Toward a wider market definition in broadband: The case of Turkey

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ABSTRACT

As broadband Internet transforms the way people connect with others, the boundaries between different modes of communications become vague. In recent years, the scope of voice and broadband markets has become a matter of concern for both policymakers and researchers. Until recently, it was thought that DSL and mobile broadband markets were separate markets and therefore they were separately regulated. However, recent empirical evidence in some countries shows that fixed and mobile broadband services are likely to be substitutes. If this is true, the definition of the relevant market for broadband has to be expanded to include mobile networks. This implies that they should be subject to the same regulatory framework. In order to follow this change, we look into the Turkish broadband market, as it is one of the fastest growing in Europe. The paper provides empirical evidence on the existence of fixed-mobile substitution in broadband Internet services in Turkey. We show that fixed and mobile broadband are substitutes in Turkey and they have to be included in the same relevant market definition. As differences between them in terms of speed, reliability and price diminish, customers increasingly see them as substitutes. These changes in the market environment require a reconsideration of the regulatory environment of fixed and mobile broadband markets.

1. Introduction

In recent years, broadband Internet transformed the way people connect with others. Mobile broadband service providers began to offer various services on a wide range of mobile devices such as cell phones and laptop computers. At the global scale mobile broadband subscriptions overtook fixed broadband in 2008 and have had a high growth rate since then. By 2016, mobile broadband is expected to occupy over 80 percent of the broadband market (ITU, 2013). In addition to data services, it provides a medium for voice and television services. These developments make the regulation of broadband the subject of intense debates over the appropriate method of regulation.

The changes on the supply and demand sides make regulatory issues more complicated for broadband markets. As consumers see them as substitutes, keeping mobile broadband and fixed broadband separate creates more issues than it resolves,. In the wake of increasing competition and the existence of similar services for similar prices, the definition of the relevant market becomes controversial. Until recently, DSL and mobile broadband markets were considered as distinct markets and regulated separately. Recent empirical evidence in some countries shows that fixed and mobile broadband services are likely to be substitutes (Srinuan et al., 2012; Grzybowski et al., 2013), and hence the relevant market for broadband should be expanded to include mobile networks. This implies that they should be subject to the same regulatory framework. The question of substitution has important implications in terms of regulatory policy. The existence of substitution may necessitate eliminating differences between fixed and mobile broadband access in terms of regulatory rules. More importantly, the expansion of the relevant market definition change channels of wealth transfers in the market.

In this paper we assess recent empirical studies about FMS in broadband Internet services and present estimations for Turkey. The Turkish broadband market is one of the fastest growing in Europe. In opposition to some of the earlier studies, we argue that the time is now ripe for deregulating fixed broadband markets in order to create a competitive environment where alternative

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methods of broadband can flourish.[1] We provide empirical evidence for fixed-mobile substitution in broadband Internet services in Turkey. We show by using the most recent data that fixed and mobile broadband are substitutes and they should be included in the same market definition. We also provide comparisons with the recent findings on FMS in broadband.

The remainder of the paper is organized as follows. In the second section we assess the literature on fixed-mobile substitution. The Turkish and European regulatory frameworks are outlined and compared in Section 3 to put FMS in perspective. The model and data are explained in the fourth section. Finally, Section 5 wraps up with concluding remarks.

2. Fixed-mobile substitution

In this section we review the literature on fixed-mobile substitution in broadband services. We first lay out the changes in the market structure and regulation in the broadband market along with theoretical background. Subsequently, we assess empirical studies on fixed-mobile substitution in the broadband market.

2.1. Market structure and regulation in the broadband market

The changes in technology and consumer preferences in recent years have opened the doors to a new interpretation of the market structure and regulatory environment in the telecommunications market. Previous studies have found that fixed-line and mobile broadband are substitutes (Cardona et al., 2009a,b; Srinuan et al., 2012).[2] In policy circles, regulators have started to discuss the idea whether they are in the same market (e.g., BEREC, 2011). New empirical evidence may bring a change in regulatory framework, as it would encourage the deregulation of the fixed-line broadband access at the wholesale level, as happened in Austria in recent years.

