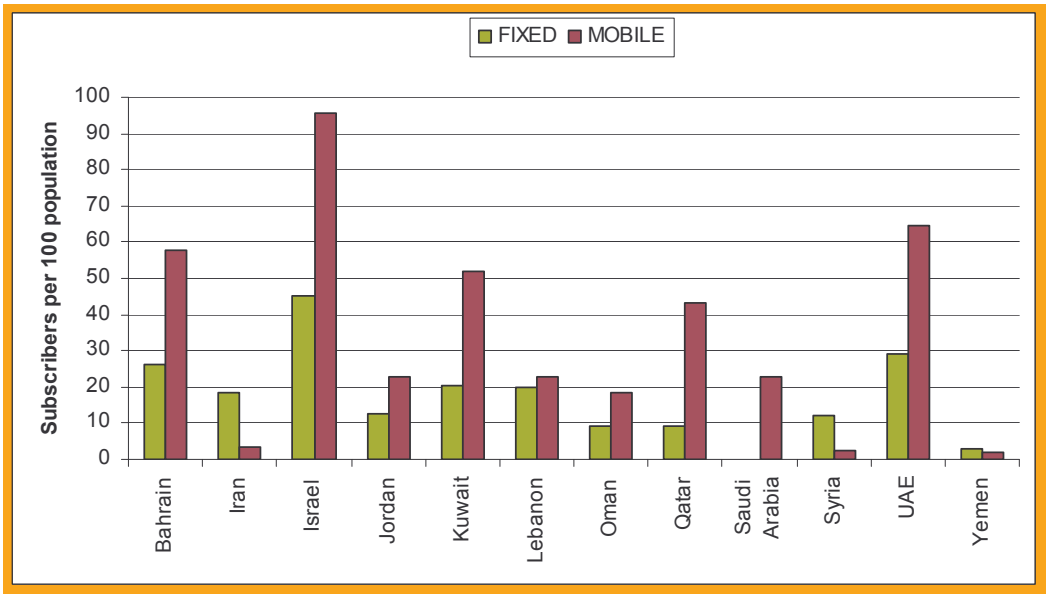
Source: ITU Yearbook of Statistics (2004)

Figure 3: Fixed Line and Mobile penetration (2002) – Asia-Pacific



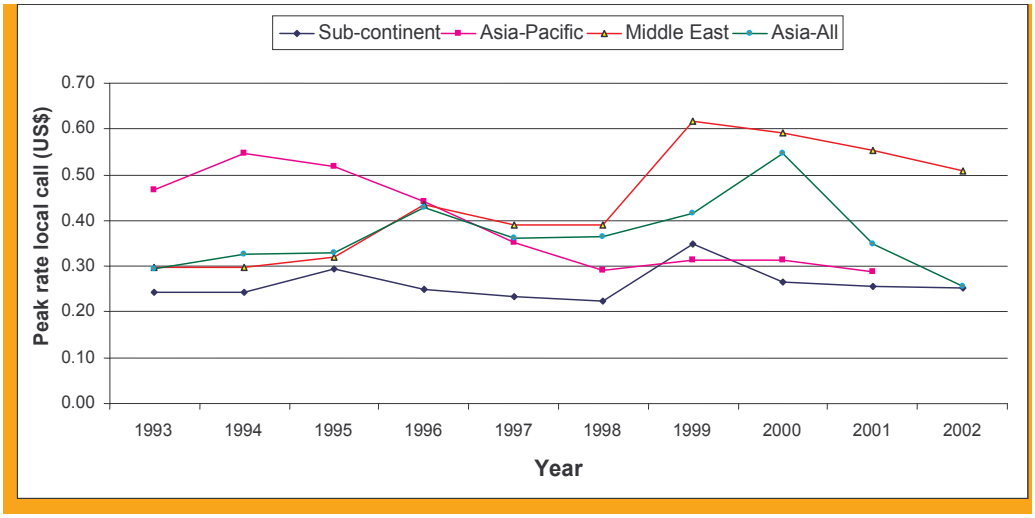
Source: ITU Yearbook of Statistics (2004)

