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Sam Hakim and Simon Neaime

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Send correspondence to:
Sam Hakim
Pepperdine University, USA.
sam.hakim@pepperdine.edu

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21 Al-Sad Al-Aaly Street
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Abstract

This study evaluates the growth and trend in the mobile telephone sector in several MENA countries between 1995 and 2007. We find that the magnitude of demand elasticities do not entice collusive behavior between service providers because the effect of price reductions is neutral on total revenues; we also find that the cost of service and administrative corruption have a strong negative effect on mobile penetration, which, surprisingly, is higher in countries with more unequal income distribution. With respect to the degree and scope of liberalization of the mobile sector, we find that the direction of deregulation is accelerated in countries with a high proportion of investment, where the sector generates high revenues, and where civil society is generally free from government interference. At the same time, the liberalization is slowed in countries characterized by a high-income inequality and average cost of service. The study discusses how market reforms in developed countries fail to translate to developing countries because several negative externalities are often overlooked. We identify several factors that should be considered for liberalization to succeed and explain how to design a strategic path for reforms in the mobile sector.

ملخص

تقيم هذه الدراسة نمو واتجاه قطاع الهاتف المحمول في عدة بلدان منطقة الشرق الأوسط و شمال افريقيا بين عامي 1995 و 2007. و نجد أن مرونات حجم الطلب لا تدلل على الاتساق بين سلوك مقدمي الخدمة بسبب حيادية تأثير انخفاض الأسعار على إجمالي الإيرادات. كما نجد أيضا أن لتكلفة الخدمات والفساد الإداري تأثيرا سلبيا قويا على انتشار الهواتف النقالة، و من المدهش أنه أعلى في البلدان ذات التفاوت الكبير في توزيع الدخل. أما فيما يتعلق بدرجة ونطاق تحرير قطاع الاتصالات الجوالة ، نجد أن هناك تسارع نحو تحرير سعر الصرف في البلدان التي لديها نسبة عالية من الاستثمار، حيث يولد هذا القطاع عائدات عالية ، ويكون المجتمع المدني بصفة عامة خالي من تدخل الحكومة. و في الوقت نفسه، يتباطأ التحرير في البلدان التي تتميز بعدم المساواة في الدخل وارتفاع متوسط تكلفة الخدمة. و من هذا المنطلق تناقش الدراسة كيف يفشل نقل اصلاحات السوق في البلدان المتقدمة إلى البلدان النامية غالبا بسبب التغاضي عن عدة عوامل خارجية سلبية. لهذا نقدم مجموعة من العوامل التي ينبغي النظر فيها من أجل نجاح التحرير وشرح كيفية تصميم مسار استراتيجي للإصلاحات في قطاع الاتصالات الجوالة.

1. Statement of the Research Problem

It is now well recognized today that the openness of the telecommunication sector contributes significantly to economic growth and social welfare. Spillover effects on other sectors of the economy are believed to create supply-driven growth.

In the Middle East and North Africa (MENA) region, the spectacular growth of the mobile telephone sector has been attributed to the introduction of digital cellular technologies, the existence of large untapped markets with limited fixed line penetration and the slow but gradual liberalization of markets. Yet, despite recent progress in a number of countries, the market liberalization in telecom has been slower in this region than elsewhere in the developing world (Rossotto et. al. 2005).

More recently, despite the challenging economic landscape due to the global financial crisis, the underlying fundamentals of the MENA telecom industry have held up well. In 2008, the number of telecom subscribers in the MENA region increased by 5% to 227 million, while telecom service providers' revenues increased by 12% percent to $40.6 billion. This strength echoes the telecom industry's historical resilience, as compared with other industries. In some MENA countries, telecom is exhibiting strong growth, driven by the expansion of network coverage. For all of these reasons, telecom investment in MENA is likely to continue to grow with positive spillover effects to other sectors in the economy. However, the potential for further industry privatization and liberalization is still large.

Despite efforts exerted throughout the past few years to liberalize the telecom markets, the range of competition varies considerably across MENA countries. For example, none of the Arab MENA countries has yet reached the level of liberalization of Jordan and Bahrain. Comparatively, the markets in Lebanon, Libya and Iran are particularly crippled, and struggling with high service tariffs or entry barriers. With the exception of Qatar and the UAE, currently all the markets in MENA have two, three or even four mobile service providers. In Qatar, the concession granted to the current and only mobile service provider (Q-Tel) will expire in 2013, and this date will mark the end of all cellular monopolies in the main MENA countries.

In terms of subscriber base, Egypt has the largest mobile subscriber base in the MENA with considerable growth rates since 2004. This is followed by Saudi Arabia where the number of mobile subscribers has double-digit growth rates but with a penetration rate around 53%, a figure below other Gulf Corporation Council (GCC) countries (Hasbani et. al, 2009).

As remarkable as these achievements may be, however, there are scant academic studies on the telecom sector in MENA countries. The available studies are based on older data that precede the recent penetration of the mobile sector (for example the significant study in this sector -- by Rossotto et. al 2005 -- is based on data for 1999) or focus on a specific country (for example Egypt, in the case of Galal, 1999). The recent performance of the telecom sector, and mobile services in particular, has not received the necessary attention it deserves, nor has the pace of market transition from monopoly to competition been investigated. This void occurs at a time when several MENA countries are currently evaluating several liberalization schemes of their mobile industry. Hence, there is a need to reassess the future market demand for airtime and sales revenues of this sector and relate these findings to the optimal market structure and the regulatory landscape that a government would select to obtain the maximum social welfare. There is now a universal admission that successful mobile telecommunications services create large gains in consumer welfare and government roadblocks that delay their penetration lead to significant losses in consumer surplus as documented by (Hausman, 2002). While there is also a wide recognition that competition is necessary for the future growth of the mobile industry, telecommunications reform will require changes in existing laws and regulatory bodies, all of which need time and experience

to function effectively. Most industrialized countries however have a substantial regulatory infrastructure when undertaking reforms, while MENA countries often do not. As we will discuss below, this project makes a significant step in explaining the steps required to develop the regulatory framework that should parallel the growth in mobile services based on the work of Beato et. al (2002) and Laffont (2005).

This study is divided into 8 sections. Section 1 explains the problem and states the objectives. Section 2 reviews the literature on the mobile telephone service industry in various markets. Section 3 relates this literature to specific MENA countries by describing the state of their mobile telephone sector and its development. Section 4 describes the data set, the sources used, and the time period of the investigation. Section 5 discusses the regulatory problems and the proposed solutions by reaching out to the theory of industrial regulation. The section identifies three key institutional problems that affect the performance, pace and success of the liberalization of that sector. In Section 6, we estimate the price elasticities that are key to set the tariffs of the mobile service operators across various MENA countries. Section 7 presents a three- stage liberalization model of the mobile telephone sector. The model is important to understand the pace of reforms from a government monopoly to a liberalized industry and identifies which factors can accelerate or slow down the liberalization process. Section 8 concludes the paper and discusses the policy implications by relating the calls for greater competition with the need of a stronger regulating agency to oversee the reforms in the mobile telephone sector.

2. Value Added

Since its inception, the mobile telephone sector has always enjoyed more competition than the fixed line telephony. There are two primary reasons for the increased competition. Firstly, the mobile sector enjoys a fundamental cost advantage: there is a relatively little startup costs after the infrastructure of the access network has been established. The marginal cost of adding additional subscribers is virtually a handset, the cost of which has been declining precipitously in recent years. This contrasts markedly with traditional fixed –line telephones where the cost of adding a subscriber may involve extending copper lines and providing physical backbone to the existing network. With this physical reality, it is not surprising that subscribers in MENA countries own and use a mobile telephone at a time when they may not have access to a traditional fixed-line. Secondly, the mobile telephone sector has flourished at a time when markets worldwide were in a deregulatory mood and in the process of being liberalized. During this period, traditional trade barriers and financial restrictions were being eased and removed worldwide in order to reap the benefits of economic and financial integration. In MENA, the telecom sector was part of this reform wave even though, as a whole, this region has a long legacy of state controls as argued by Bezzina (2003).

In the telecom literature, there is vast empirical evidence revealing that privatization and deregulation of that sector has led to performance improvements. For example, Chakravarty (2007) looked at the diffusion of mobile telephony in Asia between 1993 and 2004. His results indicate that entry and competition have played a major role in increasing the diffusion of cell phones. Furthermore, he found that the presence of an independent telecom regulator and the capacity of fixed line telephone exchanges have positively affected the diffusion of mobile services by increasing the size of the network.

