Fixed-Mobile substitution in MENA countries: What is the future of fixed-line market?

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Abstract

The aim of this paper is to study the occurrence of Fixed-Mobile Substitution (FMS) in MENA region. While there have been many studies on developed countries, empirical evidence for developing countries are somehow limited. In the last few years, mobile cellular subscriptions achieve a tremendous growth across MENA region making it the second fastest growing region in the world in 2012. Fixed subscriptions have also grown but at a slower rate than mobile subscriptions. Using data on 19 MENA countries over the period 1990-2009, we explore the relationship between fixed and mobile telephone services by using dynamic panel data models. We find empirical evidence for asymmetric one-way substitution between fixed-lines and mobile phones. The results are used to estimate own- and cross-price elasticities for fixed and mobile telephone services and to derive policy implications in terms of the extent of regulatory constraints, market redefinition and the extension of universal services to include mobile services.

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1. Introduction

The analysis of FMS becomes one of the main areas of interest in the economics of telecommunications and a key aspect for future telecommunication regulation. A better understanding of whether mobile is a substitute for or a complement of fixed-lines is of importance for policymakers to reform the telecom sector and to improve access and efficiency (Hamilton, 2003). This importance comes in line with the increase of mobile competition and the large growth in mobile subscriptions worldwide. As the fixed market is more regulated than the mobile market due to different cost structures and higher barriers to entry, the increasing evolution of the mobile market represents a considerable threat for the fixed market. Different users could switch from fixed to mobile markets, with no obligation to continue using fixed-lines. It is thus crucial to study whether the mobile market is expanding to the detriment of the fixed market. The importance of FMS appears in a large set of empirical literatures in country-level and cross-country studies. Although it is argued that mobile phones are complements for fixed-lines in developed countries, specifically in the early years of mobile telephony, it is found that they are substitutes in developing countries where access to fixed-lines is low and fixed-line infrastructure is poor (Hamilton, 2003; Grzybowski, 2014).

According to the International Telecommunication Union (ITU), total mobile-cellular subscriptions reached almost 6 billion by end 2011, corresponding to a global penetration of 86%. This growth was driven by developing countries that accounted for more than 80% of the 660 million new mobile-cellular subscriptions added in 2011. Across MENA region, mobile cellular subscriptions achieve a tremendous growth making it the second fastest growing region in the world in 2012 (Deloitte, 2013). The mobile market knows a great evolution in MENA countries, specifically with the reforms adopted in terms of private foreign ownership and competition. The mobile sector, less restricted than the fixed sector, is more attractive to private investors, as well as to consumers due to its high mobility. Furthermore, mobile revenues have direct effects on economic growth in MENA countries and an indirect effect through job creation, greater investment and integration in the global economy (Hakim and Neaime, 2014). On the other hand, the fixed market is still with importance for the region, most of the region accesses the internet through dial-up connections (Cankorel and Aryani, 2009). Some countries still also access the internet through fixed broadband internet services. However, the increasing usage of mobile communications in MENA region over the last decade along with the decline in fixed-line demand lead to important policy implications for future telecommunication regulation.

Economic consequences of FMS are a cornerstone for future regulatory obligations. Substitution from fixed-lines to mobile services leads us to analyze whether fixed and mobile services belong to the same market. We may therefore need to redefine the relevant market for regulatory and antitrust purposes. If the degree of substitution does not justify the redefinition of the relevant market for telecom services, the revision of regulatory restrictions for fixed-lines will be a necessity. With increasing competition from mobile providers and higher level of substitution, policymakers might be forced to reduce regulatory constraints in the fixed market and to review regulatory obligations in the mobile market. In Europe, mobile markets have been largely left unregulated but recently they started to draw regulators' and policymakers' attention (Hakim and Neaime, 2014). Moreover, strong regulation of bottleneck services is not of advantage for mobile operators after the substantial growth of mobile market.

Therefore, the review of regulatory obligations and the extension of universal services are crucial on a country specific level after the occurrence of FMS.

Our research question would be whether fixed and mobile technologies in MENA region are still seen as complements or a substitution relationship hinders the complementarity between them. The answer to this question leads to important policy implications in terms of regulatory obligations for both markets in MENA region. How could the regulator define the market for telecommunications, would we still define two separate markets: fixed-line and mobile communications (as defined in the regulatory framework by the European Commission)? Depending on the extent of substitution between both services, are more restricted regulatory measures for the fixed market still of importance?

According to our knowledge, there is no cross-country study for FMS for developing countries except that by Garbacz and Thompson (2007) on 53 developing countries and by Hamilton (2003) on 23 African countries. Our study is therefore of importance since the FMS issue has never been studied in MENA region. More generally, regional studies analyzing telecom sector in MENA are very limited. Rossotto et al. (2005) used data for 1999, so they do not take into account the mobile evolution in MENA region. Thus, the analysis of the evolution of fixed-mobile relationship was totally ignored[2]. It is thus important to assess fixed-mobile relationship in MENA region and review the regulatory framework in MENA countries and whether it needs further reforms. Conclusions on own and cross-price elasticities would lead to important policy implications in terms of market regulation.

This paper analyzes the demand of telecommunication services in 19 MENA[3] countries from 1990 to 2009. To overcome FMS estimation difficulties, we apply a dynamic panel data model by using Arellano-Bond (1991) estimator. The paper is organized as follows. Section 2 presents an overview of the telecom sector in MENA region. FMS emergence, its economic consequences and literature review are presented in Section 3. Section 4 provides data description and some summary statistics. Baseline specification, econometrical methodology and robustness checks are presented in Section 5. Section 6 presents results and discussions. We end by concluding remarks in Section 7.

2. Telecom market in MENA region

Mobile cellular subscriptions benefit from a tremendous growth across MENA region making it the second fastest growing region in the world in 2012, only surpassed by sub-Saharan Africa. In 2014, MENA region was the fastest growing region in the world in terms of mobile traffic and strong growth rates are expected to continue in the coming years (BuddeComm, 2015). Moreover, MENA tech-savvy population creates one of the hottest markets for smart phone growth worldwide (BuddeComm, 2015). The telecom sector, specifically the mobile sector, shows a great importance for MENA region development due to its effect on job creation, investment and integration in the global economy. For instance, the telecom sector is considered the second generator of government revenues in Lebanon (Hakim and Neaime, 2014).

[2] There is a recent study by Hakim and Neaime (2014) analyzing demand elasticity of mobile telephones in 9 MENA countries.
[3] Countries included in our study are: Algeria, Bahrain, Djibouti, Egypt, Iran, Jordan, Kuwait, Lebanon, Libya (dropped in some estimations due to missed data), Morocco, Oman, Qatar, Saudi Arabia, Sudan, Syria, Tunisia, Turkey, United Arab Emirates and Yemen. The results are robust to the exclusion of Iran and Turkey.

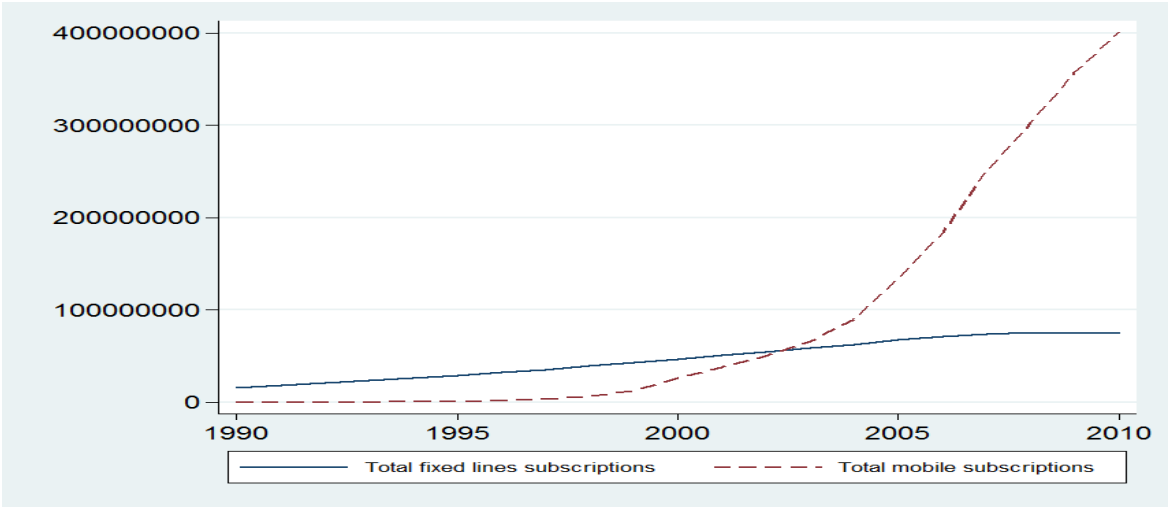
Telecom reforms took place in MENA countries since mid-1990s. Up to 2010, almost all MENA countries have two or more mobile operators, Lebanon and Libya have a government owned duopoly and Djibouti is still among the last countries where the incumbent operator is the monopolist on all telecom services. For the fixed sector, many countries still have a monopolist fixed operator, among them those that are still state-owned operators. As competition increased in the mobile sector, penetration rates in MENA region rose sharply (Hakim and Neaime, 2014). Since reforms for the fixed sector is much more limited than the mobile sector, it is expected that growth of the mobile sector would be to the detriment of the fixed sector.