Figure 4: Fixed Line and Mobile penetration (2002) - Middle East



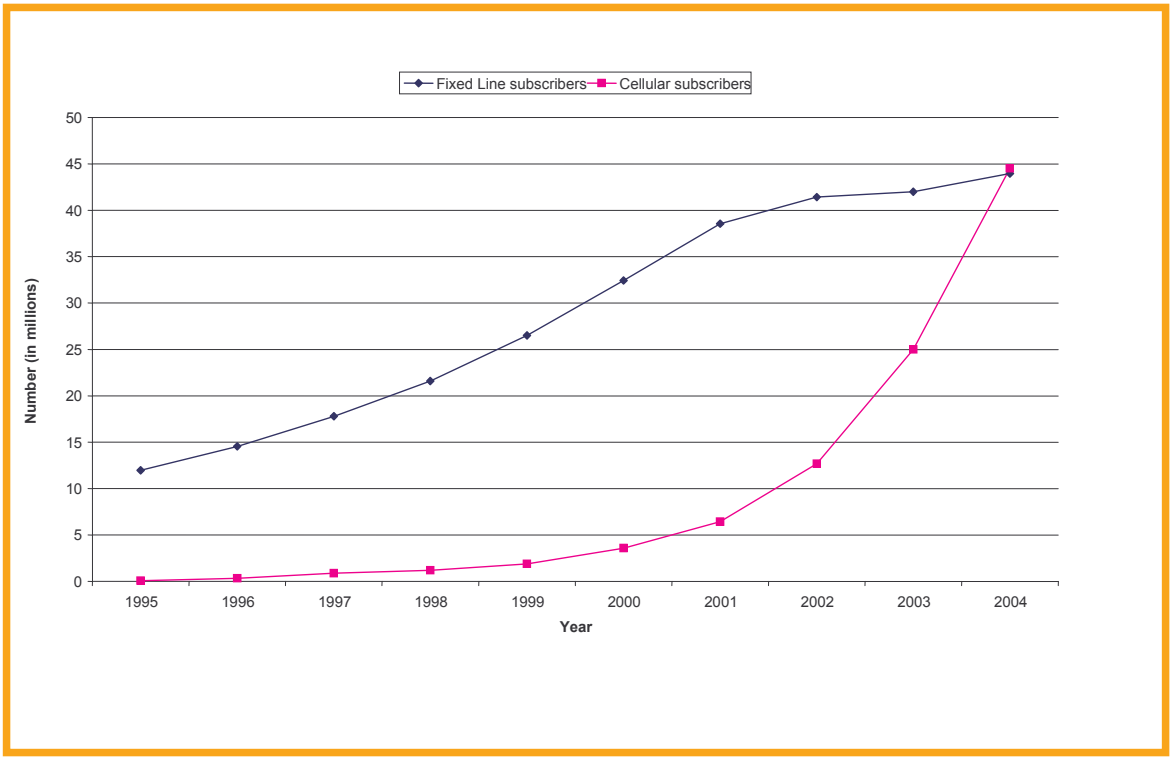
Source: ITU Yearbook of Statistics (2004)

Figure 5: Average peak rate tariff (3 minute calls) for mobile users (1993-2002)



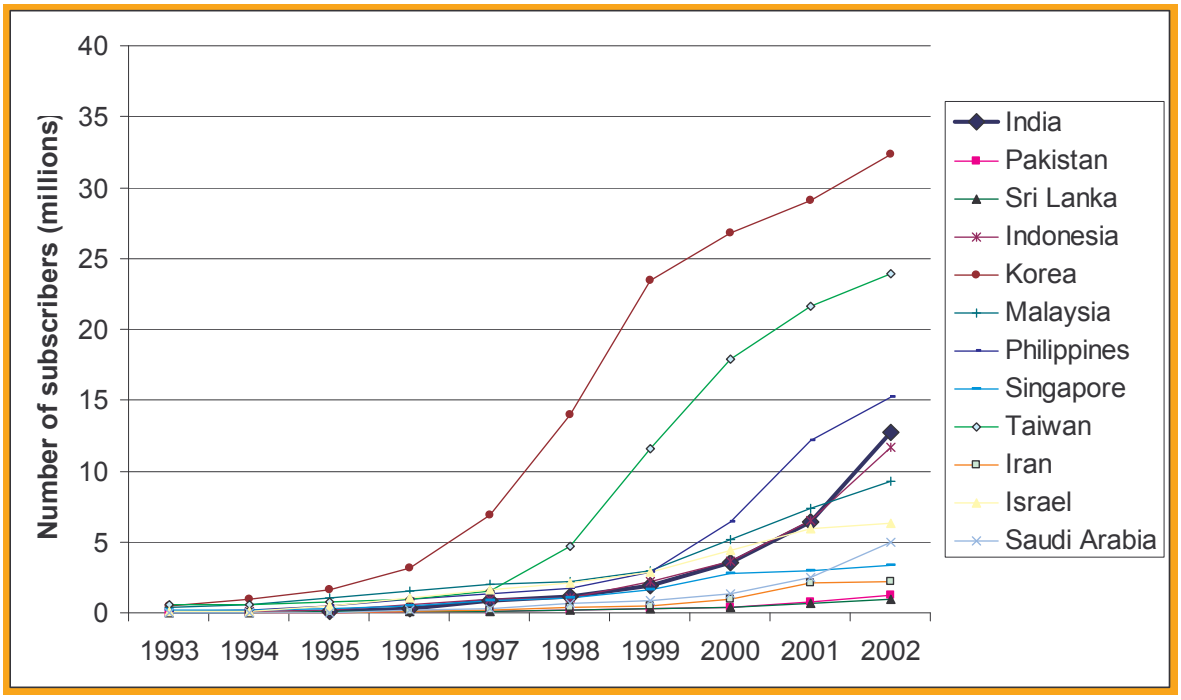
Source: ITU Yearbook of Statistics (2004)

Figure 6: Growth of Fixed line and Mobile subscriber base for India (1995-2004)