Though privatization of the telecom sector is generally found to yield significant benefits, allowing entry and competition in the sector tends to result in far greater dividends. A monopoly provider, whether state-owned or private, has little incentive to improve service and lower prices compared with firms that operate in a competitive environment. It is well recognized that simply moving a monopoly from the public to the private sphere will not

result in competitive behavior (Wallsten, 2002). This is confirmed in the results of a broad class of studies, which find that competition leads to the biggest improvements in the sector (Fink, et al. 2002; Li and Xu 2001; McNary 2001; Ros 1999).

In Europe, the mobile telecommunications markets have largely been left unregulated, but recently they began to draw regulators' and policy makers' attention (see, e.g., European Commission, 2004). While competition remains a goal, some regulatory agencies, including for example the UK Competition Commission, have argued that the mobile telecommunications industry as a whole is not prone to effective competition, due to the oligopolistic industry configuration (see Competition Commission, 2003). This argument rests on the fact that there is only a limited amount of radio spectrum available and as the fixed and common costs associated with mobile network investments are relatively high, mobile telecommunications markets may resemble natural oligopolies (see Gruber, 2001; Valletti, 2003). On the opposite end of this argument, concerns have been voiced by various regulatory authorities about the low level of competition in mobile telecommunications markets, especially with respect to the potential for collusive behavior.

3. The State of the Mobile Telephone Sector in MENA Countries

The countries in MENA have embraced telecom liberalization at various speeds, and as a requirement for accession to the World Trade Organization. The liberalization is developed in two strategies. The first step requires the enactment of a clear telecom law and the establishment of an independent regulatory authority. In the second phase, which is contingent on the success of the first step, the telecom authority can begin to liberalize the telecom market. In terms of the liberalization spectrum, Jordan and Bahrain are the most liberalized countries in terms of their telecom sectors, while UAE and Qatar are the least liberalized in the MENA region. While the number of mobile operators in the region grew rapidly since 1999, the fixed network operators are still enjoying their monopoly power in the region. The mobile operators presence ranges from 1 to 4, and in several countries, the mobile sector has succeeded in attracting foreign investment, enabling the operators to increase their coverage beyond their national borders. Because of fierce competition, new operators are fighting to grow their customer base while incumbents want to minimize losses and enjoy their high revenues. Operators are competing mainly via price reduction sometimes via service differentiation.

The penetration of mobile telecommunications has significantly increased between 1995 and 2007 in the MENA region. Competition in the MENA region is increasing not only because of the number of operators but also due to the legal framework improving. It took between 2 and 9 years to fully liberalize the telecom sector in some of the MENA countries. In various countries, competition began with price reduction, even before the entry of new competitors, then with differentiation by enhancing the service and the introduction of new offers.

As competition increased in the mobile sectors, both the penetration and productivity (revenue per employee) rates in the MENA region rose sharply. Mobile revenues have had positive direct effects on economic growth after the mobile liberalization and a positive indirect effect through job creation, greater investment and integration in the global economy. Below is a summary of the liberalization steps in various MENA countries.

Kuwait

The Kuwaiti telecommunication sector is one of the least liberalized in the MENA region. There is no independent telecom operator because there is no regulatory framework. MoC acts as the telecom regulator, controlling the communication sector and acting as a monopoly. The mobile market is composed of two local providers (Zain and Wataniya) and one foreign provider (Viva). Viva's fast penetration into the Kuwaiti market increased the competition by introducing new services and threatened the other providers by gaining additional market

share. The Kuwaiti government, through MoC, still has some control over the policies of the mobile sector and owns one fifth of the stakes.

Liberalization and privatization are needed in Kuwait to enhance performance, increase business opportunities and allow local mobile service providers to outperform their regional rivals.

Oman

In Oman, the Telecommunication Regulatory Authority (TRA) offers 3 classes of licenses according to offered services:

- Class1: set up or operate public telecom networks, international telecom infrastructure or offer public telecom or international access service that requires the use of national resources.
- Class 2: the license holder can provide public telecom service. It is contingent in the usage of class 1 license network
- Class 3: the license holder can set up or operate private telecom networks or services not connected to the public network. This class has a life of not more than 5 years.

The telecom industry has been expanding in Oman, mainly from the increase in mobile subscription as opposed to a growth in Internet and fixed line subscriptions. The penetration rate in the mobile sector increased from 33% to 138% between 2004 and 2009. It is expected that the demand for data services would increase and be offset by the moderate decline in voice services demand.

Until 2005, Omantel held the only class 1 fixed and mobile license. Later in that year, Nawras acquired a license to provide mobile network services and in 2009, it was granted a fixed line license. Both licenses are class 1 licenses.

Company	Service	License class	Network provider
Omantel	Mobile	Class I	-
Omantel	Fixed	Class I	-
Nawras	Mobile	Class I	-
Nawras	Fixed	Class I	-
Majan Telecom	Mobile	Class II	Omantel
FRiENDi mobile	Mobile	Class II	Omantel
Samatel	Mobile	Class II	Omantel
Injaz International	Mobile	Class II	Nawras
Mazoon Mobile	Mobile	Class II	Nawras
Kalam Telecommunications	Mobile	Class II	NA

In 2008, the TRA granted 5 class 2 licenses for a period of 5 years and a class 1 license was granted later. Only 4 licensees are providing the services, with 2 operators reselling the services to Nawras and 2 to Omantel. A third company is reselling the services to Nawras but didn't provide the service yet.

Omantel market share has declined from 82% to 53% between 2005 and 2009 and decreased to 47% after three mobile resellers began operations in 2009. Nawras was affected by the entry of these resellers as well. Nawras was able to expand and invade Omantel's market share.

Jordan

Jordan has the most liberalized telecom market in the MENA region. Liberalization began in 1995. Zain (formerly Fastlink) was the first to enter the market and in a period of 3 years, around 90,000 people subscribed to the service with a penetration rate of 1.9%. In 2000, around 290,000 people subscribed. JTG Orange (formerly Mobilcom) entered the market in late 2000 and around 70,000 people subscribed achieving a penetration rate of 7.1%. In 2009, the subscribers to the telecom sector reached 6.8 million people, out of which 89% were

subscribed to the mobile sector, fixed line 7.4 % and the remaining share was occupied by the Internet sector.

Operator	Date of award	Valid through	Range of spectrum
Zain	30-Oct-94	21-Feb-21	2x17.5MHz in 900
Orange Mobile	23-Jan-00	9-May-14	2x12.5MHz in 900
Xpress	23-Oct-03	5-Apr-15	2x5MHz in 800
Umniah	9-Aug-04	8-Aug-19	2x15MHz in 1800

JTG Orange launched the 3G network in late 2009 and 3G+ at the beginning of 2010. All players, introduced service improvements, which increased customers from 1 million in 2001 to 6 million at the end of 2009. In 2009, the penetration rate surpassed 100% and reached 103% at the end of the first quarter in 2010. At the end of 2009, Zain was the dominant player in the mobile market with 43% market share, Orange 29% Umniah 27% and Xpress1%. But it is important to note that 90% of the mobile subscriptions are prepaid and not subject to any contract commitments between the subscriber and the service provider.

Egypt

High competition and aggressive marketing strategies are undertaken between 3 mobile operators of Mobini, Vodaphone, and Etisalat. Mobinil is the leading company with 44% of the mobile market share followed by Vodafone, and Etisalat, which entered the market in 2007. Marketing strategies include doubling the Sims trend and reducing the call rate. Just as the decline in the handset prices increased the mobile penetration rate, so will the decline of personal computers due to the expansion of broadband services. The minister of communication expects the broadband penetration rate to quadruple by 2013. These figures can change given the volatile political situation in that country and the overthrow of the Mubarak regime in January 2011.

Qatar

Vodafone's recent entry into Qatar's mobile market officially ended the monopoly of Qatar Telecom. In the beginning, the company targeted high-income subscribers with its postpaid plan, and added in September 2009 the prepaid cards to capture 45% of all new subscribers by the end of 2009.

Vodafone Qatar attracted subscribers by diminishing the international call rates by almost 50% of Qatar Telecom, and by offering a certain amount of free mobile Internet per month. Vodafone Qatar has managed to capture 14% of the market share from Qatar Telecom within one year of operation. Although Qatar Telecom is still in the lead, the entering of Vodafone Qatar in the market has stimulated competition and prices are expected to decline and services and offerings expected to increase.