It is noteworthy that the fixed voice market is almost saturated in some MENA countries like in Algeria, Djibouti, Morocco, Oman, Saudi Arabia and Tunisia…, while it declines in other countries like Bahrain, Egypt, Jordan, Kuwait, Qatar and UAE. Broadband market becomes the focus of incumbent operators, since fixed-line voice revenues continue to decline (BuddeComm, 2015). Thus, the internet may be an important factor in determining telephone demand (Garbacz and Thompson, 2007).

On the other hand, the level of mobile penetration in many MENA countries has surpassed 100%, specifically in GCC countries. Kuwait, Oman and Saudi Arabia have some of the highest mobile penetration in the World, exceeding 150% by end 2010. Moreover, it exceeded the 100% in non-GCC countries as in Jordan, Libya, Morocco and Tunisia. According to ITU, MENA countries with very high mobile penetration rates, essentially GCC countries, are experiencing the so-called *"double-SIM"* effect. Also, for developing countries, there is a strong "prestige effect" of owning the latest cell phone and associated services offered by competing service providers (Garbacz and Thompson, 2007). According to ITU, different parameters affect this trend, between them are countries' market structures (for example, high share of prepaid customers) and the relatively late introduction of mobile number portability (introduced in 2006 in Saudi Arabia) and/or no portability at all (like the case of Bahrain and UAE). In general, mobile penetration was increasing over time for the group of MENA countries. However, it declined in Bahrain since 2009 and it seems to be saturated in Algeria and UAE since 2010.

Fig (1) below illustrates the evolution of fixed and mobile markets in MENA countries in terms of number of subscribers. It shows that fixed-lines subscriptions are growing at very low rates whereas mobile subscriptions are growing at exponential rates. Up to 2003, fixed and mobile subscriptions were converging, with a higher growth for mobile subscriptions. Mobile subscribers have surpassed the number of fixed-lines subscribers in 2003, with 65.6 million mobile subscribers against 59.3 million fixed-lines subscribers. However, the recent slow growth rates indicate the maturity of MENA mobile markets. Fixed subscriptions have also increased but at a slower rate than mobile subscriptions. Although the number of fixed subscribers showed a small decline in 2009 to be 74.8 million in MENA region, it succeeded to reincrease in 2010 to 75.8 million subscribers (highest number for the whole period), with a declining growth rate. We should consider that, for developing countries, although the mobile has the advantage of mobility and of being displayed more quickly and easily in some geographical areas than fixed networks, the fixed market still enjoys the advantage of internet capacity which influences the demand for access (Garbacz and Thompson, 2007; Vogelsang, 2010).

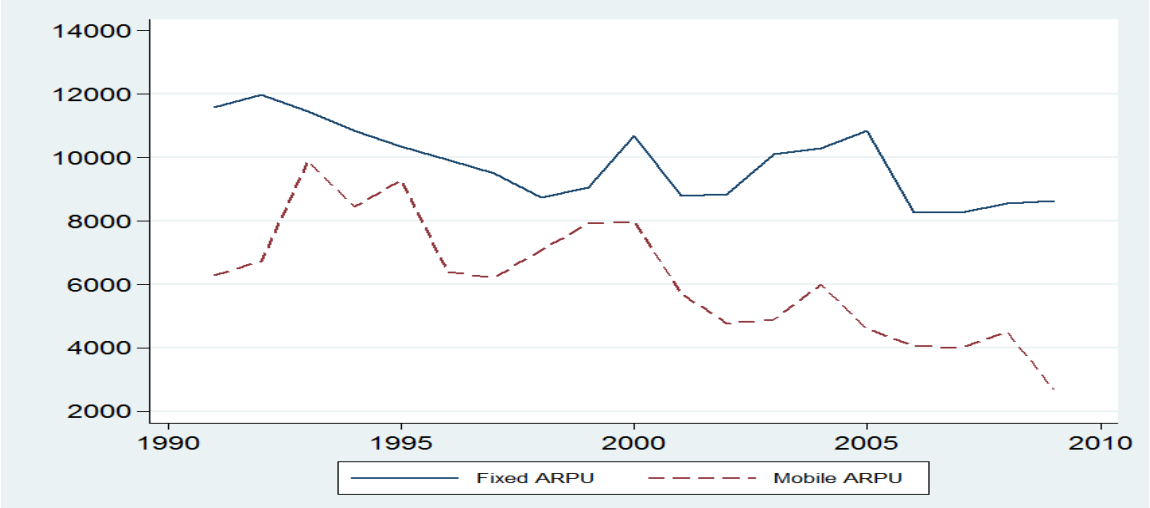
Figure 1. Evolution of fixed and mobile subscriptions in MENA region (1990-2010)



The increasing growth rate of mobile subscriptions may be a result of the high level of competition in the mobile sector compared to the fixed sector. Also, it may serve as a substitute in places where fixed penetration is low (Hamilton, 2003) or to satisfy unmet demand for fixed-lines. For instance, in the Egyptian case, landline usage shows a decline since the introduction of reforms, driven by the penetration of cellular services. In 2009, households spent an average LE 76 a month on their mobile bills but only LE 44 on their fixed-line bills (El-Haddad and Attia, 2012).

Fig (2) indicates the evolution of Average Revenue Per User (ARPU) for the fixed and mobile sectors over time. As shown in the figure, although mobile ARPU is lower than fixed ARPU, there is a substantial decline in both fixed and mobile ARPU with higher decline in the mobile sector over time. Moreover, the figure shows that the greatest decline was around 2003, the year during which mobile subscriptions exceeded the number of fixed subscriptions. While price reductions have been dramatic for mobile services, fixed-lines services have also known some price reductions due to privatization, liberalization and regulatory obligations (Vogelsang, 2010).

Figure 2. Evolution of fixed and mobile ARPU in MENA region (1990-2010)



The fast evolution of mobile technologies around the world questions the relationship between fixed and mobile technologies. FMS mostly occurs in developing countries due to the lack of fixed network infrastructures and since mobile networks are constructed more rapidly and at lower prices (Vogelsang, 2010). However, it is not clear-cut whether the relationship between fixed and mobile technologies in MENA region is a complementarity or a substitution relationship.

Mobile sector enjoys more competition than fixed sector due, primarily, to cost advantage. As stated by Hakim and Neaime (2011), the marginal cost of adding a new subscriber in the mobile sector is virtually a handset. On the other hand, the cost of an additional fixed-line subscriber may involve extending copper lines and providing physical backbone to the existing network. Moreover, mobile sector has succeeded at a time where markets were in a deregulatory mood and during the process of liberalization.

Another factor that affects FMS is the internet provision. Fixed broadband technologies have been deployed in MENA region, but mobile broadband technologies are either not yet deployed (as in Algeria and West Bank and Gaza) or they are not yet accessible to the whole population (as in Iraq and Iran) (Gelvanovska et al., 2014).

As it appears in Table (1), in 2012, fixed broadband penetration in some MENA countries still largely exceeds mobile broadband penetration[4], as in Djibouti, Iraq, Iran and Tunisia. However, the difference between both penetrations is lower in favor of the fixed broadband for other countries as for Bahrain, Lebanon, Morocco, Qatar, United Arab Emirates and Yemen. For other groups of countries, mobile broadband succeeded largely to overtake the fixed broadband as in Egypt, Jordan, Kuwait, Libya, Oman, Saudi Arabia and Syria. Overall, this suggests that households may still keep their fixed-line connection to access the internet.

The competition dynamic in the broadband market is highly impacted by the existence of inter-platform competition (either on the basis of WiMax technologies as in Bahrain and Jordan, or via FTTx technologies as in UAE) providing alternative broadband access to the traditional copper line telephone network equipped with xDSL technologies. The market share of incumbent fixed operators tends to be much lower in countries with vibrant infrastructure-based competition. For other countries where intra-platform competition[5] is non-existent (8 of 19 MENA countries[6] still have a monopolist), market share of incumbent fixed operators is much higher. Up to now, fixed broadband market share of incumbent operators is lower than 50% only in Bahrain and Saudi Arabia (Gelvanovska et al., 2014). However, consumer decision to access the internet through fixed-lines is not considered in our model due to the lack of data.