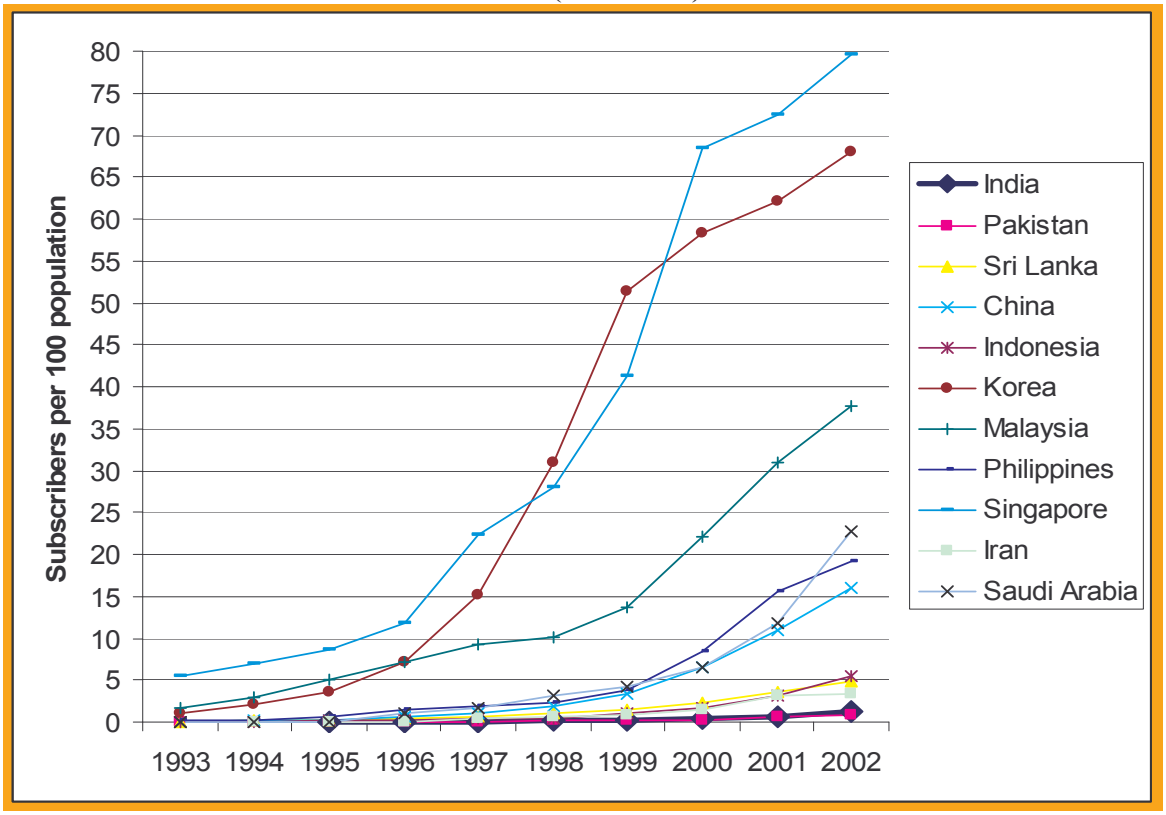
Source: Cellular Operators Association of India (COAI), Telecom Regulatory Authority of India (TRAI)

Figure 7: Growth of India's mobile subscriber base compared to other countries (1993-2002)



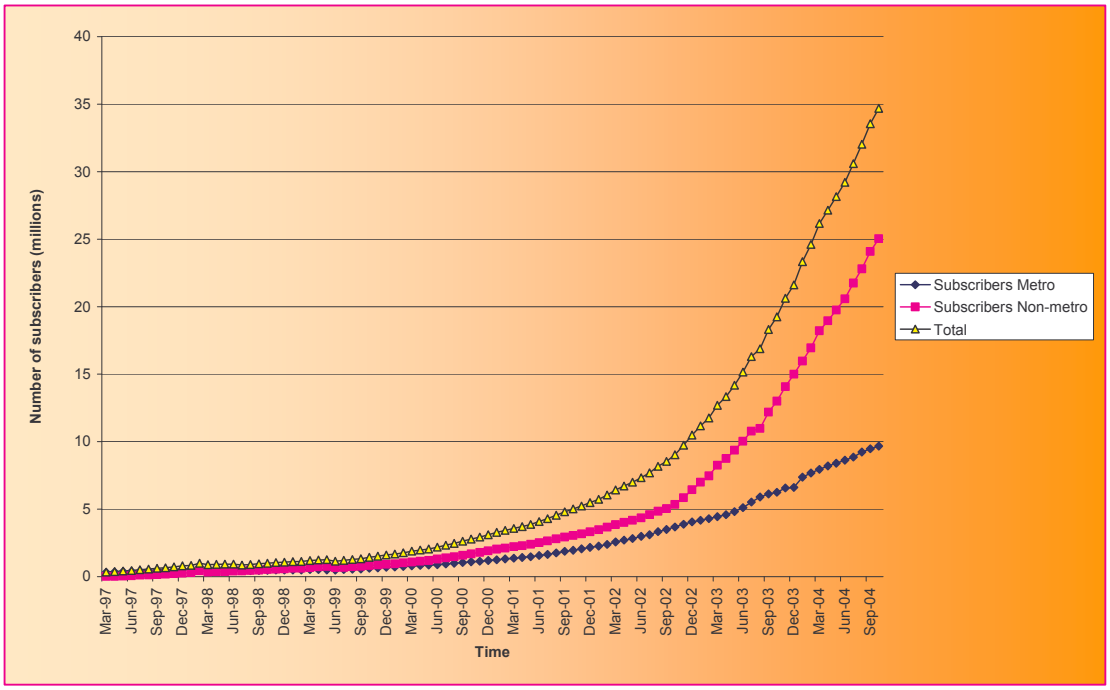
Source: ITU Yearbook of Statistics (2004)