The changing market structure of broadband and the increasing number of choices to access Internet require a reconsideration of the logic of regulation in telecommunications. In the broadband market competition began with cable Internet services. Many countries now accept that cable and DSL are in the same market. The recent introduction of mobile broadband has considerably changed the market. The distance between mobile and fixed-line networks is closing very fast in terms of quality and price of the services. We expect the fixed-mobile substitution (FMS) in broadband to follow the same path as in FMS in voice services.[3] The similarity of the institutional evolution of both markets brings about convergence as well. The advances in VoIP technology also have played a major role in the evolution of intermodal broadband competition.

The rationale for regulation in the broadband market follows the natural monopoly theory in a number of slightly different forms. When broadband was limited to fixed-lines, regulation seemed easier. The required infrastructure to provide DSL services

necessitated full regulation of a natural monopoly. However, the emergence of intermodal competition has weakened the natural monopoly justification of regulation. As the market becomes more oligopolistic as a result of intermodal competition, unregulated oligopoly tends to be more efficient than a strictly regulated monopoly (Shelanski, 2006; Spulber and Yoo, 2009).

We observe that the regulatory view on FMS lags behind the change of seas in economic thinking. The 'wait and see' approach of regulatory agencies favors some operators against others in the fast-changing structure of the telecommunications markets. Recent interactions between the Austrian regulator and the European Commission reflect this approach (BEREC, 2011). The restriction on the competition between fixed-line and mobile operators opens doors to discriminations and anti-competitive consequences. An important consequence of these developments is the changing role of competition and regulation in telecommunications. The existence of FMS requires a new market definition in broadband services. A consequence of FMS is the possibility of deregulating broadband services (Briglauer et al., 2011). As a result, a shift from the regulatory framework to competition policy evolves around the world, somehow slowly and with social costs.

2.2. Review of empirical studies

FMS has been a hot issue in telecommunications markets for the last decade (ITU, 2013). While fixed broadband stalls and loses its importance, mobile broadband continues to grow. The direction of the trend is similar across countries. However, the transition to mobile networks is faster in the developing world as the fixed-line infrastructure is either nonexistent or very limited. In the developed world, fixed-line broadband services, even if they keep their market shares to some extent, begin to lose their high profit margins.

While the connection between fixed-line and mobile telephony services and deregulation of fixed-line telephony market are discussed in the literature to some extent (e.g., Vogelsang, 2010; Briglauer et al., 2011), broadband still remains an area to be explored. The trend in broadband follows the path of the voice market. The direction of empirical studies reflects a trend from complementarity toward substitution between retail mobile and fixed-line broadband services.

Fixed and mobile networks have become substitutes as a result of technological improvements of mobile services and increasing use of mobile networks in recent years (Rodini et al., 2003; Madden and Coble-Neal, 2004; Chu et al., 2009; Narayana, 2010; Vogelsang, 2010). FMS is most visible in telephone services. The substitution between fixed and mobile telephony is well established and a large literature on empirical tests of FMS in telephone services have emerged recently (e.g., Barth and Heimeshoff, 2012; Grzybowski, 2012). The move toward mobile culture and change in cross-elasticities, the fall in mobile network costs and advances in mobile technology play prominent roles in FMS (Briglauer et al., 2011; Heimeshoff, 2008; Yoon and Song, 2003). Income levels are sometimes used to explain the direction of the relationship. In developed countries fixed and mobile services tend to be substitutes whereas complementarity dominates in developing and less-developed countries (Garbacz and Thompson, 2007; Vogelsang, 2010). Similarly, as one country becomes wealthier, the move towards mobile-only consumers accelerates.

Whether households have fixed line broadband services makes an important difference in terms of the substitutability of mobile and fixed line voice services (Grzybowski and Verboven, 2013: 21). The relationship is symmetrical in the sense that if the person has mobile voice services the substitutability between fixed and mobile broadband is also strong. Bundle effects create a slippery slope

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[1] As a result, competition policy may take a more prominent role in telecommunications markets. While we do not deal with this issue in this paper, there is an extensive literature on the relationship between competition policy and regulation in telecommunications (e.g., Ardıyok and Oğuz, 2010; Hovenkamp, 2006; and Shelanski, 2006).

[2] The definition of 'substitute' seems quite clear in economics jargon. Positive cross-price elasticities are usually adequate. However, in a market where prices move in the same direction for some reason, further qualifications are necessary. For example, if the prices of fixed and mobile broadband fall at the same time, as it happened in recent times, cross-price elasticities should be approached warily (Banerjee, 2007).