3. Literature Review

We will start by defining FMS and its economic implications. Then, we will present previous literature review, while focusing on studies for cross-country data.

[4] Most of MENA fixed broadband markets are in the emerging development phase. Moreover, they are largely underdeveloped and suffer from low investments, lack of infrastructure, weak competition and high prices. However, mobile broadband markets are developing increasingly well in terms of penetration and coverage due to effective and vibrant competition (Gelvanovska et al., 2014).

[5] Intra-platform competition takes place when competitors can access the traditional copper line network of incumbent fixed operators through regulated wholesale broadband offers, such as bitstream or local loop unbundling.

[6] Algeria, Syria, West Bank and Gaza, Kuwait, Qatar, Djibouti, Yemen and Morocco.

3.1.Definition of FMS

As defined by Vagliasindi et al. (2006), FMS is the use of mobile instead of fixed phone for calls or access to telecom services. In the beginning of the mobile technology, cellular phones were expensive and designed mainly for business customers (Barth and Heimeshoff, 2014). People usually use it in conjunction with fixed telephone. Moreover, most mobile calls had as destination fixed-lines. The idea of complementarity between fixed and mobile markets implies that both technologies are used together. Therefore, when mobile networks were young, they were complements for fixed networks and mobile growth strengthens fixed networks. Later on, they appear to become substitutes to fixed networks and mobile growth reduces the size of fixed networks and may lead to their demise (Vogelsang, 2010). Specifically, in the early 1990s, after the GSM technology, mobile demand increased and prices declined (Gruber, 2005). The trend of substitution between fixed and mobile services started to occur with different magnitudes. Since then, as mobile telephony becomes more widely spread, FMS becomes a subject of interest for economists and policymakers.

Theoretically, Vogelsang (2010) shows that models explaining FMS are scarce and inconclusive regarding the balance between substitution and complementarity of the fixed and mobile sector. However, empirically, FMS explanations focus on the interaction of positive cross price elasticities and reductions in mobile prices relative to fixed communications. Barth and Heimeshoff (2014) define two levels of substitution. The first level is "access substitution" when the consumer abandons his fixed-line contract and switches to mobile services. The second one is "usage substitution" defined as the use of mobile phone instead of a fixed-line without abandoning the fixed-line contract. Intuitively, substitution at the usage level can drive substitution at the access level (Vogelsang, 2010). On the other hand, it is clear that access substitution may trigger complete substitution of usage (Barth and Heimeshoff, 2014).

3.2. Economic consequences of FMS

Fixed and mobile telecommunication markets have different regulatory measures (Laffont and Tirole, 2001), with the fixed market being generally more restrictive and less competitive, and much more restrictive in MENA region. During the last century, the monopolist incumbent operator is the main provider of fixed telecom services and is working under high regulatory obligations. When FMS occurs, mobile operators could be considered as a threat for fixed operators since they can increase subscriptions at the expense of fixed subscriptions. Thus, an incumbent can lack dominance due to the effect of mobile competition although they are not in the same market (Vogelsang, 2010).

FMS is a retail issue and it is less likely to arise at a wholesale level (REPEC, 2012). Hence, it is important to test if FMS is sufficient to define a single retail market for fixed and mobile services. The extent of the level of substitution would justify having a common market for fixed and mobile services for antitrust and regulation purposes or not, by referring to the SSNIP[7] test (Motta, 2004). If the extent of FMS justifies having one common market, competition between fixed and mobile operators will reduce the market power of the fixed incumbent operator. If it is not the case i.e. fixed and mobile services are not considered to be

[7] SSNIP stands for Small but Significant and Non-transitory Increase in Price and this test answers whether a hypothetical monopolist in the market could profitably sustain a price increase of 5-10% for some period of time.

in the same market, FMS will always matter and have implications in terms of market regulatory obligations, ex-ante regulation[8] and the analysis of significant market power (BEREC, 2012).

More specifically, the overregulation of fixed networks compared to mobile networks leads to price changes in favor of mobile operators. Such changes prevent fixed operators to compete with mobile operators (Vagliasindi et al., 2006). Therefore, one of the most important policy effects faced by regulators is whether FMS is exerting enough pressure on incumbent fixed providers that would lead to deregulation. *With mobile penetration levels substantially exceeding fixed-line penetration, mobile ought not to be advantaged by handicapping fixed networks with burdensome regulation or asymmetric termination rates* (Vogelsang, 2010). In this case, a review of regulatory obligations is crucial on a country specific level after the occurrence of FMS.

Another relevant factor to consider in the analysis of FMS is whether the relationship is symmetric or asymmetric. Mobile and fixed telephone services could be substitutes or complements. However, the results on the substitution or complementarity between fixed and mobile services could be asymmetric. In other words, mobile phone may be considered as a substitute for fixed phone. However, a fixed-line might be a poor substitute or just a complement for mobile phone. This asymmetry becomes more important with the evolving mobile services. Asymmetric substitution means that end users may substitute from fixed services to mobile services but not the other way around (REPEC, 2012).

Another important implication highlighted by Vogelsang (2010) is the goal of universal service. If fixed subscriptions tend more and more to be substituted by mobile markets, universal service should include mobile services. In this case, it would be more efficient to pursue Universal Service Obligation by mobile service subsidization instead of fixed services subsidization. In MENA, as mentioned in Arab States Mobile Observatory report (2013), mobile operators are required to pay into the Universal Services Funds (USFs), for instance up to 2% of revenues in Morocco and 3% in Algeria. Thus, considerations should be taken as USFs should be appropriately targeted and to see whether USFs are still valid given the high coverage of mobile services (Deloitte, 2013).

Finally, when analyzing FMS, we should highlight the importance of fixed networks. Even if fixed and mobile services are substitutes for the end consumer, they are complements in transport because connections between calls are done over the fixed network (Vogelsang, 2010). Another importance of the fixed network remains in fixed broadband access that affects the persistence of fixed subscriptions, as shown in the previous section. As argued by Briglauer et al. (2011), fixed-lines are not only used for national calls, but also for other services as international calls and broadband access. So, users may retain their fixed-line for other purposes. Hence, the use of internet services through fixed-lines postpones FMS. In 2013, the number of fixed broadband subscriptions in developing countries overtook the number in developed countries, a trend that is expected to continue given higher growth rates in developing countries compared to developed countries (ITU, 2014).

[8] It is an application of the three criteria test for determining which markets are susceptible to ex-ante regulation, three criteria should be cumulatively met (a) the presence of high and non-transitory barriers to entry of a structural, legal or regulatory nature; (b) a market structure which does not tend towards effective competition within the relevant time horizon; (c) the insufficiency of competition law alone to adequately address the market failure(s) concerned (ERG, 2008).

3.3. Previous FMS studies

The importance of FMS is emphasized in a large set of empirical literature in country-level and cross-country studies. At the country-level, FMS was studied in USA by Rodini et al. (2003), Ingraham and Sidak (2004), Ward and Woroch (2010) and Caves (2011). They almost all conclude that there is a substitution relationship between fixed and mobile phones. Other studies were conducted for South Korea starting by Sung and Lee (2002), Yoon and Song (2003) and ending by Rhee and Park (2011). They identify a substitution relationship and, more specifically, Rhee and Park (2011) predict that the two markets will converge in the near future. Other studies exist for European countries as for the UK by Horvath and Maldoom (2002), for Portugal by Barros and Cadima (2000), for Austria by Briglauer et al. (2011) and for Spain by Suarez and Garcia-Marinoso (2013) who also all conclude a FMS. Other country-level studies exist also for India by Narayana (2010) and for China by Ward and Zheng (2012) that find also that fixed and mobile phones are substitutes.

More in detail, Rodini et al. (2003) estimate substitutability between fixed and mobile access by applying a logit model to a US household survey from 2000 to 2001. They find that second fixed-line and mobile services are substitutes and they conclude that the mobile line is a moderate substitute for fixed-line access. Briglauer et al. (2011) study FMS in Austrian markets from 2002 to 2007. By using instrumental variable estimation, they estimate own- and cross-price elasticities and find a long run cross-price elasticity of 0.5, however, short run elasticities are insignificant. Ward and Zheng (2012) use a panel of province level data for 31 Chinese provinces from 1998 to 2007 to estimate own- and cross-price elasticities for fixed and mobile telephone services. By using Arellano-Bond dynamic models estimation, they find a strong substitution between fixed and mobile services with cross-price elasticity between 0.20 and 0.28 in the short run, 0.39 and 0.56 in the long run.