Figure 8: Mobile subscriber base as percentage of population compared to other countries (1993-2002)



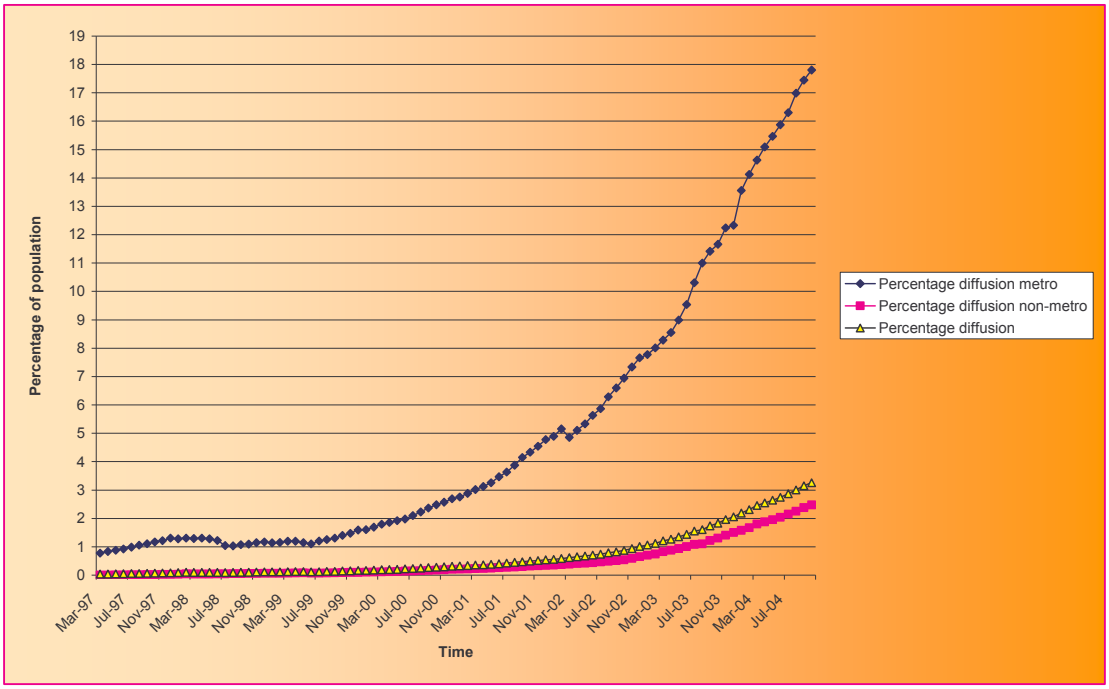
Source: ITU Yearbook of Statistics (2004)

Figure 9: Growth of GSM Cellular Subscribers in India (metro and non-metro), 1997-2004



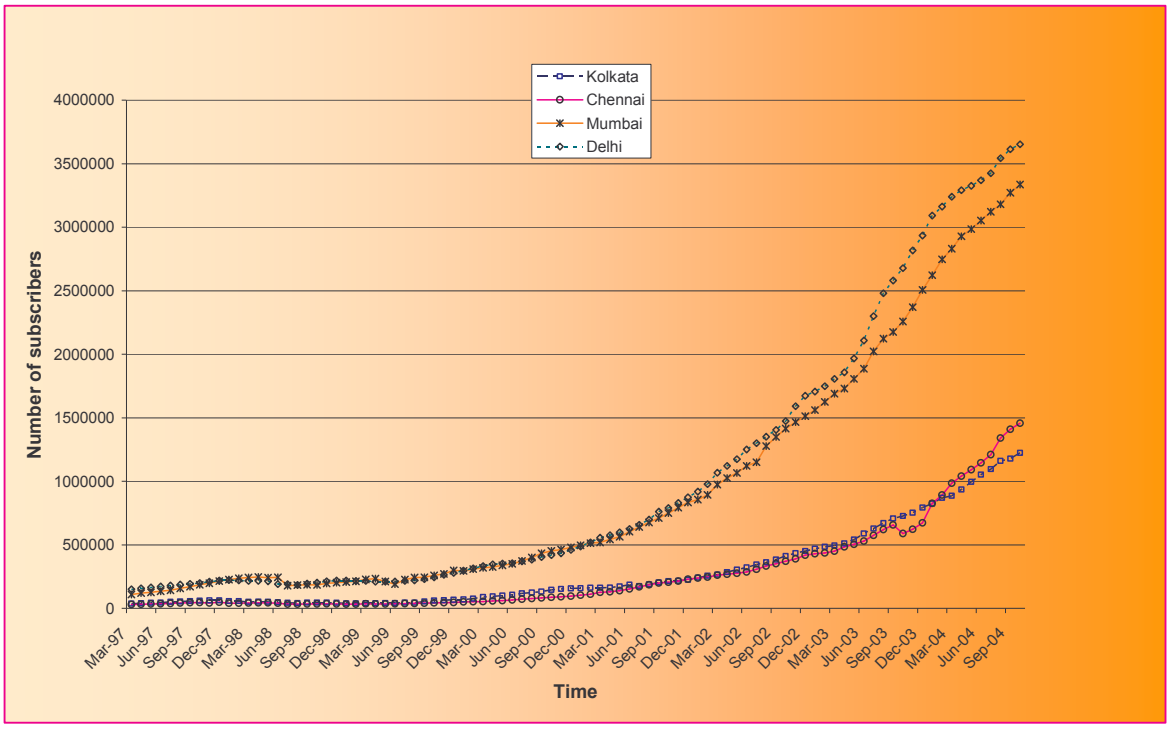
Source: Cellular Operators Association of India (COAI)