Lebanon

The telecom sector is the second generator of government revenues in Lebanon. Privatization and a skilled labor force are recognized to be the necessary pre-requisites to keep up with the latest technological advances in the mobile sector. This is the lesson learned from the experience drawn in the fixed line sector where performance has significantly improved since 2004, when a private company, Ogero, began managing this service. In other countries, it has been shown that privatization leads to higher wages, more productivity, and creates a positive impact on the labor force. However, prior privatizations of utility assets in Lebanon have caused massive layoffs among telecom employees when the postal service was deregulated and awarded to Libanpost (Ghaleb, 2007). As such, Lebanon needs to approach privatization carefully to avoid the errors of prior experiences and ensure a positive impact on the economy and the labor force. To that end, a number of policies and actions need to be taken to resolve the labor implications and make sure the transition is smooth.

4. Description of the Data and Sources Used

The bulk of the country data for this project was purchased from the International Telecommunications Union (ITU), the leading United Nations agency for information and communication technology issues, and the global focal point for governments and the private sector in developing networks and services. For 145 years, ITU has coordinated the shared global use of the radio spectrum, promoted international cooperation in assigning satellite orbits, worked to improve telecommunication infrastructure in the developing world, established the worldwide standards that foster seamless interconnection of a vast range of communications systems and addressed the global challenges of our times, such as mitigating climate change and strengthening cyber-security. From broadband Internet to latest-generation wireless technologies, from aeronautical and maritime navigation to radio astronomy and satellite-based meteorology, from convergence in fixed-mobile phone, Internet access, data, voice and TV broadcasting to next-generation networks, ITU is committed to connecting the world. ITU is based in Geneva, Switzerland, and its membership includes 192 Member States and more than 700 Sector Members and Associates.

Our project relied primarily on The World Telecommunication/ICT Indicators database which contains time series data for the years 1960, 1965, 1970 and annually from 1975-2009 for around 150 different telecommunication and ICT statistics covering the telecommunication network and ICT uptake, mobile services, quality of service, traffic, staff, tariffs, revenue and investment. Because the ITU relies primarily on official country data, availability of data for the different indicators and years varies. The database also includes selected demographic, macro-economic and broadcasting statistics. The leading studies on telecommunications generally rely on the ITU data, notably Armstrong (1997) Wallsten (2001),

The scope of the database is broad and includes data for over 200 economies. The data are collected from an annual questionnaire sent to official country contacts, usually the regulatory authority or the ministry in charge of telecommunication and ICT. Additional data are obtained from reports provided by telecommunication ministries, regulators and operators and from ITU staff reports. In some cases, ITU staff makes estimates; these are noted in the database. The data series we extracted for this project are provided below:

International Telecommunications Union (ITU), Geneva, Switzerland Data Series, 1997 – 2007[1]
Residential monthly telephone subscription (US$)
Residential telephone connection charge (US$)
Revenue from fixed telephone service (US$)
Revenue from mobile communication (US$)
Business telephone connection charge (US$)
Business telephone monthly subscription (US$)
Mobile cellular - price of 3-minute local call (off-peak - US$)
Mobile cellular - price of 3-minute local call (peak - US$)
Mobile cellular connection charge (US$)
Mobile cellular monthly subscription (US$)
Mobile communication investment (US$)
Mobile cellular telephone subscriptions per 100 inhabitants
Price of a 3-minute fixed telephone local call (off-peak rate - US$)
Price of a 3-minute fixed telephone local call (peak rate - US$)
No. of telecomm providers
Domestic mobile telephone traffic (minutes)
Incoming international minutes to mobile network
International incoming and outgoing (fixed and mobile) total telephone traffic (minutes)
Outgoing mobile minutes to fixed networks
Outgoing/originating mobile minutes to international
Outgoing/originating mobile minutes to other mobile networks
Outgoing/originating mobile minutes to same mobile network
SMS sent
Cellular tariffs - Pre-paid per min. local call (peak)

[1] The choice of this data period was driven primarily because of data availability from ITU. Mobile services did not exists prior to 1997 and 2007 was the last year that official country data was collected.

Cellular tariffs - Pre-paid per min. local call (peak) (US$)
Consumer price index (2000=100)
Cost of a local 3-minute call (off-peak rate) (US$)
Domestic fixed to fixed telephone traffic(minutes)
Domestic mobile telephone traffic (minutes)
Fixed telephone lines per 100 inhabitants
Fixed telephone lines to mobile networks traffic (minutes)
Fixed telephone service investment (US$)
Imports - telecommunication equipment (US$)
Incoming international minutes to mobile network
International incoming and outgoing (fixed and mobile) total telephone traffic (minutes)
International incoming and outgoing fixed telephone traffic (minutes)
International incoming fixed telephone traffic (minutes)
International incoming total telephone traffic (minutes)
International outgoing fixed telephone traffic (minutes)
International outgoing total telephone traffic (minutes)
Mobile cellular - price of 3 minute local call (off-peak) (US$)
Mobile cellular - price of 3 minute local call (peak) (US$)
Mobile cellular monthly subscription charge (US$)
Mobile cellular postpaid connection charge (US$)
Mobile cellular prepaid – price of local call per minute (off-peak, off-net) (US$)
Mobile cellular prepaid – price of local call per minute (off-peak, on-net) (US$)
Mobile cellular prepaid – price of local call per minute (off-peak, to fixed) (US$)
Mobile cellular prepaid – price of local call per minute (peak, off-net) (US$)
Mobile cellular prepaid – price of local call per minute (peak, on-net) (US$)
Mobile cellular prepaid – price of local call per minute (peak, to fixed) (US$)
Mobile cellular prepaid – price of local call per minute (weekend/evening, off-net) (US$)
Mobile cellular prepaid – price of local call per minute (weekend/evening, on-net) (US$)
Mobile cellular prepaid – price of local call per minute (weekend/evening, to fixed) (US$)
Mobile cellular prepaid – price of SMS (off-net) (US$)
Mobile cellular prepaid – price of SMS (on-net) (US$)
Mobile cellular prepaid connection charge (US$)
Mobile cellular subscriptions per 100 inhabitants
Mobile cellular subscriptions with access to data communication at broadband speed per 100 inhabitants.
Mobile cellular telephone subscriptions (post-paid + prepaid)
Mobile communication investment (US$)
Mobile telecommunication staff
Monthly subscription for business telephone service (US$)
Monthly subscription for residential telephone service (US$)
National (fixed) trunk telephone traffic (minutes)
Number of Personal Computers
Outgoing mobile minutes to fixed networks
Outgoing/originating mobile minutes to international
Outgoing/originating mobile minutes to other mobile networks
Outgoing/originating mobile minutes to same mobile network
Percent coverage of mobile cellular network (population)
Price of a 3-minute fixed telephone local call (peak rate) (US$)
Proportion of households with a fixed line telephone
Proportion of households with a mobile cellular telephone
Revenue from fixed telephone service (US$)
Revenue from mobile networks (US$)
Roaming minutes (outside home network)
Roaming minutes by foreign subscribers
Total annual investment in telecommunication (US$)
Total full-time telecommunication staff
Total revenue from all telecommunication services (US$)
Waiting list for fixed telephone lines

The ITU database was complemented with annual time series from the World Development Indicators available from the World Bank in Washington, DC. In addition, we relied on political development, transparency, and corruption data obtained by country from Freedom House, also in Washington DC. Both data sources and variables are listed below:

World Bank
Gross Domestic Product (GDP) (US$)
Gross Fixed Capital Formation (GFCF) (US$)
Gini Coefficient of Income Inequality
Population
Annual government expenditures (budget) $mn
Annual Government Revenues (budget) $mn
Average annual exchange rate per US$
Freedom House
Political Rights
Civil Rights
Corruption Index

We complement the ITU database by constructing additional variables to measure the cost of cellular service these are:

AVGPRICE: Annual revenue from mobile networks (US$) divided by the total cellular traffic in a given year and by country. The methodology is consistent with the analysis of Dewenter and Haucap (2004) and represents the average call 'rate' per mobile service subscriber.

PRICEPROXY: the connection price + the costs of (100 minutes on-peak + 100 minutes off-peak), all in US$.

AFFORDIBILITY: The AVGPRICE divided by per capita GDP for that country and for the same year.

Our data set also uses various measures of corruption and political liberties which have been determined to affect the demand for telecommunication services as, for example, in Laffont (2005). Specifically, a positive view towards the deregulation of mobile services suggests that privatization of that sector may occur because of the existing inefficient regulation or the presence of rampant corruption.