Other studies exist for cross-country data. The most important study on developing countries is that of Hamilton (2003) on 23 African countries from 1985 to 1997. She finds that although there is substitution between mobile and fixed-lines, mobile's role as a complement dominates. The complementarity effect outweighs the substitution effect. Thus, it is possible that they are complements even where fixed-line access is low. However, mobile elasticity indicates that they are not close complements. Hodge (2005) uses a survey on South Africa from 1998 to 2001 and finds that fixed and mobile lines are substitutes for low-income households that cannot afford both of them. However, they are complements when the level of incomes increases.

Studies on cross-country data include also Madden and Coble-Neal (2004) who study 56 countries from Africa, Asia, Europe, Middle East and Western Hemisphere from 1995-2010. They estimate a dynamic demand model by using Arellano and Bover dynamic random effects estimation and they find a substantial substitution effect between fixed-lines and mobile subscriptions. Vagliasindi et al. (2006) explore the level of competition between fixed-lines and mobile services by using enterprise-level variables in 25 Eastern Europe and Former Soviet Union countries for business users in 2002. They use a probit model and they prove the presence of strong substitution effect between fixed and mobile communication services and evidence of some substitution effects at the country-level. Garbacz and Thompson (2007) estimate telecommunication demand for residential mainline and mobile services for 53 developing countries from 1996-2003. By using instrumental variables, they find that although

landlines are substitutes in the mobile market, the opposite is not true, mobile lines are not substitutes in the landline market but they may be considered as complements. Barth and Heimeshoff (2014) study FMS on the subscriber level in 27 EU countries from 2003-2009. By applying dynamic panel data techniques, they find strong empirical evidence for substitution from fixed to cellular networks and they conclude that substitutional effects become larger, due to further price reductions in mobile markets. In a study by Grzybowski (2014), for 27 EU countries from 2005 to 2010, he derives a structural model of household's demand for fixed-line only, mobile only and both fixed-line and mobile access. He concludes that FMS is slowed down by the spread of internet but it may continue with the spread of mobile broadband.

For MENA countries[9], there is a descriptive study on Egyptian voice telecommunication market by El-Haddad and Attia (2012). They state that cellular and fixed services are not perfect substitutes. Although it is difficult to quantify their degree of substitutability, it is obvious that the introduction of mobile services exerted competitive pressures on the landline operator. In the Egyptian case, Egyptians prefer cellular voice due to lower prices, more transparent billing, its convenience and finally, the lack of desire to deal with public servants of the incumbent operator.

Vogelsang (2010), in his survey on the relationship between fixed and mobile communications, states that, based on positive cross-price elasticities between fixed and mobile services in both directions, a price decline of mobile relative to fixed services would help to explain FMS. A further price decline of mobile services would make them more substitutable.

From the previous literature, we conclude three main remarks. First, the question of complementarity and substitution occurs mainly in the voice telephone services. Then, previous studies are mostly on developed countries. Finally, most of the previous country-level studies conclude that fixed and mobile phones are substitutes on the access level, the usage level or on both levels. However, cross-country studies find mixed results of substitution and complementarity between fixed and mobile services.

4. Data description and summary statistics

The sample we use consists of 19 MENA countries from 1990-2009[10]. Table (2) provides details on all variables used in our analysis. We estimate the effect of different telecom prices on fixed-line and mobile subscriptions in national residential markets.

4.1. List of variables[11]

There is no sufficient information about traffic data for all MENA countries. Therefore, our main dependent variables reflecting quantity per sector are the fixed and mobile subscriptions

[9] Hakim and Neaime (2014) analyze the demand for mobile telephone for 9 MENA countries from 1995-2007, by testing the effect of mobile subscriptions and mobile prices on traffic volume. They find negative significant unitary elasticities of demand. They conclude that demand elasticities do not entice collusion between different operators.

[10] Other studies have approximately the same number of observations as Garbacz and Thompson (2007) who work on 190 to 303 observations, Ward and Zheng (2012) who work on 248 observations and Hamilton (2003) who works on 299 observations.

[11] For more details on list of variables, see Table 2

in log. These variables measure the number of total fixed-line and mobile subscribers.[12] Although we admit high evolution of mobile market and increase in the number of subscriptions, the number of mobile subscriptions may be somehow inflated by the double sim effect or some inactive users. Data for these variables come from ITU database.

As in most of previous studies, accurate measures of prices are not available. There are many tariff plans for targeting different groups of consumers in fixed and mobile markets. Moreover, subscription to a phone is associated with different types of costs as: installation costs, monthly fees, price of calls depending on time of day, call destination, whether it is for the same network or for another network (Hodge, 2005). Due to a lot of missed data and low number of observations for MENA region, we use as price proxies the fixed and mobile Average Revenue Per User (ARPU)[13] calculated as revenue per sector divided by the number of subscribers. Data on telecommunication revenues are also extracted from the ITU database. The data we use are the best data available up till now.

Finally, we control for demographic and macroeconomic variables, such as GDP per capita based on Purchasing Power Parity (PPP) in constant 2005 international dollars and population density. Data are extracted from World Development Indicators database of the World Bank. Due to the small number of observations, other country-level variables are accounted for by using country fixed effects. We use time fixed effects or time trend interchangeably. All variables are measured in logarithms, so different coefficients could be interpreted in terms of elasticities.

4.2. Descriptive statistics and correlations matrix

Table (3) reports summary statistics for variables in levels. Comparing lower income countries to higher income countries in terms of GDP per capita in constant US$ in Purchasing Power Parity (PPP)[14], we can observe that higher income countries are characterized by higher fixed and mobile penetration, as well as higher ARPU, than lower income countries.

Table (4) presents the correlation matrix between different variables in our model. We can see that fixed and mobile subscriptions are negatively related with fixed and mobile ARPU respectively, while cross correlation between fixed and mobile markets is negative.

When estimating FMS, we should take into account inter-sector differences in MENA region. First, mobile sector shows high technological evolution compared to fixed sector. Such evolution leads to high increase in the mobile market subscriptions with a moderate growth in the fixed market. Second, mobile pricing scheme (including messages, roaming services, minutes of calls…) are much more complex than fixed pricing scheme. The main problem in estimating FMS is the problem of endogeneity occurring mainly due to the joint determination

[12] We prefer to measure quantity in terms of subscribers, rather than in terms of telephone penetration (number of subscribers per 100 inhabitants). However, our results for cross-price elasticities are robust for both dependent variables.

[13] As in Briglauer et al. (2011), they use average revenue for access (per subscriber) and for calls (per minute) as price indicator to estimate price elasticities in Austria. Also, Ward and Zheng (2012) measure price by constructing Average Revenue Per User (ARPU) as revenue divided by subscribers and Average Revenue Per Minute (ARPM) as revenue divided by the number of minutes.

[14] We divide the sample into two groups depending on the mean of the GDP per capita that equals 28372 US $.

of prices and quantities although it is problematic in our case[15]. Other problems may occur due to prices measurement errors and missing variables reflecting technology level and costs functions.

In the section that follows, we will provide more formal evidence on the effects of ARPU on the number of subscriptions per sector. We will also investigate whether the relationship is a substitution or a complementarity relationship.

5. Baseline specification and econometrical methodology

We present in this section our baseline equation. Then, we describe the econometric methodology we use.

5.1. Baseline specification

We use a cross-country time-series panel data to estimate the relationship between fixed and mobile markets. We follow Houthakker-Taylor model[16], where an individual subscriber's demand for telephone calls (q) depends on the price of a call, the price of a substitute, the past number of network subscribers and the income of the consumer (Houthakker and Taylor, 1970).

Therefore, the level of subscriptions is a function of the subscription level of the previous year to reflect consumption path dependencies. Also, it is a function of the market price level (fixed or mobile), the other market price level (mobile or fixed), the level of GDP per capita and the total population per country. We will estimate the model once for the fixed market, then for the mobile market. We can thus test whether it is one-way asymmetric substitution, two-way symmetric substitution or two-way asymmetric substitution. In equation (1), we test for substitution from fixed-lines to mobile market[17]. In Equation (2), we test for reverse substitution from mobile to fixed-lines markets.

Our baseline regression takes the following form:

$$q_{f_{it}} = \alpha_0 + \alpha_1\, q_{f_{it-1}} + \alpha_2\, Price_{f_{it}} + \alpha_3\, Price_{m_{it}} + \alpha_4\, GDPPC_{it} + \alpha_5\, TotalPop_{it} + \lambda_i + \delta_t + \epsilon_{it} \quad (1)$$

$$q_{m_{it}} = \beta_0 + \beta_1\, q_{m_{it-1}} + \beta_2\, Price_{m_{it}} + \beta_3\, Price_{f_{it}} + \beta_4\, GDPPC_{it} + \beta_5\, TotalPop_{it} + \lambda_i + \delta_t + \xi_{it} \quad (2)$$

[15] As argued by Hakim and Neaime (2014), it is important to notice that prices and quantities are not simultaneously determined, since the market is almost non-competitive. Tariffs are set in negotiations between the government (the regulator) and mobile operators, then quantities are adjusted to their levels.