Figure 10: GSM mobile penetration in India (metro, non-metro and total), 1997-2004



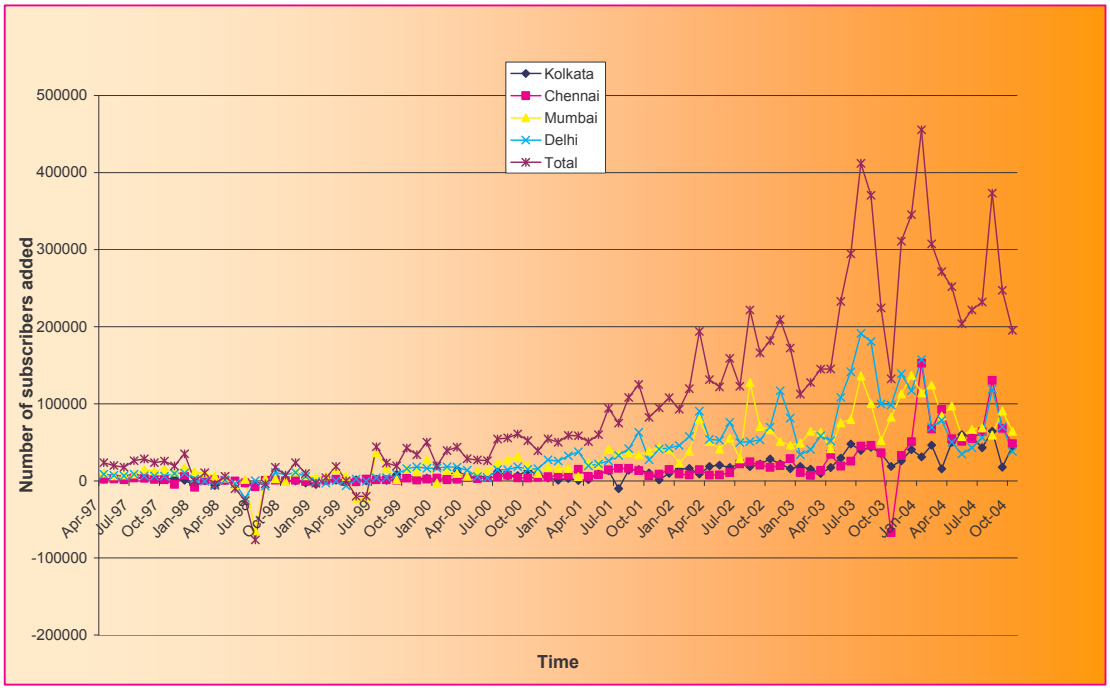
Source: Cellular Operators Association of India (COAI)

Figure 11: Market Sizes of the main metropolitan areas in India



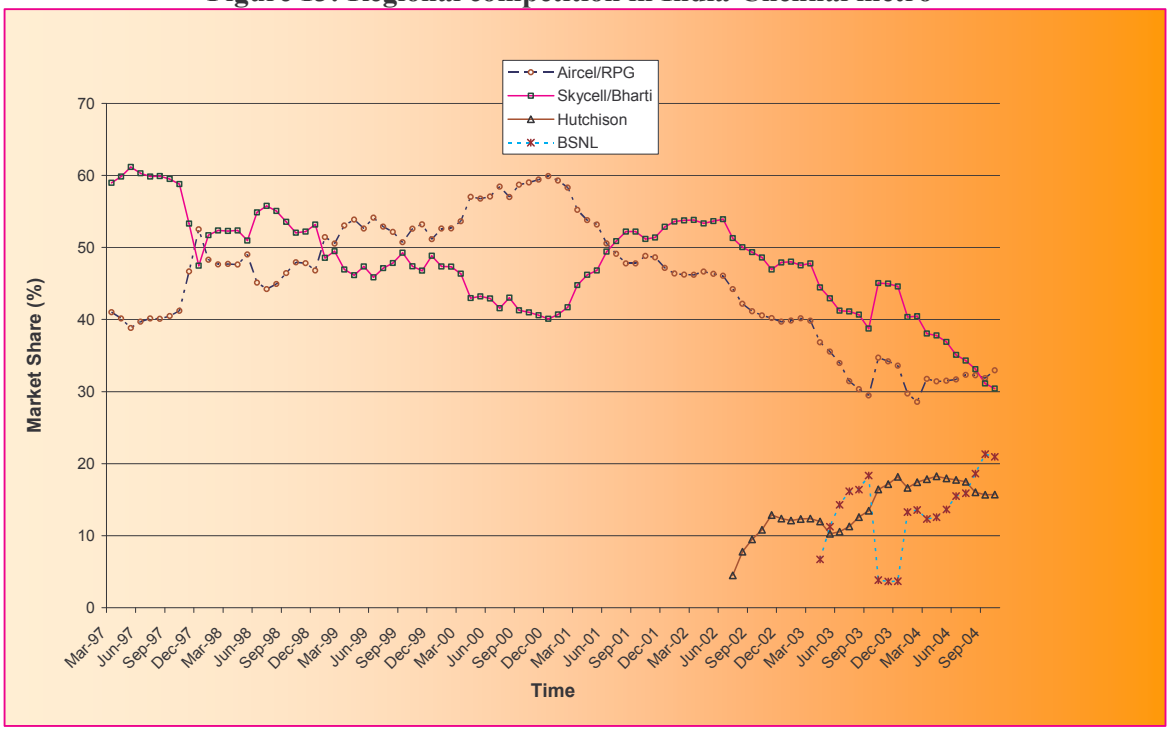
Source: Cellular Operators Association of India (COAI)