For starters, we examined the statistical properties of these variables and calculated their descriptive statistics. This information is provided in Table 1.

A plot of the 3min peak phone call across MENA countries and over time is provided in Figure 1. The mobile telephone subscriptions per 100 inhabitants by country between 1995 and 2007 is reported in Figure 2, where it appears that Egypt has the largest growth in the MENA countries.

5. Regulatory Problems and Solutions in the Mobile Telephone Sector

In less developing and emerging countries, government regulation suffers from the existence of weak public institutions, which complicate the relationship between the regulator and the provider of a utility service such as mobile telephone services. For example, only a small number of countries have reliable accounting data. This data is necessary to set fair tariffs for the mobile operator that would operate as a regulated private monopoly. Instead, the accounting standards at the mobile company owned and operated the government tends to be poor in general and this creates a big challenge for privatization because the private monopoly cannot gauge the future revenues, costs, and profits of the industry being deregulated. As a result, the tariffs of the mobile telephone operator end up being negotiated with the government rather than calculated from a clear set of accounting data. In that negotiation, the private monopoly is operating with limited accounting information and is trying to ensure that the transition from a government monopoly will not result in a loss.

In the theory of industrial regulation applied to developing countries, three key institutional problems have been identified with important effects on performance. These are: (1) resource constraints, (2) contract uncertainty, and (3) poor governance (corruption, lack of transparency, and deficient political establishment). Laffont (2005) and Acemoglu (2006) and Acemoglu and Robison (2006) analyzed all of these factors. Below, we briefly describe each of these problems as they relate to the deregulation of the mobile telephone sector.

Resource Constraints: In many MENA countries, government pay scales lag significantly behind those of the private sector. As a result, regulators are unable to attract a skilled staff and are forced to rely on civil service employees. Moreover, an inexperienced judiciary system puts more limits on implementation and creates high costs and time delays in resolving disputes. The regulating agency may also lack sufficient resources to exercise adequate control because of a shortage of government revenues and the need to compete for public funds with other state agencies. In other extreme cases, the government may actually

be deliberately depriving the agency of resources in an attempt to undermine it. As a result, regulation is often poor or ineffective, leading to other problems such as corruption. Finally, poor fiscal policy and incorrect accounting practices makes public institutions unable to raise sufficient revenue to make direct subsidies because their sources of funds are constrained.

Contract uncertainty: Another impediment to a successful privatization is the demand for contract renegotiation often made by a MENA government to the mobile telephone operator. Oftentimes, the government demands that key terms of the privatization are renegotiated which raises the costs and increases the project risk to the private sector. Concerns about the potential of a future contract renegotiation creates a major reason why the government fails to attract the participation of the private sector in the reform process especially if the costs of reform are front-loaded, with the gains accruing later[2].

Poor governance: A third factor that could derail a privatization in the mobile telephone sector is the lack of obligation of the regulating body to account for its activities, accept responsibility for them, and disclose the results in a transparent manner. Collusion between the regulator and different interest groups (including the regulated mobile operators) sometimes takes place. With corruption, mobile service efficiency is reduced, network expansion decreased, and the social benefits from the diffusion of the new technology curtailed.

These three factors exist to varying degrees in MENA countries. However, there is a universal recognition that they are the primary cause of weakness of government institutions in general, and the existence of inefficient regulating agencies. Undoubtedly, they complicate the goal of reforms and the privatization of the mobile telephone sector.

That being said, many countries have privatized their mobile infrastructure and increased the independence of regulation in order to raise investment and improve efficiency. For example outside the MENA countries, according to Estache et. al (2005), by 2004 , 60% of developing countries had privatized their telecoms industry. However, for many countries, particularly those with the lowest income, private sector participation has been disappointing. Private ownership and management often have not improved performance, notably in sectors where there is no competition. Failures to improve performance, accompanied by increases in prices, have led to widespread dissatisfaction with privatization. The main problem was that regulatory institutions were not developed to meet the necessary challenges, and were instead ignored on the belief that the market could take care of itself. Instead, if the government is unable to adequately support regulatory agencies or attract the talented staff because of civil service wage constraints, it is imperative to outsource parts of the regulatory functions to third parties. The key here is to encourage the development of public interest groups that would observe costs, monitor performance, and provide solutions to the government. The role of these public advocacy groups would not include enforcement but they will provide a pro-consumer bias and give the regulator the necessary information they need to fulfill their task more effectively. The public advocacy groups could, for example, review the price structure of the services offered by the mobile service providers to ensure that they are set at a level that achieves the maximum social welfare. Clearly, such a level will require a detailed calculation of the price elasticities for each service, and for various strata of income levels. If, in some cases, it is difficult to calculate such elasticities, these public interest groups may suggest the introduction of price caps, as proposed by Laffont (2005)[3]. In the next section, we take a step in that direction by using annual data aggregated across mobile service operators in several MENA countries.

[2] See for example Bardhan (2006)

[3] We refer the reader to pages 124 to126 in Laffont (2005)

In the context where the mobile telephone sector is operated as a regulated monopoly, economic theory proposes various ways to share risks and discourage the government from renegotiating a privatization contract. One such solution is through the financial structure of the firm where the privatization of the mobile sector is not complete and the government retains a significant ownership in the regulated privatized monopoly. A higher ownership automatically creates an incentive for the government to support the firm.

Finally, an area of grave concern to successful reforms of the mobile telephone sector is the type of political governance in the country where the reforms are being implemented. If the government is unaccountable to the public, it could make damaging decisions about privatization and competition or take drastic measures that could increase corruption. It is important to underscore that competition may not be effective in reducing collusion. This is because the government may have less incentive to make the regulator enforce its actions. In addition, the transition to competition itself may create new opportunities for corruption such as government favoritism. In fact, the record of transitions to competition in developing countries suggests, at best, mildly positive effects with many cases of liberalizations that have gone wrong as reviewed by Armstrong and Sappington (2006). As a result, both the level of corruption and degree of civil liberties are key variables that will be used in explaining the pace and success of the transition to completion in the liberalization model we present in Section 7.

6. Estimating the Elasticities and Penetration of Mobile Telephone Demand

In the industrial organization literature, oligopolies are often suspected to entice collusion much to the detriment of the consumer. To control for such possibility, when only a handful of market participants exists, a regulatory body is established to carefully monitor their conduct and ensure that no collusive behavior is taking place. Apart from factors such as the number of operators, and product differentiation, one important indicator for the firms' incentives to engage in collusive behavior is the market's demand elasticity (see, e.g., Carlton and Perloff, 2004). If the market demand is relatively inelastic, the reward from engaging in collusive conduct is high, as prices can be increased without significantly losing customers. Conversely, an elastic demand implies that the additional sales revenue from collusion is low.

Given that the price elasticities of demand play a central role in the choice of market structure, we propose their analysis using aggregate data on traffic and tariffs in a regional setting. These results are expected to shed light for the first time on the potential penetration of mobile telephones in each MENA country and allow us to compare their level with results from other countries, notably Latin America. The elasticities are also useful to support the work of regulating agencies or public advocacy groups to set tariffs for the mobile service operator. When price elasticities are unavailable, the regulating agency cannot determine which tariff level maximizes social welfare and the benefit from the penetration of the mobile technology to consumers with various income levels. As a result, the regulating agency resorts to imposing price caps, which is often inefficient and creates market distortions. The policy implications from estimating the price elasticities are discussed in more detail below.

To that end, we present an econometric model based on the Houthakker-Taylor model, which takes the form:

$$Q_{it} = \alpha_{it} + \beta_1 P_{it} + \sum_{j=1}^{M} \beta_k X_{it.j} + u_{it} \qquad (1)$$

where Q_{it} is the natural logarithm of the total volume of call minutes placed in year t by country i, P_{it} is natural logarithm of the corresponding average cost for a mobile call, u is an error term, α and β are parameters to be estimated, and X represents a vector of the natural logarithm of the following independent variables:

- Affordability Index, measures the relative cost of cellular service with respect to income and defined in the previous section
- Number of subscriptions: Total number of cellular subscriptions in country *i* and year *t*. This variable controls for the natural growth in cellular penetration over time that is unrelated to any changes in the price of service over time.