[16] We follow this model as in Briglauer et al. (2011), Ward and Zheng (2012) and Barth and Heimeshoff (2014).

[17] We find three groups of studies. (1) Some studies test both models as in Garbacz and Thompson (2007) find that although wireline phones are substitutes in the mobile market (effect of fixed prices on mobile demand is positive), the contrary is not true, mobile phones are not substitutes in the wireline market, and may be considered as complements (effect of mobile price on residential demand is negative). Barth and Heimeshoff (2014) also test for cross-price elasticities of access (found to be asymmetric). (2) Other studies consider only the fixed demand equation as Briglauer et al. (2011) when testing for cross-price elasticities of calls and access and Barth and Heimeshoff (2014) by testing the effect of mobile prices on fixed calls. (3) The third type of studies use the mobile demand equation only to test for FMS as in Madden and Coble-Neal (2004).

where i indexes Countries, and t Time. f stands for the fixed market and m for the mobile market. q_{it} is either the fixed subscriptions or the mobile subscriptions. $Price_{it}$ is the proxy we use for the prices indicators. $GDPPC_{it}$ and $TotalPop_{it}$ are the control variables: the GDP per capita in constant US$ in PPP and the total number of population per country, respectively. Finally, country fixed effects and time fixed effects are denoted by λ_i and δ_t respectively, and ϵ_{it} and ξ_{it} are idiosyncratic components.

All our variables are used in logarithms, so we can interpret different coefficients as elasticities. The lagged dependent variable is expected to have positive effect due to consumer habits. The short run own-price elasticity is equal to α_2 and β_2 for the fixed and mobile sector respectively. With the inclusion of lagged subscription level, the long run own-price elasticity equals $\alpha_2/(1-\alpha_1)$ and $\beta_2/(1-\beta_1)$ for the fixed and mobile equation respectively. The short run cross-price elasticity is equal to α_3 and β_3 for the fixed and mobile sector respectively. With the inclusion of lagged subscription level, the long run cross-price elasticity equals $\alpha_3/(1-\alpha_1)$ and $\beta_3/(1-\beta_1)$ for the fixed and mobile equation respectively. Cross-price elasticity may be negative, so fixed and mobile markets would be considered as complements. Or, it may be positive, so, they can be seen as substitutes.

It would be interesting to measure own- and cross-price elasticities for many reasons. The demand elasticity affects the choice of market structure and the occurrence of collusive behaviors[18] in the market. Also, computing demand elasticity is of great importance for policymakers to determine the best regulatory regime[19] to adopt. Furthermore, for firms, elasticities determine price setting, future sales and thus, consumer surplus as well as total welfare gains.

The time coefficient we use can be interpreted as an upgrade in service quality and technological evolution, and also as a sign of increasing network performance and decreasing prices (Barth and Heimeschoff, 2014; Grzybowski, 2005). The country fixed effects account for country specific characteristics and heterogeneity across countries.

5.2. Econometric methodology

Ward and Zheng (2012) note that the demand structure may be too complex for most models to accommodate, due to pricing and services features that become quite complex. We use Arellano-Bond dynamic GMM estimator.

By focusing on the level of subscriptions and denoting with y the logarithm of fixed subscriptions or mobile subscriptions respectively, the demand equation can be expressed as follows:

$$\boldsymbol{y_{i,t} = \theta_0 y_{i,t-1} + \gamma x_{i,t} + \omega_i + \sigma_t + \mu_{it}} \qquad \textbf{(3)}$$

y_{it} is either fixed subscriptions or mobile subscriptions. $y_{i,t-1}$ is the lagged dependent variable. The vector $x_{i,t}$ includes the set of our explanatory variables (prices proxies and control

[18] If the demand is inelastic, this encourages collusive behaviors in the market.

[19] When price elasticities are unavailable, the regulating agency resorts to imposing price caps (to limit increase in access tariffs of mobile services) which is often inefficient and creates market distortions (Hakim and Neaime, 2014).

variables). Finally, country fixed effects and time fixed effects are denoted by ω_i and σ_t respectively, and μ_{it} is an idiosyncratic component.

The model for the level in Equation (3) can be expressed for the increase of y as follows:

$$\Delta \boldsymbol{y_{i,t}} = (\boldsymbol{\theta_0} - \mathbf{1})\boldsymbol{y_{i,t-1}} + \boldsymbol{\lambda}\, \boldsymbol{x_{i,t}} + \boldsymbol{\omega_i} + \boldsymbol{\sigma_t} + \boldsymbol{\mu_{it}} \qquad \textbf{(4)}$$

Due to the simultaneous presence of the country fixed effects and the lagged dependent variable, the estimator is biased and inconsistent, as the lagged dependent variable is correlated with the error term[20]. Moreover, in our specification, most of the explanatory variables can be expected to be endogenously determined (as the quantities and prices are simultaneously determined) and some of them are likely to be measured with error. To solve for the endogeneity arising both from the dynamic specification of the equation and from reverse causality, we rely on internal instruments, using Generalized Method of Moments (GMM) panel estimator[21]. This method relies on first differencing the equation to wipe out the country-specific fixed effect, and uses appropriate lags of the right-hand side variables as instruments.

First differencing equation (3)[22] thus allows us to eliminate the country-specific effects $\boldsymbol{\omega_i}$, as follows in equation (5):

$$\boldsymbol{y_{i,t}} - \boldsymbol{y_{i,t-1}} = \boldsymbol{\theta_0}(\boldsymbol{y_{i,t-1}} - \boldsymbol{y_{i,t-2}}) + \boldsymbol{\lambda}\,(\boldsymbol{x_{i,t}} - \boldsymbol{x_{i,t-1}}) + (\boldsymbol{\sigma_t} - \boldsymbol{\sigma_{t-1}}) + (\boldsymbol{\mu_{i,t}} - \boldsymbol{\mu_{i,t-1}}) \quad \textbf{(5)}$$

After eliminating country fixed-effects in Equation (5), we still need instruments to control for possible endogeneity of the explanatory variables. Moreover, we need to deal with the correlation between $(y_{i,t-1} - y_{i,t-2})$ and $(\mu_{i,t} - \mu_{i,t-1})$ due to the possibility that past shocks predict contemporary regressors.

The GMM first difference estimator implies that values of y and of all the xs lagged twice or more can be used as instruments in our regressions. However, the GMM first-difference estimator has a limitation shown by Blundell and Bond (1998); when the explanatory variables are persistent over time, lagged levels of these variables are weak instruments for the regression equation in first-difference. Such problem would lead to biased coefficients, specifically in small samples. Blundell and Bond (1998) propose a system GMM estimator to avoid this bias. This estimator combines in a system the first differenced Equation (5) plus the same equation in levels Equation (3). Instruments for the regression in differences are the variables at levels lagged twice or more, while instruments for the equation in levels are lagged differences of the variables. By using system GMM estimator and by including additional moments conditions, this improves the estimation by reducing the finite sample bias limitation.[23]

To ensure the consistency of system GMM estimator, we test for the validity of the instruments by using Sargan test for overidentifying restrictions under the null hypothesis of instruments validity, and we use the test for second order serial correlation of the residuals under the null hypothesis of no second-order serial correlation, which check the legitimacy of

[20] This bias is known as Nickell (1981) bias.

[21] This estimator is proposed by Arellano and Bond (1991) and Blundell and Bond (1998).

[22] The first difference GMM estimator is developed by Arellano and Bond (1991).

[23] The GMM estimator applies a first-difference transformation, so non-stationary variables cannot cause spurious regressions problems (Barth and Heimeshoff, 2014).

variables lagged $(t-2)$ and used as instruments. Both tests are suggested by Arellano and Bond (1991).

5.3. Robustness checks

To ensure our results are robust across different specifications, we estimate a dynamic fixed effects panel model by using Newey-West procedure to avoid distortions in standard errors due to autocorrelation and heteroscedasticity (Wooldridge, 2010, pp. 310-315). We include country dummies, as well as time trend. The results are robust to the increase of the number of lags[24] up to 2.

6. Regression results and Discussions

Table (5) reports system GMM estimates of Equation (1) and (2). Table (6) reports regression with Newey-West procedure. The results fail to reject Sargan test hypothesis of instruments validity, and also fail to reject the hypothesis of no second-order serial correlation in different specifications. Although our results are robust across different specifications, we will focus on specification (1) in the system GMM estimates to compute own- and cross-price elasticities.

The lagged dependent variable is positive and highly significant for both equations. This reflects that past level of telephone subscriptions has a positive effect on current level of subscriptions. That is due to network effects and to the persistence in subscribers' series.