Figure 12: GSM subscribers added in main metropolitan areas in India



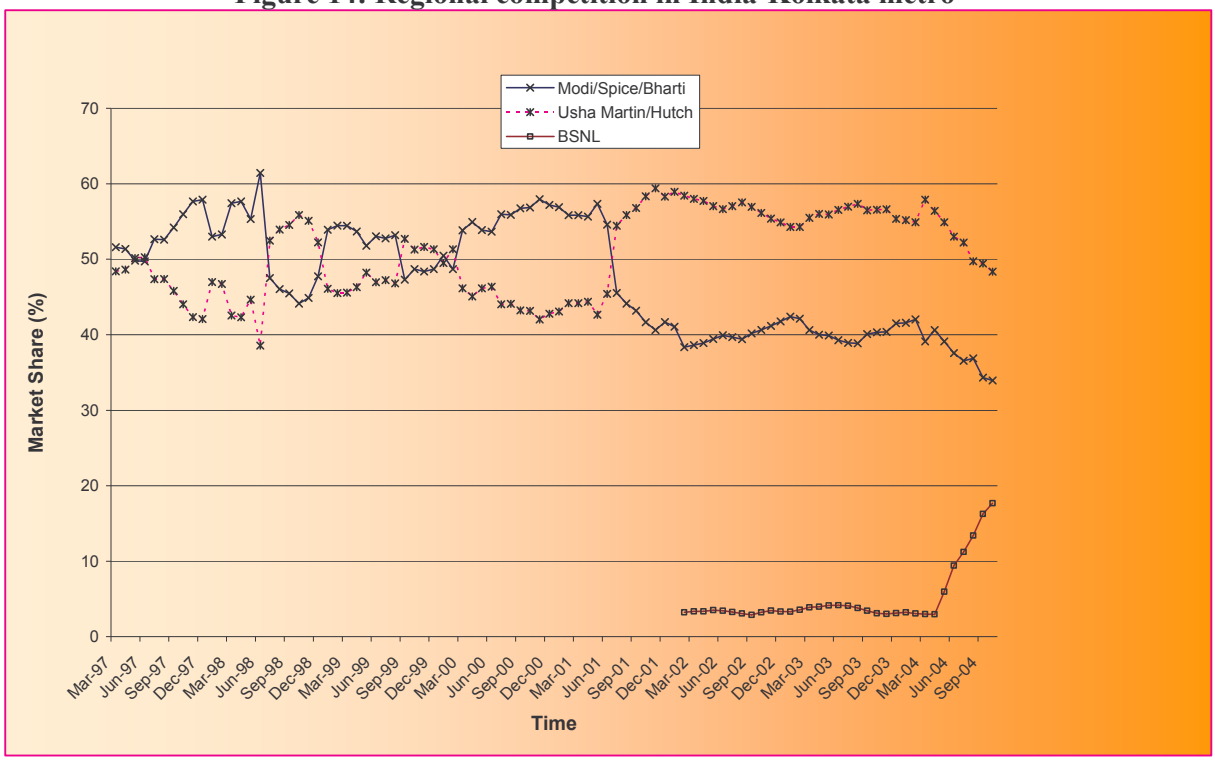
Source: Cellular Operators Association of India (COAI)