There are 2 possible ways to estimate model 1. Assuming that α_{it} is fixed over time, but differs across countries (cross-sections), model (1) can be estimated using fixed effects. Furthermore, if α_{it} can be decomposed into a common constant α and a unit specific random variable (ξ_i) so that $\alpha_{it} = \alpha + \xi_i$, then model (1) can be estimated with the random effects. In this study, we used a panel instrumental variable method to correct for the possible endogeneity problem. In the context of Equation 1, it is important to understand that the prices and quantities are not determined simultaneously because the market is almost always non-competitive. Tariffs are set based on negotiations between the government and the mobile service providers. They are set *first*, and quantities adjust to the level of these tariffs or prices.

To correct for any residual endogeneity, we follow the choice of the instrumental variable as explained in Murray (2006). For instrument, we use the penetration rate of mobile telephone in year t in country i per 100 inhabitants[4]. The 'two-stage least-squares within' estimator was applied for the fixed-effects model and the 'two-stage least-squares one-way error component model' using feasible generalized least squares (FGLS) was used for the random effects model. Given that our panel is unbalanced, we applied the consistent estimator of the variance components of Baltagi (1995).

To be sure, the elasticity measures of mobile communication in MENA are important on many fronts ranging from predicting future sales, taxation, setting prices for competitive strategy, to measuring gains in consumer welfare. Firstly, the elasticity results are important because they enable a policymaker to predict what may happen to total sales revenues when the mobile service provider lowers prices. In that sense, our results have a direct application on forecasting the size of potential sales revenues in the mobile market and determine the financial concessions a country should derive from privatization. In countries where the mobile market is already liberalized, the elasticities are useful to determine their pricing strategy. Setting the rate for mobile communication requires an understanding of the level of competition, and how sales revenues will respond to the new price. Secondly, the price elasticities represent a critical piece of a government tax strategy. For many MENA countries (Lebanon in particular), the tax imposed on cellular communication represents a key source of government revenue. Thirdly, the demand elasticities enable policymakers to evaluate the welfare gains from offering and expanding mobile services. As Hausman (2002) explains, the measurement of the improved consumer surplus from mobile communication rests uniquely on the estimation of the price elasticity of this service. As explained in Section 5, without a measurement of the price elasticities, regulatory bodies resort to imposing price caps in an effort to limit the increase in access tariffs of mobile communication services.

The elasticities for fixed- and random-effects models are reported in Table 2. The results are virtually identical in both models. The coefficients of the price elasticities are negative which is consistent with economic theory and suggests that price changes are negatively related to demand. The elasticities hover around unity and are strongly statistically significant in terms

[4] We estimate equation 1 in two stages. In the first stage, we estimate a reduced form equation by using the penetration rate as an instrumental variable and regress the price proxy P_{it} on that variable and the total number of subscriptions. From this regression we form fitted values of the price variable (P_{it} hat). In the second stage, we replace the original price variable P_{it} with the fitted values from the first-stage to estimate equation 1.

of their influence on the average demand of mobile demand. For the random effects model, we performed the Hausman specification test, and the results cannot reject the applicability of this model. The magnitude of the price elasticity coefficient suggests that the proportionate price reductions in mobile service have an "equal" effect on the volume of traffic, and therefore leave total revenue of mobile telephony unchanged. The coefficient of the mobile telephone subscriptions variable, and which controls the natural growth of mobile service over time, is positive at 0.69. This suggests that, across MENA countries, a doubling (or a growth of 100%), in the number of mobile subscribers has resulted in a 69% growth in traffic minutes. This result is important to plan for the mobile telephone infrastructure that is necessary to support the growth in the volume of subscribers. Finally, the Affordability index of mobile service is statistically insignificant and has no impact on the growth in the volume of traffic minutes.

To understand how mobile telephone penetration varies across countries, and over time, we re-estimate model (1) using the following variables:

Dependent variable:

- Mobile Penetration = Mobile cellular subscriptions per 100 inhabitants

Independent variables:

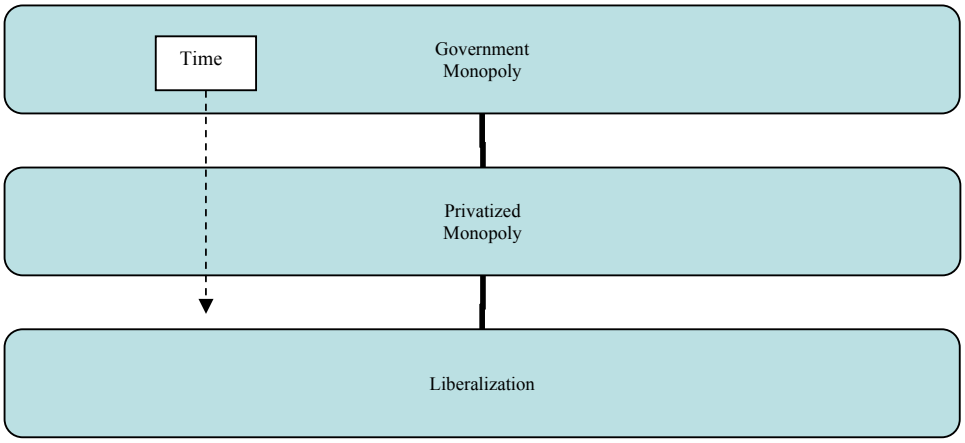
- Affordability Index, defined above
- Corruption Index, an annual country score from Freedom House that varies between 1 (totally transparent) to 10 (most corrupt). Laffont (2005) ,and more recently Veiseh (2010), have investigated the impact of corruption on the privatization process in developing countries.
- Gini coefficient of income inequality
- Cell investment, the total mobile communication investment in US$.

The results in Table 3, clearly show that the mobile penetration is negatively related with the cost of service measured by the affordability index. By far, this variable is the most statistically significant with respect to the changes in the mobile penetration over time and across countries. The corruption index is negative, suggesting that countries with more opaque governance (high corruption index) experience less mobile penetration, everything else held constant. The coefficient of the Gini coefficient is surprisingly positive and suggests that penetration is higher in countries with a large income disparity. This may indicate that the mobile service is perceived as a luxury item and therefore individuals want to purchase mobile service to demonstrate a certain social status. This is especially true in MENA countries where mobile service was slow to penetrate either because of high costs or government red tape. While the amount of actual investment in mobile communication is properly signed and suggests that such undertaking positively increases penetration, the coefficient is statistically insignificant.

7. A Liberalization Model of the Mobile Telephone Sector

The adoption of a liberalization model affects mobile rates and mobile rates in turn affect the selection of liberalization models. This represents an endogeneity issue and complicates the analysis. To correctly evaluate this relationship, we introduce a 3-step approach to evaluate the liberalization status of the mobile sector. Usually countries in their process of liberalization do not open their mobile telephone sector in one stroke. Liberalization occurs in stages, and in each step, competition is slowly introduced to the sector. The three steps are represented in the figure below:

Choices of Market Structures



The econometric analysis for choice among alternative market structures is discussed below where we place each country in one of three ordered selections:

1) Government owned monopoly model

2) Privatized monopoly model. A single provider exists. There is no competition among the serviced providers yet, however, there is likely to be a more diverse selection of products offered to the consumer beyond voice communication (eg. data). This step may also entail more competition in the development of the mobile infrastructure at the wholesale level and which would support more retail competition.

3) Liberalized sector where a privatization has taken place and multiple service providers exist.

The choice of the three steps of market reforms is inspired by the work of Rossotto et. al (2005) who also segregate the average degree of competition in the telephone market in 3 buckets with a monopoly and full competition on each end of the spectrum. These market structures are also consistent with Wallsten (2001) who explored the effects of privatization, competition, and regulation on mobile operator performance in 30 African and Latin American countries.

Data on liberalization models was collected from the Ministry of Telecommunications in each country and then sorted according to different choices of market structures. Liberalization models were coded "1, 2, 3" corresponding to each step of the mobile sector liberalization consistent with the coding in Rossotto et al. (2005).