Fixed subscriptions decrease with increases in fixed prices, which indicates negative own-price elasticity, however the coefficient is either not significant or weakly significant. Moreover, it appears to be very low and close to zero. Previous findings show that when price elasticities for fixed services approach to zero, subsidies have little or no impact on universal services (Garbacz and Thompson, 2007).

For equation (2), we find that mobile own-price elasticity equals 0.25 and it equals 1.46 in the long run which reflects a much more elastic demand. The elasticity reflects the degree of market power of mobile operators and their ability to increase prices. Market power of MENA mobile operators is much lower in the long run. As explained by Vogelsang (2010), low levels of elasticities under oligopolistic markets indicate that mobile services form their own market and that the market is fairly competitive (not as the monopoly pricing).

To find whether both markets are complements or substitutes, we are interested in the sign of α_3 and β_3 in Equation (1) and (2) reported in Table (7). This reflects cross-price elasticities. In Equation (1), when mobile prices decrease, fixed subscriptions decrease. Thus, the user substitutes fixed-line by a mobile line. This reflects that the fixed-mobile relationship is a substitution rather than a complementarity relationship. Short run cross-price elasticity is highly significant and equals 0.032. In the long run, it becomes more elastic with the value of 1.52. A 10% decrease in mobile prices would lead to 0.32% decrease in fixed subscriptions in the short run and to 15.2% decrease in the long run. The high positive cross-price elasticity in the long run suggests that advanced FMS in MENA region may strongly result in the future in considering both access markets as one market.

[24] The number of lags m in dynamic regressions should be equal to $m = 0.75\, T^{1/3} = 2.035$

In Equation (2), looking at the cross-price elasticity, we find that it is not significant in the short run, as well as in the long run. Although both cross-price elasticities are positive, the cross-price elasticity at Equation (2) is not significant since fixed-line can never be a full substitute for mobile lines. This confirms asymmetric one-way substitution between fixed and mobile services.

Finally, population density has a significant positive effect in all our specifications, with a higher effect on mobile subscriptions rather than on fixed subscriptions. That is due to the fact that households usually have one fixed-line contract, which is not the case for mobile phones. Moreover, GDP per capita has a positive effect, although it is not always significant. In general, as individual income increases, demand for telephones increases, however, it is not the case when the lack of access is due to insufficient supply rather than low demand. Year dummies show an upward trend when testing their effect on mobile subscriptions which reflects quality improvements. However, they show a downward trend when testing their effect on fixed subscriptions.

From the previous results, three important remarks occur. First, these results are an indication of substitution between fixed and mobile markets at the access level. However, it is not tested whether the same user abandons his fixed telephone line or not. Second, we find one-way asymmetric substitution. Mobile subscriptions serve as a substitute for fixed-lines in Equation (1). However, in Equation (2), fixed-lines could not serve as a substitute for mobile lines, due to high technological evolution in the mobile usage, as well as the advantage of mobility. Moreover, it could be due to the low quality of fixed networks. Finally, low cross-price elasticity in the short run reflects that fixed and mobile lines are not close substitutes. Therefore, we argue that a mobile phone is used both as a substitute for and as a complement of a fixed-line. Mostly, we get such results due to the fact that its role as a substitute outweighs its role as a complement. So, more people are moving towards the mobile market but others still use both of them together, mostly due to the use of fixed internet services.

Despite the high growth of mobile internet penetration, MENA region still trail behind the average of the developing world that reaches 45% in 2015, with half of the region's population still unconnected (GSMA, 2015). *It is still early days for the mobile economy in the region* (GSMA, 2015), many steps remain for policymakers to expand access to broadband and different valuable services delivered by mobile networks. Key barriers for mobile internet access are the shortage of network infrastructure, limited amounts of spectrum, costs limitations and high levels of taxations. Governments also have an important role in making it easier for mobile operators to have access to the necessary infrastructure, in order to be able to address the fast growing demand for mobile services including mobile broadband.

For instance, excessive taxation policies for mobile operators need to be reviewed, specifically with the growing importance of the mobile sector in economic growth and job creation. The mobile taxes in MENA are considered as big barrier to mobile development. According to the Mobile Economy Arab States report (2015), mobile taxes reach 6.9% of the total cost of mobile ownership (TCMO), compared to 3.2% globally. In MENA region, mobile sector is subject to higher taxes than fixed-line sector, as if mobile services are a luxury item or harmful product such as tobacco (GSMA, 2015).

These results describe the evolution of mobile usage in MENA region. Overall, the role of a mobile line as a substitute for a fixed-line begins to dominate the telecommunication markets in MENA region. To see whether the level of substitution would justify having a

common market for fixed and mobile services for antitrust and regulation purposes, we refer to SSNIP[25] test and compute critical elasticity of demand. Following Vogelsang (2010), the critical own demand elasticity is equal to $\eta = 1/(m_0 + t)$ where m_0 is the Lerner Index at zero profit and t is the standard threshold markup (usually 0.05 or 0.1). The m_0 calculated for fixed-line access and used in the literature (Stumpf, 2007; Barth and Heimeshoff, 2014) is $\leq$ 0.5. Therefore, the critical elasticity of demand for access falls between is -1.7 and -1.8. The estimated own-price elasticity varies from different specifications between -0.02 and -0.05 (and the long run own-price elasticity varies between -0.5 and -1) which is very far from this threshold. In spite of the substitution between fixed and mobile markets in MENA region, they still form two separate markets. Even if fixed and mobile services are not considered to be in the same market on the access level, our results on FMS have implications for fixed and mobile markets in terms of regulatory and universal services obligations.

7. Conclusion

In this paper, we study fixed-mobile substitution in MENA region by testing the effect of prices on fixed and mobile subscriptions and computing cross-price elasticities. By using dynamic panel data models, we find one-way asymmetric substitution from fixed to mobile lines. Fixed access prices have no effect on the mobile market, however, mobile access prices affect the fixed market. Moreover, we find low short run cross-price elasticity, which implies that the role of mobile as a substitute dominates its role as a complement of fixed-lines, but it is not eliminating it. These results have a wide impact on the telecommunications regulatory framework in MENA countries.

Although the computed level of substitution doesn't justify having one common market for both services, more restricted regulatory measures for the fixed market are no longer reasonable. High level of restrictions for MENA fixed markets is not of advantage for mobile operators, specifically after the substantial growth of mobile subscriptions and the low growth of fixed subscriptions. A review of regulatory obligations is therefore crucial on a country specific level after FMS occurrence. Moreover, since fixed subscriptions tend to be more substituted by mobile subscriptions, universal service should be extended to include mobile services and excessive taxation policies for mobile operators need to be reviewed.

Is the expansion of the mobile market to the detriment of the fixed market causing its demise in MENA region? Our answer is "no", in spite of the large mobile growth, users still retain their fixed-line for other purposes other than national calls, as fixed internet services. At the retail level, the importance of fixed networks still remains in the fixed broadband access and the internet access through dial-up connections, which affect the persistence of fixed subscriptions and also it remains in the role of fixed networks in calls connections.

Governments have an important role in making it easier for mobile operators to have access to the necessary infrastructure, so they would be able to address the fast growing demand for mobile services including mobile broadband. As a policy recommendation, it is important to allow mobile operators to invest directly in the infrastructure, as well as in the international gateway services, in order to improve services availability and costs and bring

[25] SSNIP test stands for Small but Significant and Non-transitory Increase in Price test and it answers whether a hypothetical monopolist in the market could profitably sustain a price increase of 5–10% for some period of time.

competition to the market. The question for future research is what would be the economic implications on fixed networks if MENA region could provide internet services only through mobile technology?

References

Arellano, M., & Bond, S. (1991). Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. *The review of economic studies*, 58(2), 277-297.

Barth, A. K., & Heimeshoff, U. (2014). Does the growth of mobile markets cause the demise of fixed networks?–Evidence from the European Union. *Telecommunications Policy*, 38(11), 945-960.

Barth, A. K., & Heimeshoff, U. (2014). What is the magnitude of fixed–mobile call substitution? Empirical evidence from 16 European countries. *Telecommunications Policy*, 38(8), 771-782.

Barros, P. P., & Cadima, N. (2000). *The impact of mobile phone diffusion on the fixed-link network* (Vol. 2598). Centre for Economic Policy Research Discussion Paper.

BEREC. (2012). *BEREC Report on Impact of Fixed-Mobile Substitution in Market Definition*. BoR (12) 52.

Blundell, R., & Bond, S. (1998). Initial conditions and moment restrictions in dynamic panel data models. *Journal of econometrics*, 87(1), 115-143.