Figure 13: Regional competition in India-Chennai metro



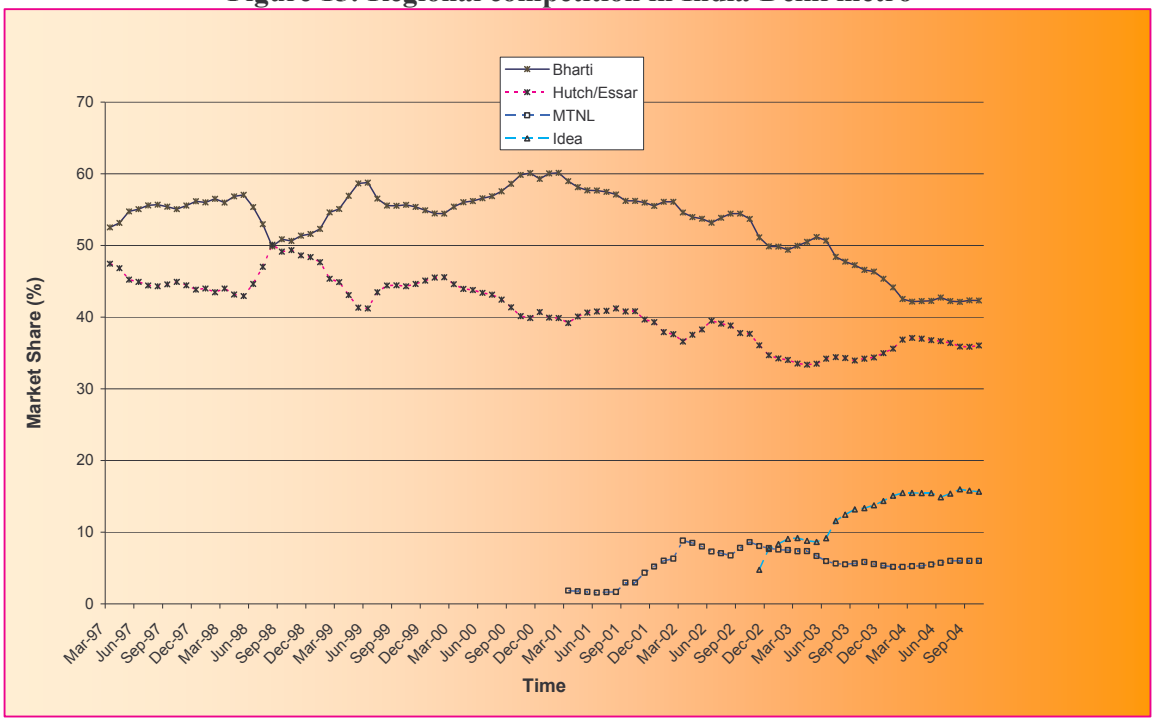
Source: Cellular Operators Association of India (COAI)

Figure 14: Regional competition in India-Kolkata metro



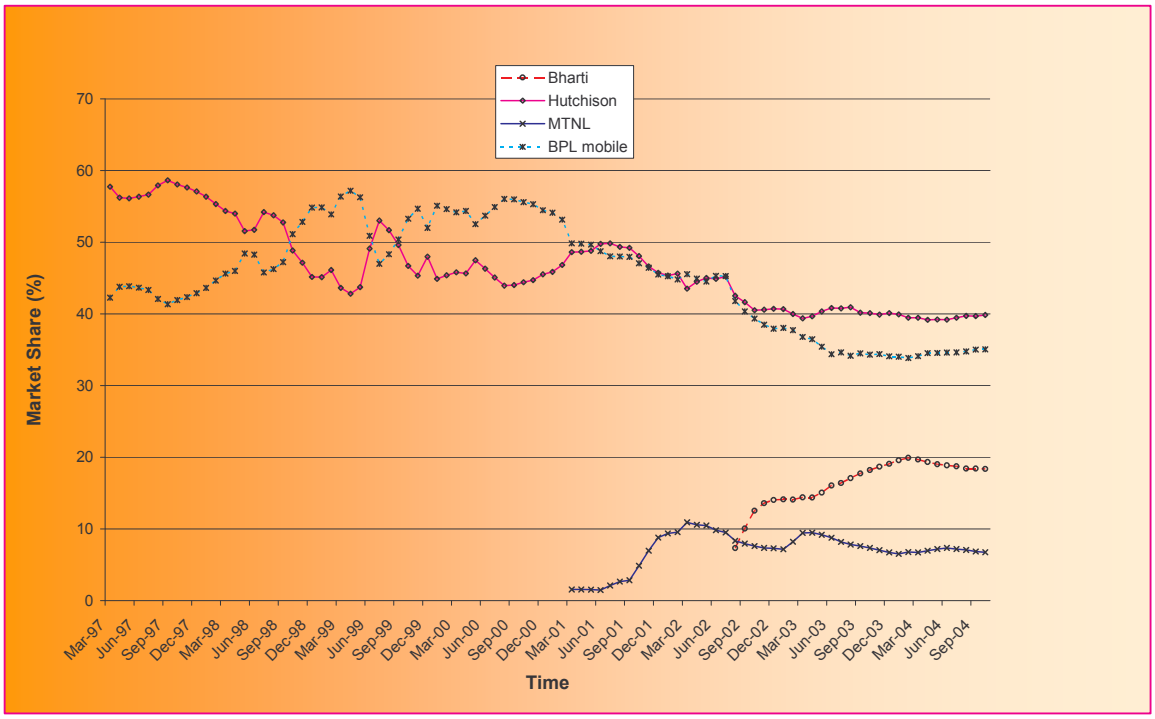
Source: Cellular Operators Association of India (COAI)