To observe the effect of rates on the selection of mobile sector liberalization, we employed an ordered logit model for discrete choices. Denoting the liberalization model as $\boldsymbol{y}$, the equation is written as follows:

$$\boldsymbol{\gamma}^{*}_{it} = \boldsymbol{\alpha} + \boldsymbol{\beta}\, \boldsymbol{X_{it}} + \boldsymbol{\gamma_i} + \boldsymbol{u_{it}}$$

where $\boldsymbol{\gamma}^{*}_{it}$ is a latent variable which will not be observed as a continuous numerical data and the true measure of liberalization models adopted. We only observe the ordinal variable $\boldsymbol{y}$, which represents the choice of the mobile sector liberalization made by the policymaker. β is the vector of parameters to be estimated. $\boldsymbol{X_{it}}$ is a vector of variables representing:

- Gini Coefficient of country i in year t
- Time, to measure how many years each market reform takes
- Cell penetration, to measure the penetration rate of mobile telephone in year t in country i per 100 inhabitants

- Cell Revenues to GDP, a measure of mobile telephone revenues to total GDP
- CR, a score of civil rights in country i in year t. The score represents the level of openness and governance as reported by Freedom House. The score varies between 1, representing a country with complete full civil rights in the electoral process, judiciary, and unions, and 10 for a totally closed society. The use of this variable in the context of developing countries was motivated in Section 5. Laffont who found that the privatization was accelerated with increased political rights also used it[5].
- AVGPRICE: Annual revenue from mobile networks (US$) divided by the total cellular traffic in a given year and by country. This represents the average call 'rate' per mobile service subscriber.
- Cell investment to Revenue: is the mobile communication investment relative to the revenue from mobile networks, both in US$

γ^*_{it} is an unobserved time-invariant country specific effect and u_{it} is an error term. γ^*_{it} varies between $\pm \infty$. To map γ^*_{it} to discrete choices of market structures, the model assumes that γ^*_{it} is divided into 3 selections. The estimation procedure is detailed in Forcina and Dardanoni (2008) and Takanori and Kuroda (2009).

The ordered logit model can be represented in the form:

$$logit\ (p_1) = log\ p_1/(1-p_1) = \alpha_1 + \beta'X$$

$$logit\ (p_1+ p_2) = log\ (p_1 + p_2)\ /(1-p_1 - p_2) = \alpha_2 + \beta'X$$

$$logit\ (p_1+ p_2 + p_3) = log\ (p_1 + p_2 + p_3)\ /\ (1-p_1 - p_2 - p_3) = \alpha_3 + \beta'X$$

where the probabilities p's represent the likelihood of each of the ordered market structures described above and $p_1 + p_2 + p_3 = 1$.

The results of this model show how and the extent to which a change in mobile telephone rates affects the transition of the liberalization model (from a government monopoly ➔ privatization without competition ➔ privatization with competition).

The results of the liberalization model are presented in Table 4. They reveal that the direction of deregulation from government monopoly to a liberalized industry is accelerated by a more developed and liberalized civil society, a high proportion of investment in the mobile sector relative to revenues from that sector, and a mobile sector with a significant contribution to government revenues relative to GDP. The liberalization is slowed in countries with a high-income inequality, and where the average cost of a mobile call is high. However, after controlling for these variables, the penetration of the mobile sector doesn't seem to represent a driver to the choice of market structure. This would suggest that mobile telephone sectors with a single or multiple service providers are equally likely to achieve a desirable level of penetration into that sector. This result is somewhat consistent with the findings of Wallsten (2001) where privatization, in and by itself, does not bring any benefit to the market. However, privatization and a separate regulator jointly have a positive effect. Thus, privatization of a monopoly without bringing regulatory reforms will not yield benefits. Only when privatization is accompanied with regulation, this combination has a positive effect on the telecom sector. Finally, the speed of market reforms, measured by the "Time" variable is also statistically insignificant, suggesting that, on average, and across countries, there is no preset or expected number of years for market reform to take place.

[5] Laffont's analysis used economic data from African Development Indicators on 30 African countries to estimate the privatization rate. See page 88 of Laffont (2005).

8. Conclusion

This study has evaluated the growth and trend in the mobile telephone sector in several MENA countries over 13 years, between 1995 and 2007. Our results, have demonstrated that the price elasticities across countries are unitary suggesting that price reductions in the mobile service have an "equal" effect on the volume of traffic, and therefore produce no effect on the total revenue from mobile telephony. In addition, a 10% growth in the number of mobile subscribers results in a 6.9% growth in traffic minutes.

In terms of the drivers of mobile penetration, we found a strong negative effect from the cost of service measured by the affordability index and high corruption. Surprisingly the penetration is higher in countries with more unequal income distribution, perhaps a reflection that mobile service is perceived as a luxury item in these countries.

With respect to the influences on the degree and scope of the liberalization of the mobile telephone sector, we suggested 3 steps ranging from a pure government monopoly to a liberalized market with multiple service providers. The results of an ordered logit model

revealed that the direction of deregulation is accelerated with a free civil society, a high proportion of investment in the mobile sector relative to revenues, and a mobile sector with a significant contribution to government revenues relative to GDP. At the same time, the liberalization is slowed in countries characterized by a high-income inequality and average cost of service.

From a strategic perspective, our results are expected to determine the optimal market structure for mobile telephony. On a tactical level, our quantitative results help policymakers in MENA countries conclude that the demand elasticities do not necessarily entice collusive behavior between service providers because the effect of price reductions is neutral on total revenues.

These results are expected to support more qualitative and comparative studies that have called for greater competition (liberalization) in the mobile telephone sector and steer a regulatory policy for increased government supervision. In that context, there is now ample evidence that the market reforms of utility sectors in developed countries such as mobile telecommunications do not translate well to developing countries where several negative externalities are often overlooked. Borrowing from the theory of incentives, this study identified, discussed, and analyzed several factors that should be considered when designing the strategic path of reforms in the mobile sector and how to establish a reliable regulatory framework to support it.

First, MENA governments, in general, face several resource constraints. A weak tax collection constrains the government's fiscal space, and prevents it from allocating sufficient public investment to expand the mobile network widely. Government regulators often face a significant shortage in physical resources, or have volatile budgets that prevent effective planning. Because civil servants pay scales lag behind those of the private sector, the government is unable to attract the skilled staff that can effectively monitor and oversee the desired market reforms. As a result, it is advisable to foster the development of public advocacy groups who can fulfill that role, provided there is at least a regulator with sufficient independence and power to enforce laws and penalties adequately.

Second, in areas where contracts to mobile service providers are subject to renegotiation by the government, we suggested ways to reduce the risk to the private sector through a limited privatization scheme of the mobile sector itself. By increasing the ownership of government in a semi-privatized entity, the private capital is ensured that a government has an incentive in the successful operation of the mobile service provider as it transitions away from total government ownership.

Third, in areas of governance and transparency, we explained that competition is often wrongly perceived as a method of reducing collusion. In reality, corruption may be reduced if competition decreases the power of the regulator, reduces asymmetric information, or lowers rents. However, if competition is just substituted for regulation, the government may have less incentive to hold the regulator accountable on the premise that a free market would take care of itself. As a result, the lack of regulation may actually encourage corruption.

These factors will be key to the market reforms and the liberalization underway in MENA countries. Judging from the experiences of other developing countries, failures to improve performance and widen access, accompanied by increases in prices, have led to widespread dissatisfaction with privatization.

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Figure 1: A Plot of the 3min Peak Phone Call Across MENA Countries