Briglauer, W., Schwarz, A., & Zulehner, C. (2011). Is fixed-mobile substitution strong enough to de-regulate fixed voice telephony? Evidence from the Austrian markets. *Journal of Regulatory Economics*, 39(1), 50-67.

BuddeComm (2015). Mobile Voice and Mobile Operators Market.

Caves, K. W. (2011). Quantifying price-driven wireless substitution in telephony. *Telecommunications Policy*, 35(11), 984-998.

Deloitte (2013). *Arab states mobile observatory 2013*. Retrieved 2014, from http://www.gsma.com/spectrum/arab-states-mobile-observatory-2013/

El-Haddad, A., & Khaled, A. (2012). *Welfare Effects of Institutional Reform in Public Utilities: The Case of Voice Telecommunication in Egypt.* ERF Policy Research Report, No. 36, Cairo: ERF.

European Regulators Group, (2008). *ERG Report on Guidance on the application of the three criteria test*. June 2008. Available at: http://www.ictregulationtoolkit.org/en/toolkit/docs/Document/3661

Garbacz, C., & Thompson, H. G. (2007). Demand for telecommunication services in developing countries. *Telecommunications policy*, 31(5), 276-289.

Gelvanovska, N., Rogy, M., & Rossotto, C. M. (2014). *Broadband Networks in the Middle East and North Africa: Accelerating High-Speed Internet Access*. World Bank Publications.

Gruber, H. (2005). *The economics of mobile telecommunications*. Cambridge University Press.

Grzybowski, L. (2005). Regulation of mobile telephony across the European Union: An empirical analysis. *Journal of Regulatory Economics*, 28(1), 47-67.

Grzybowski, L. (2014). Fixed-to-mobile substitution in the European Union. *Telecommunications Policy*, 38(7), 601-612.

GSM Association. (2015). The Mobile Economy Arab States 2015. Available at: https://gsmaintelligence.com/research/?file=7910cff3a3e6f96219cd50e31d6d3e1c&download

Hakim, S., & Neaime, S. (2014). The demand elasticity of mobile telephones in the Middle East and North Africa. *Research in International Business and Finance*, 32, 1-14.

Hakim, S., & Neaime, S. (2011). *An analysis of the mobile telephone sector in MENA: Potential for deregulation and privatization*. ERF Working Paper, No. 649, Cairo: ERF.

Hamilton, J. (2003). Are main lines and mobile phones substitutes or complements? Evidence from Africa. *Telecommunications Policy*, 27(1), 109-133.

Hodge, J. (2005). Tariff structures and access substitution of mobile cellular for fixed line in South Africa. *Telecommunications Policy*, 29(7), 493-505.

Ingraham, A. T., & Sidak, J. G. (2004). Do states tax wireless services inefficiently-evidence on the price elasticity of demand. *Virginia Tax Review*, 24, 249-261.

ITU. (2014). *ICT facts and figures*.

ITU. (2010). *ITU Regulatory Database.*

Laffont, J. J., & Tirole, J. (2001). *Competition in telecommunications*. MIT press.

Madden, G., & Coble-Neal, G. (2004). Economic determinants of global mobile telephony growth. *Information Economics and Policy*, 16(4), 519-534.

Motta, M. (2004). *Competition policy: theory and practice*. Cambridge University Press.

Narayana, M. R. (2010). Substitutability between mobile and fixed telephones: Evidence and implications for India. *Review of Urban & Regional Development Studies*, 22(1), 1-21.

Nickell, S. (1981). Biases in dynamic models with fixed effects. *Econometrica: Journal of the Econometric Society*, 1417-1426.

Rhee, H., & Park, M. (2011). Fixed-to-mobile call substitution and telephony market definition in Korea. *Journal of Regulatory Economics*, 40(2), 198-218.

Rodini, M., Ward, M. R., & Woroch, G. A. (2003). Going mobile: substitutability between fixed and mobile access. *Telecommunications Policy*, 27(5), 457-476.

Rossotto, C. M., Sekkat, K., & Varoudakis, A. (2005). Opening up telecommunications to competition and MENA integration in the world economy. *Journal of International Development*, 17(7), 931-955.

Stumpf, U. (2007). *Regulatory approach to fixed-mobile substitution, bundling and integration*. Wiss. Inst. für Infrastruktur und Kommunikationsdienste Discussion Paper.

Suárez, D., & García-Mariñoso, B. (2013). Which are the drivers of fixed to mobile telephone access substitution? An empirical study of the Spanish residential market. *Telecommunications Policy*, 37(4), 282-291.

Sung, N., & Lee, Y. H. (2002). Substitution between mobile and fixed telephones in Korea. *Review of Industrial Organization*, 20(4), 367-374.

Taylor, L. D., & Houthakker, H. S. (2010). *Consumer demand in the United States: prices, income, and consumption behavior*. Springer Science & Business Media.

Vogelsang, I. (2010). The relationship between mobile and fixed-line communications: A survey. *Information Economics and Policy*, 22(1), 4-17.

Vagliasindi, M., Güney, I., & Taubman, C. (2006). Fixed and mobile competition in transition economies. *Telecommunications Policy*, 30(7), 349-367.

Ward, M. R., & Woroch, G. A. (2010). The effect of prices on fixed and mobile telephone penetration: Using price subsidies as natural experiments. *Information Economics and Policy*, 22(1), 18-32.

Ward, M. R., & Zheng, S. (2012). Mobile and fixed substitution for telephone service in China. *Telecommunications Policy*, 36(4), 301-310.

World Bank. (2014). *World Development Indicators.*

Wooldridge, J. M. (2010). *Econometric analysis of cross section and panel data*. MIT press.

Yoon, C. H., & Song, Y. W. (2003). Telecom development in Korea: Substitution and integration of fixed-mobile services and regulatory implications. *Communications & Strategies*, *5*, 257-270.

Table 1. Overview of Broadband market in MENA region (2012)

Economy	Fixed Broadband penetration (% of households)	Mobile broadband (3G+4G) penetration (% of population)	Population 2011 (millions)
Algeria	18.1	0	35.98
Bahrain	88.9	74.24	1.32
Djibouti	10.3	2.22	0.9
Egypt, Arab Rep.	14.1	56.37	82.54
Iraq	6.7	0.49	32.96
Iran	12.00	0.05	74.8
Jordan	25.4	52.69	6.18
Kuwait	32.1	67.78	2.82
Lebanon	29.6	26.65	4.26
Libya	8.6	23.35	6.42
Morocco	10.9	10.14	32.27
Oman	25.7	56.95	2.85
Qatar	66.4	64.44	1.87
Saudi Arabia	51.7	55.89	28.08
Syrian Arab Republic	3.6	4.33	20.82
Tunisia	23.4	5.1	10.67
United Arab Emirates	69.4	69.23	7.89
West Bank and Gaza	25.1	0	4.00
Yemen, Rep.	2.4	1.82	24.8
MENA, Simple Average	27.6	30.09	
MENA, Weighted Average	17.1	22.2	

Source. Gelvanovska, N., Rogy, M., & Rossotto, C. M. (2014). *Broadband Networks in the Middle East and North Africa: Accelerating High-Speed Internet Access*. World Bank Publications.

Table 2. List of variables

Dependent variables	Description	Source of the data
Fixed Access	Log (Number of fixed-lines in a country)	ITU database
Mobile Access	Log (Number of mobile lines in a country)	ITU database
Independent variables		
Fixed ARPU	Log (Average revenue per subscriber as the total (gross) fixed telecommunication revenue in US$ (both network and virtual operators) offering services within the country divided by the number of fixed subscribers)	By the author from ITU database
Mobile ARPU	Log (Average revenue per subscriber as the total (gross) mobile telecommunication revenue in US$ (both network and virtual operators) offering services within the country divided by the number of mobile subscribers)	By the author from ITU database
Control variables		
	Log (GDP per capita)	WDI (World Development Indicators), WB
	Log (Total population)	WDI (World Development Indicators), WB

Table 3. Descriptive Statistics

Variable	Entire sample (1)	Lower Income countries (2)	Higher Income countries (3)
Fixed-lines subscriptions	1122175 (340, 1740376)	3446149 (228, 5739427)	897720.4 (152, 1067333)
Mobile subscriptions	2755828 (340, 6860291)	5227749 (228, 1.20e+07)	1067333 (152, 5750502)
Fixed penetration	12.73 (380, 9.21)	9.16 (228, 9.17)	18.1 (152, 8.25)
Mobile penetration	24.29 (380, 37.36)	15.7 (228, 25.53)	37.12 (152, 47.41)
Fixed ARPU	741.1 (257, 525.97)	511.81 (172, 515.97)	918.72 (119, 437.3)
Mobile ARPU	572.11 (191, 472.9)	418.52 (172, 448.39)	696.88 (95, 425.22)
GDP per capita in constant US $ in PPP	28372.11 (296, 34387.83)	8201.1 (228, 4861.25)	64983.88 (108, 33000.45)
Total population	1.42e+07 (337, 1.68e+07)	2.79e+07 (228, 2.43e+07)	6594841 (149, 7692863)

Notes. This table reports the variables' means. Number of observations and standard deviations are reported in parentheses respectively. Column (2) refers to country-year observations characterized by a level of GDP per capita in constant US$ in PPP lower than the sample mean. Column (3) refers to country-year observations characterized by a level of GDP per capita in constant US $ in PPP higher than the sample mean.