Figure 15: Regional competition in India-Delhi metro



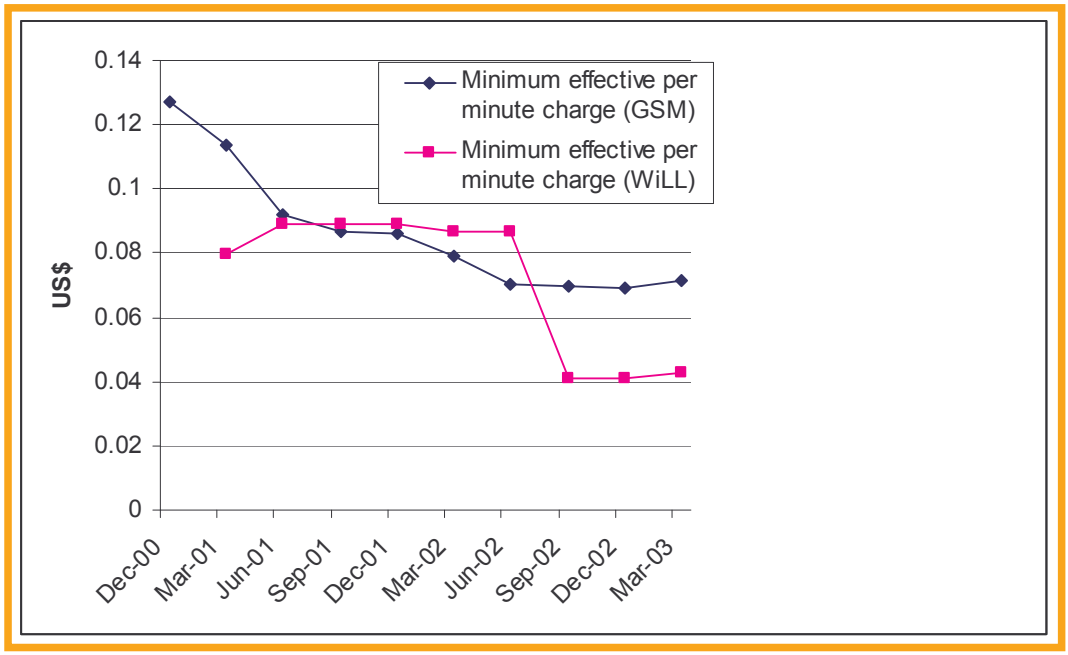
Source: Cellular Operators Association of India (COAI)

Figure 16: Regional competition in India-Mumbai metro



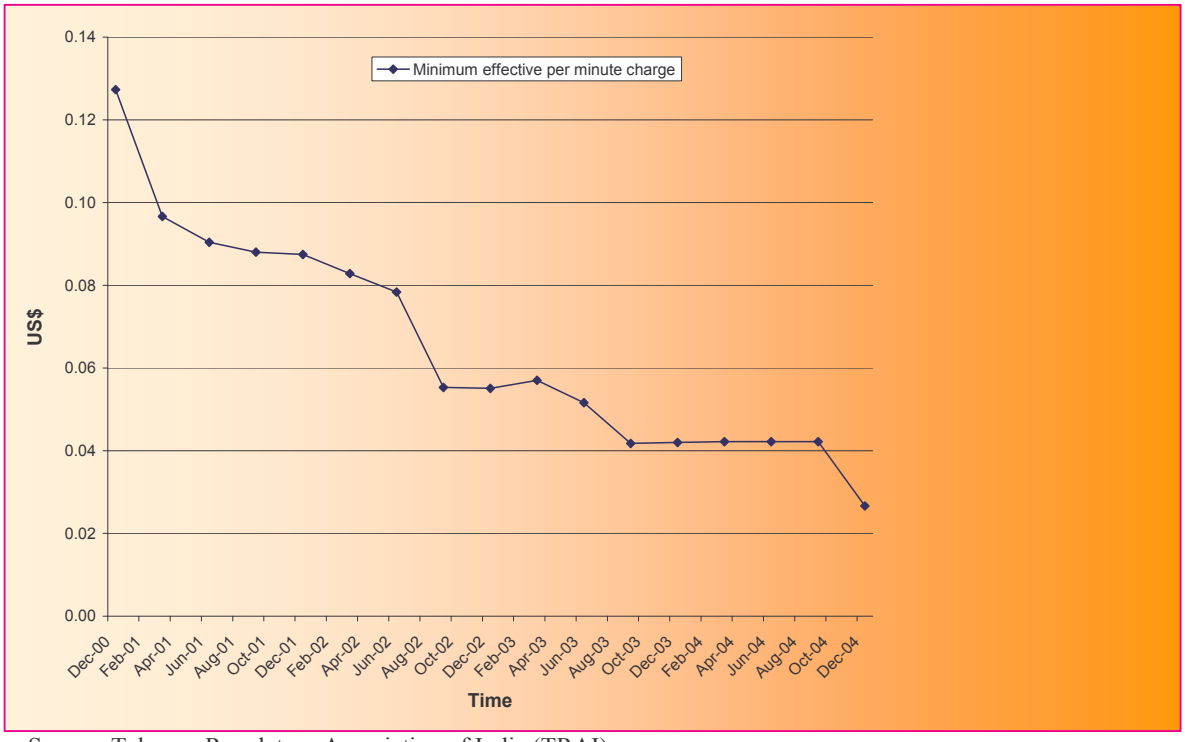
Source: Cellular Operators Association of India (COAI)

Figure 17: Minimum effective per minute charge for GSM and WiLL subscribers



Source: Telecom Regulatory Association of India (TRAI)

Figure 18: Minimum effective per minute charge for mobile subscribers in India



Source: Telecom Regulatory Association of India (TRAI)