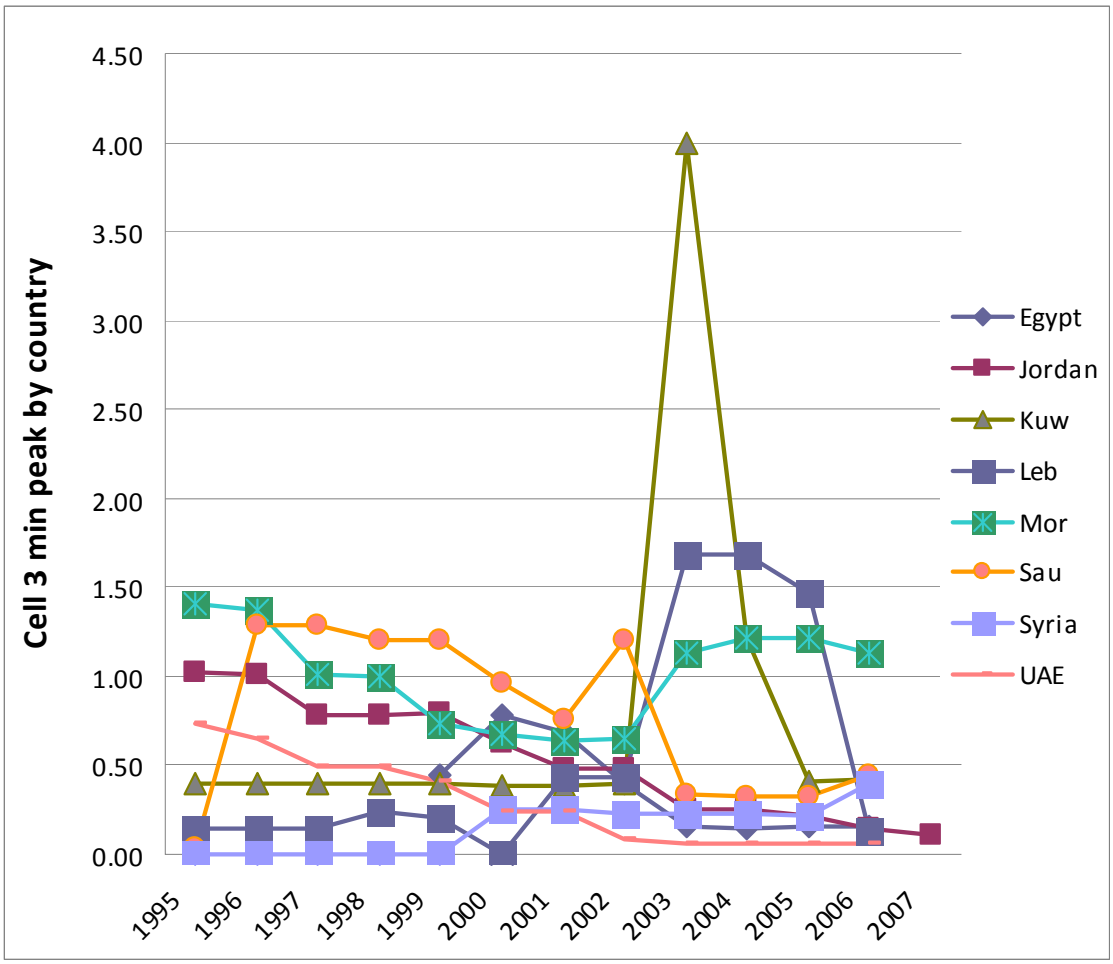

Figure 2: Mobile Telephone Subscriptions per 100 Inhabitants by Country, 1995 - 2007

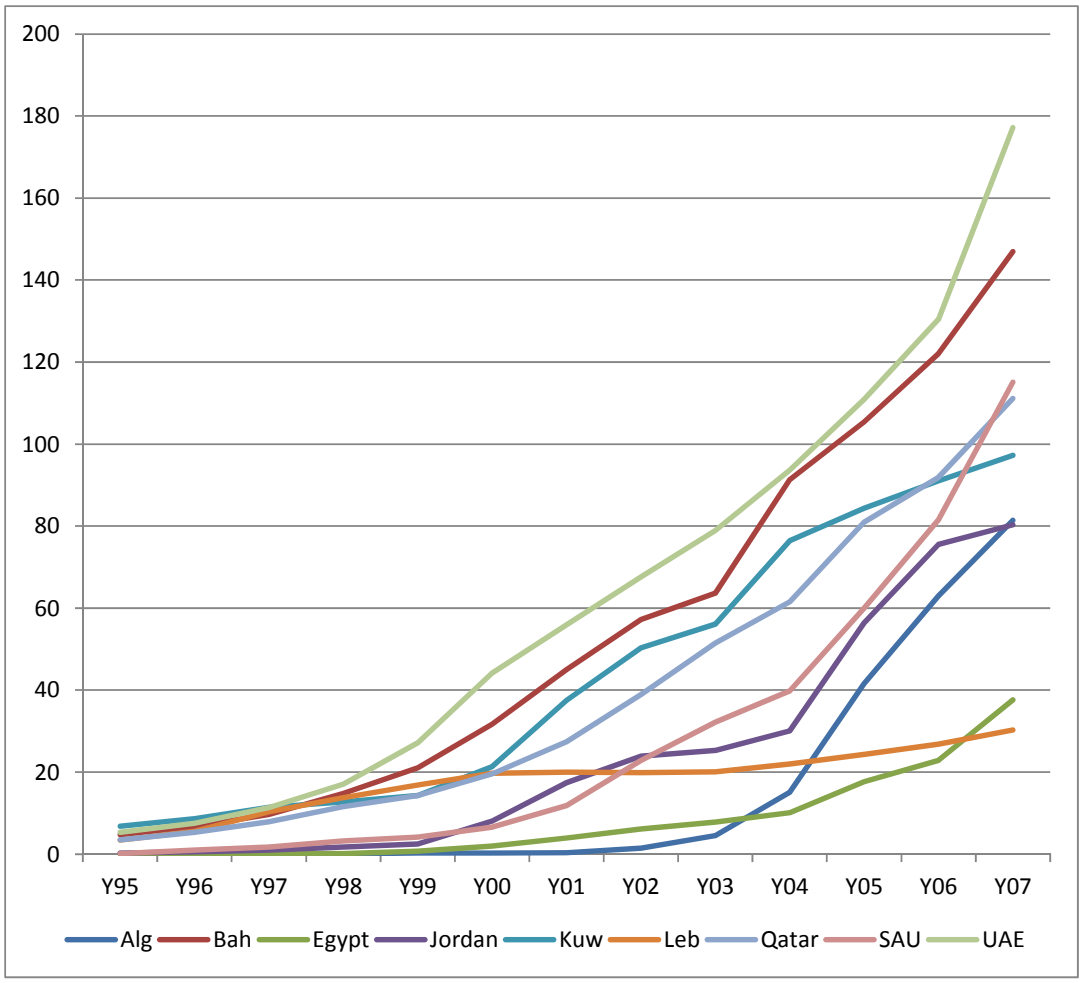

Table 1: Statistical Properties of the Variables

Res tel subs	
Mean	5.346624318
Standard Error	0.287161775
Median	4.087193489
Mode	7.792207718
Standard Deviation	3.937363881
Sample Variance	15.50283433
Kurtosis	5.829039107
Skewness	1.439761782
Range	28.49736875
Minimum	0.502631247
Maximum	29
Sum	1005.165372
Count	188
Confidence Level(95.0%)	0.566492932

Res tel conn	
Mean	90.9393721
Standard Error	5.781335763
Median	66.78094101
Mode	54.9450531
Standard Deviation	78.84690759
Sample Variance	6216.834837
Kurtosis	23.33988699
Skewness	3.984059592
Range	701.2566376
Minimum	8.743362427
Maximum	710
Sum	16914.72321
Count	186
Confidence Level(95.0%)	11.40582333

Rev fix tel	
Mean	634573581
Standard Error	55570765.72
Median	343319104
Mode	#N/A
Standard Deviation	673759727.5
Sample Variance	4.53952E+17
Kurtosis	3.421507367
Skewness	1.979542544
Range	3098522608
Minimum	46010640
Maximum	3144533248
Sum	93282316412
Count	147
Confidence Level(95.0%)	109827039.6

Rev mob comm	
Mean	866569258.7
Standard Error	125639182.8
Median	327127648
Mode	0
Standard Deviation	1448941740
Sample Variance	2.09943E+18
Kurtosis	13.63101595
Skewness	3.388075234
Range	9072714752
Minimum	0
Maximum	9072714752
Sum	1.15254E+11
Count	133
Confidence Level(95.0%)	248526718.4

Bus tel conn	
Mean	125.2121781
Standard Error	7.67276975
Median	80
Mode	54.9450531
Standard Deviation	104.642628
Sample Variance	10950.07959
Kurtosis	4.859237617
Skewness	1.782307253
Range	694.9737043
Minimum	15.02629566
Maximum	710
Sum	23289.46513
Count	186
Confidence Level(95.0%)	15.13737652

Bus tel subs	
Mean	8.601314379
Standard Error	0.612250913
Median	5.971830845
Mode	32.04944992
Standard Deviation	8.372405314
Sample Variance	70.09717075
Kurtosis	1.987523108
Skewness	1.599490823
Range	31.64022535
Minimum	0.502631247
Maximum	32.1428566
Sum	1608.445789
Count	187
Confidence Level(95.0%)	1.207848645

cell 3min off-peak	
Mean	0.402752759
Standard Error	0.059550766
Median	0.252631575
Mode	0
Standard Deviation	0.739005574
Sample Variance	0.546129238
Kurtosis	75.47102948
Skewness	7.958001347
Range	7.964601994
Minimum	0
Maximum	7.964601994
Sum	62.02392482
Count	154
Confidence Level(95.0%)	0.117647915

cell 3min peak	
Mean	0.525905744
Standard Error	0.057056046
Median	0.382341355
Mode	0
Standard Deviation	0.737326603
Sample Variance	0.54365052
Kurtosis	64.9473775
Skewness	6.999777426
Range	7.964601994
Minimum	0
Maximum	7.964601994
Sum	87.82625926
Count	167
Confidence Level(95.0%)	0.112649044

cell conn	
Mean	196.3591212
Standard Error	80.79049599
Median	66.66666412
Mode	0
Standard Deviation	1044.043298
Sample Variance	1090026.409
Kurtosis	158.2376872
Skewness	12.42716434
Range	13431.24121
Minimum	0
Maximum	13431.24121
Sum	32791.97324
Count	167
Confidence Level(95.0%)	159.50934

cell subs	
Mean	12.38301723
Standard Error	1.007064061
Median	12.24319935
Mode	0
Standard Deviation	13.0918328
Sample Variance	171.396086
Kurtosis	22.52059306
Skewness	3.356974135
Range	114.8197632
Minimum	0
Maximum	114.8197632
Sum	2092.729912
Count	169
Confidence Level(95.0%)	1.988130918