Table 4. Correlation matrix

	Fixed penetration	Mobile penetration	Fixed-lines	Mobile subscriptions	Fixed ARPU	Mobile ARPU	GDP per capita	Total population
Fixed Pentration	1.00							
Mobile penetration	0.43***	1.00						
Fixed-lines subscriptions	0.39***	0.0928*	1.00					
Mobile subscriptions	0.26***	0.47***	0.64***	1.00				
Fixed ARPU	0.08	0.05	-0.41***	-0.24***	1.00			
Mobile ARPU	0.04	-0.34***	-0.3***	-0.36***	0.34***	1.00		
GDP per capita in constant US $	0.68***	0.44***	-0.16**	-0.08	0.38***	0.23**	1.00	
Total population	-0.018	-0.09*	0.78***	0.49***	-0.61***	-0.3***	-0.4***	1.00

Notes. *** p<0.01, ** p<0.05 and * p<0.1

Table 5. System GMM estimation

	Specification (1) With year fixed effects		Specification (2) With time trend	
	(1)	(2)	(3)	(4)
VARIABLES	$q_{f_{it}}$	$q_{m_{it}}$	$q_{f_{it}}$	$q_{m_{it}}$
$q_{f_{it-1}}$	0.979***	---	0.917***	---
	(0.0193)	---	(0.0719)	---
$q_{m_{it-1}}$	---	0.830***	---	0.671***
	---	(0.0281)	---	(0.132)
$Price_{f_{it}}$	-0.0295	0.119	-0.0512	0.175
	(0.0193)	(0.0742)	(0.0376)	(0.124)
$Price_{m_{it}}$	0.0319*	-0.248**	0.0351**	-0.483*
	(0.0157)	(0.0872)	(0.0154)	(0.241)
$GDPPC_{it}$	0.0100	0.139***	0.0552	0.316*
	(0.0125)	(0.0360)	(0.0503)	(0.172)
$TotalPop_{it}$	0.0250	0.193***	0.1000	0.292**
	(0.0175)	(0.0448)	(0.0804)	(0.131)
Year dummies	Yes (-)***	Yes (+)***	---	---
	---	---	---	---
Trend	---	---	-0.00478	0.0803*
	---	---	(0.00437)	(0.0421)
Constant	1.362***	-1.603	-0.778	-1.881
	(0.269)	(1.223)	(0.737)	(2.272)
Observations	187	187	187	187
Number of countries	18	18	18	18
Hansen Test	1	1	1	1
AR(1)	0.140	0.138	0.184	0.0848
AR(2)	0.128	0.861	0.123	0.722

Notes. All regressions are estimated using system-GMM estimator. All variables are expressed in logarithms. All right hand-side variables were instrumented using two or more lags of themselves in the first-differenced equation, and their first-difference lagged once in the levels equation. Standard errors (in parentheses) are asymptotically robust to heteroskedasticity. AR (2) is a test for second-order serial correlation in the first-differenced residuals, under the null of no serial correlation. The Sargan statistic (Hansen Test) is a test of the overidentifying restrictions, under the null of instrument validity. *** p<0.01, ** p<0.05 and * p<0.1.

Table 6. Newey-West estimation

	(1)	(2)
VARIABLES	$\mathbf{q_{f_{it}}}$	$\mathbf{q_{m_{it}}}$
$\mathbf{q_{f_{it-1}}}$	0.903***	---
	(0.0632)	---
$\mathbf{q_{m_{it-1}}}$	---	0.669***
	---	(0.137)
$\mathbf{Price_{f_{it}}}$	-0.0572*	0.128
	(0.0303)	(0.0937)
$\mathbf{Price_{m_{it}}}$	0.0300*	-0.466**
	(0.0162)	(0.209)
$\mathbf{GDPPC_{it}}$	0.0546	0.338**
	(0.0423)	(0.168)
$\mathbf{TotalPop_{it}}$	0.104	0.310**
	(0.0689)	(0.126)
Trend	-0.00532	0.0855
	(0.00390)	(0.0522)
Constant	-0.565	-2.100
	(0.462)	(1.834)
Observations	187	187
Prob > F	0.0000	0.0000

Notes. All variables are expressed in logarithms. Robust standard errors (in parentheses). *** p<0.01, ** p<0.05 and * p<0.1.

Table 7. Computed short run and long run elasticities (Specification 1)

		Equation (1)	**Equation (2)**
		Fixed	**Mobile**
Short run	**Fixed**	NS	NS
	Mobile	0.032	-0.25
Long run	**Fixed**	NS	NS
	Mobile	1.52	-1.46

Notes. Author's calculation from Table 4, Column 1&2. NS stands for Non-Significant.

Appendix
Results without Turkey and Iran

Table 8. System GMM estimation

	Specification (1) With year fixed effects		**Specification (2) With time trend**	
	(1)	(2)	(3)	(4)
VARIABLES	$\mathbf{q_{f_{it}}}$	$\mathbf{q_{m_{it}}}$	$\mathbf{q_{f_{it}}}$	$\mathbf{q_{m_{it}}}$
$\mathbf{q_{f_{it-1}}}$	0.975***	---	0.980***	---
	(0.0205)	---	(0.0165)	---
$\mathbf{q_{m_{it-1}}}$	---	0.834***	---	0.869***
	---	(0.0269)	---	(0.0321)
$\mathbf{Price_{f_{it}}}$	-0.0104	0.0531	-0.0126	0.0287
	(0.0163)	(0.0334)	(0.0159)	(0.0498)
$\mathbf{Price_{m_{it}}}$	0.0392**	-0.277***	0.0431**	-0.248*
	(0.0152)	(0.0862)	(0.0152)	(0.131)
$\mathbf{GDPPC_{it}}$	0.00243	0.159***	0.00301	0.130**
	(0.0155)	(0.0377)	(0.0110)	(0.0553)
$\mathbf{TotalPop_{it}}$	0.0280	0.192***	0.0254	0.155***
	(0.0190)	(0.0308)	(0.0176)	(0.0376)
Year dummies	Yes	Yes	---	---
	---	---	---	---
Trend	---	---	0.000123	0.0108
	---	---	(0.00276)	(0.0127)
Constant	-0.239	-0.757	-0.279	-0.377
	(0.176)	(0.651)	(0.261)	(0.934)
Observations	158	158	158	158
Number of countries	16	16	16	16
Hansen Test	1	1	1	1
AR(1)	0.155	0.157	0.186	0.224
AR(2)	0.269	0.881	0.181	0.376

Notes. All regressions are estimated using system-GMM estimator. All variables are expressed in logarithms. All right hand-side variables were instrumented using two or more lags of themselves in the first-differenced equation, and their first-difference lagged once in the levels equation. Standard errors (in parentheses) are asymptotically robust to heteroskedasticity. AR (2) is a test for second-order serial correlation in the first-differenced residuals, under the null of no serial correlation. The Sargan statistic (Hansen Test) is a test of the overidentifying restrictions, under the null of instrument validity. *** p<0.01, ** p<0.05 and * p<0.1.

Table 9. Newey-West standard errors estimation

	(1)	(2)
VARIABLES	$\mathbf{q_{f_{it}}}$	$\mathbf{q_{m_{it}}}$
$\mathbf{q_{f_{it-1}}}$	0.969***	---
	(0.0186)	---
$\mathbf{q_{m_{it-1}}}$	---	0.868***
	---	(0.0473)
$\mathbf{Price_{f_{it}}}$	-0.0162	0.0358
	(0.0147)	(0.0666)
$\mathbf{Price_{m_{it}}}$	0.0442***	-0.250*
	(0.0164)	(0.141)
$\mathbf{GDPPC_{it}}$	0.00709	0.129*
	(0.0130)	(0.0713)
$\mathbf{TotalPop_{it}}$	0.0337*	0.158***
	(0.0190)	(0.0595)
Trend	0.000418	0.0114
	(0.00235)	(0.0129)
Constant	-0.283	-0.431
	(0.190)	(1.051)
Observations	158	158
Prob > F	0.0000	0.0000

Notes. All variables are expressed in logarithms. Robust standard errors (in parentheses). *** p<0.01, ** p<0.05 and * p<0.1.