Mob invest	
Mean	218571538.3
Standard Error	38576610.37
Median	131549296
Mode	#N/A
Standard Deviation	237802197.1
Sample Variance	5.65499E+16
Kurtosis	4.086095735
Skewness	2.005570419
Range	1077078978
Minimum	231485.6719
Maximum	1077310464
Sum	8305718454
Count	38
Confidence Level(95.0%)	78163636.58

cell subs per100	
Mean	26.16220394
Standard Error	2.422960236
Median	12.70653439
Mode	0
Standard Deviation	33.74793095
Sample Variance	1138.922843
Kurtosis	3.301184439
Skewness	1.812203039
Range	176.5007629
Minimum	0
Maximum	176.5007629
Sum	5075.467564
Count	194
Confidence Level(95.0%)	4.778881115

3min fix tel off-peak	
Mean	0.075657988
Standard Error	0.027872244
Median	0.023255814
Mode	0
Standard Deviation	0.360188767
Sample Variance	0.129735948
Kurtosis	145.7925066
Skewness	11.7590023
Range	4.550000191
Minimum	0
Maximum	4.550000191
Sum	12.63488395
Count	167
Confidence Level(95.0%)	0.055029779

3min fix tel peak	
Mean	0.058148265
Standard Error	0.006953018
Median	0.034400001
Mode	0
Standard Deviation	0.09328453
Sample Variance	0.008702004
Kurtosis	25.6403083
Skewness	4.595890042
Range	0.650195062
Minimum	0
Maximum	0.650195062
Sum	10.46668778
Count	180
Confidence Level(95.0%)	0.013720429

Table 2: Panel Regression Estimation Two Stage Estimation*

$$Q_{it} = \alpha_{it} + \beta_1 P_{it} + \sum_{j=1}^{M} \beta_k X_{it.j} + u_{it}$$

Qit: the natural logarithm of the total volume of call minutes placed in year t by country i, Pit: the natural logarithm of the Average Price of mobile service defined as the annual revenue from mobile networks (US$) divided by the total cellular traffic in a given year and by country.

X represents a vector of the natural logarithm of the following independent variables:

Affordability Index, measures the relative cost of cellular service with respect to income and defined in the previous section

Number of subscriptions: Total number of cellular subscriptions in country i and year t. This variable controls for the natural growth in cellular penetration over time that is unrelated to any changes in the price of service over time

Fixed-Effects (FE) Model					
Variable	**Coefficient**	**std. error**	**t-ratio**	**p-value**	
Const	10.068	0.608	16.56	0.000	***
Affordability Index	0.018	0.056	0.3304	0.746	
Average Price	-1.008	0.026	-38.42	0.000	***
Number of subscriptions	0.692	0.040	17.28	0.000	***

Sum squared resid 0.214; S.E. of regression 0.123604; Adjusted R-squared 0.995, F(9, 14) 522.9; P-value(F) 4.06e-16; Log-likelihood 22.58953 Akaike criterion -25.18; Schwarz criterion -13.39

Random-Effects (RE) Model					
Variable	**Coefficient**	**std. error**	**t-ratio**	**p-value**	
Const	9.178	5.513	1.665	0.112	
Affordability Index	-0.200	0.294	-0.681	0.504	
Average Price	-1.241	0.583	-2.128	0.046	**
Number of subscriptions	0.686	0.338	2.029	0.056	**

Mean dependent var 20.88; S.D. dependent var 1.77; Sum squared resid 24.54; Log-likelihood -34.32; Akaike criterion 76.64; Schwarz criterion 81.35. Hausman test - Null hypothesis: GLS estimates are consistent, Asymptotic test statistic: Chi-square(3) = 0.97 with p-value = 0.80 *Significant @ 10% (**) or 1% (***)*

The estimation is done in two stages. In the first stage, we estimate a reduced form equation by using the penetration rate as an instrumental variable and regress P_{it} on that variable and Number of subscriptions. From this regression we form fitted values of the price variable (P_{it} hat). In the second stage, we replace the original price variable P_{it} with the fitted values from the first-stage to estimate the original equation.

Table 3: Panel Regression Estimation

$$Q_{it} = \alpha_{it} + \sum_{j=1}^{M} \beta_k X_{it.j} + u_{it}$$

Q_{it}: Mobile Penetration defined as mobile cellular subscriptions per 100 inhabitants

X_{it}:

• Log of the Affordability Index

• Corruption Index, varies between 1 (totally transparent) to 10 (most corrupt),

• Gini coefficient of income inequality

• Cell investment, the total mobile communication investment in million US$.

Fixed-Effects (FE) Model **Variable**	**Coefficient**	**std. error**	**t-ratio**	**p-value**	
Const	-343.239	113.747	-3.018	0.008	***
Affordability Index	-22.947	2.649	-8.662	0.000	***
Corruption Index	-12.793	4.533	-2.822	0.012	***
Gini Coefficient	9.196	3.175	2.897	0.010	***
Cell investment	0.009	0.008	1.101	0.286	

Mean dependent var 50.76; S.D. dependent var 32.75; Sum squared resid 2732.37; S.E. of regression 12.68;

Adjusted R-squared 0.85; F(4, 17) 30.79 P-value (F) 1.38e-07; Log-likelihood -84.26; Akaike criterion 178.51; Schwarz criterion 183.97.

Significant @ 10% (**) or 1% (***)

Table 4: Ordered Logit Panel Estimation

$\gamma^*_{it} = \alpha + \beta X_{it} + \gamma_i + u_{it}$

$\text{logit}(p_1) = \log p_1/(1-p_1) = \alpha_1 + \beta'X$

$\text{logit}(p_1+ p_2) = \log (p_1 + p_2) /(1-p_1 - p_2) = \alpha_2 + \beta'X$

$\text{logit}(p_1+ p_2 + p_3) = \log (p_1 + p_2 + p_3) / (1-p_1 - p_2 - p_3) = \alpha_3 + \beta'X$

X_{it} is a vector of variables which includes:

- Gini Coefficient of country i in year t
- Time, to measure how many years each market reform takes
- Cell penetration, to measure the penetration rate of mobile telephone in year t in country i per 100 inhabitants
- Cell Revenue to GDP, a measure of mobile telephone revenues to total GDP
- Civil Rights, a score of civil rights in country i in year t. The score represents the level of openness and governance as reported by Freedom House. The score varies between 1, representing a country with complete full civil rights in the electoral process, judiciary, and unions, and 10 for a totally closed society.
- AVGPRICE: Annual revenue from mobile networks (US$) divided by the total cellular traffic in a given year and by country. This represents the average call 'rate' per mobile service subscriber.
- Cell investment Relative: is the mobile communication investment relative to the revenue from mobile networks, both in US$

Variable	Coefficient	std. error	t-ratio	p-value	
Const	15.1093	1.850	8.168	0.001	***
Gini	-0.3866	0.042	-9.207	0.001	***
Time	0.0180	0.044	0.407	0.705	
Cell penetration	0.0001	0.004	0.015	0.988	
Cell Revenue to GDP	30.9491	3.416	9.061	0.001	***
Civil Rights	-0.1198	0.057	-2.096	0.104	**
AVGPRICE	-0.8063	0.251	-3.211	0.033	**
Cell investment Revenue	0.4295	0.107	3.998	0.016	**

Sum squared resid. 0.007; S.E. of regression 0.043; Adjusted R-squared 0.99; F(7, 4) 205.55; P-value(F) 0.000060; Log-likelihood 27.21641; Akaike criterion -38.43; Schwarz criterion -34.55.

Significant @ 10% (**) or 1% (***)