[3] See Vogelsang (2010) for a survey of the fixed-mobile substitution in voice services.

toward the mode of communications which has stronger demand. As mobile voice take over fixed line voice services, FMS in broadband gets stronger as well.

However, FMS in broadband has attracted relatively less attention. One major reason is that mobile broadband is a recent phenomenon and hence not enough data are available for empirical analysis. However, it has been found in various studies that cable broadband has recently become a substitute for fixed broadband in the last few years. Studies on countries such as Austria, United Kingdom, Portugal, and Malta support FMS between cable and DSL in broadband (Srinuan et al., 2012). Vogelsang (2010: 15) argues that though there is a lack of empirical studies about FMS in broadband, it is a strong possibility and, hence, more empirical studies are needed. Substitution in the broadband services seems to be especially high for residential users. Business users usually prefer fixed broadband (Briglauer et al., 2011: 53–54). On the other hand, changing technology and consumer preferences along with the liberalization movements around the world push for a reconsideration of the traditional boundaries of residential broadband markets. Increasing demand for mobile communications pressures fixed-line services (Barth and Heimeshoff, 2012). Supply-side innovations bring the mobile and fixed services closer to each other.

FMS is important for regulatory issues as well. The empirical studies, using household-level survey data and discrete choice models, have provided evidence about FMS and discussed the market definition in the relevant countries' broadband markets. Among these studies, the earliest one by Cardona et al. (2009a,b) accepted the increased pressure from mobile on fixed broadband in Austria. However, they argue that it was still early to expand the broadband market to include mobile network. Srinuan et al. (2012) examined FMS in broadband in Sweden and found that there is FMS and fixed DSL and mobile broadband should be included in the same market as they are close substitutes. Finally, Grzybowski et al. (2013) find FMS in Slovakia and suggest that market definition for broadband should be revised to include mobile broadband (cited from Grzybowski and Verboven, 2013).[4]

Srinuan et al. (2012) provide a review of the literature on the substitution between narrow and broadband and also between various broadband services. In the case of the substitution between narrowband and broadband, dialup was found to be substitute for DSL in the US (Flamm and Chaudhuri, 2007) but the narrow-band ISDN service and DSL were found to be complements in the case of Greece (Yannelis et al., 2009). In the case of the substitution between broadband services, fixed broadband (copper and fiber) and cable TV is mostly taken granted (Crandall et al., 2002). Empirical studies usually find evidence for the substitution between DSL and cable, and hence DSL and cable are considered to be in the same market (e.g., Ida and Sakahira, 2008; Cardona et al., 2009a,b).

A major problem with empirical studies originates from data periods. In most studies there is at least a two-year period with the data and publication of the results. Beginning with Cardona et al. (2009a,b), this trend makes it harder to assess the magnitude of the substitution. For example, in a recent study, Wulf et al. (2013) finds no substitution between fixed and mobile broadband. They conclude that 'from a regulation perspective, the results suggest that on the overall OECD region level, wireless broadband and fixed broadband do not belong to the same market at the moment' (Wulf et al., 2013: 1461). However, their data end in 2009. The same is

true for other recent studies. Substitution has been particularly strong since 2011. Observational data shows that as prices fall and quality increases in mobile broadband the substitution accelerates. This is a drawback of econometric studies in markets where there is a rapid technological change. In these cases, observational data and basic microeconomic theory provides more insights toward understanding the change in the market structure.

The empirical literature also overemphasizes the distinction between past demand and potential demand. In other words, the role of potential competition in the market is discounted heavily and this preference encourages wealth transfers in the market from fixed networks to mobile networks. Increasing competition among cable, DSL, fiber and mobile broadband networks makes them substitutes. In this environment, technological barriers lose their importance and market variables such as price become more prevalent in consumers' choice between fixed and mobile broadband.[5]

3. An outline of the regulatory framework: EU and Turkey

In this section we explain the regulatory framework in Turkey by comparing it with the European Union. Since the Turkish regulatory agency follows the European regulations, we provide a short description of regulation in both Turkey and the European Union.

3.1. The European framework

This section provides a brief account of the EU position on broadband regulation. Member states in the EU follow the European Commission (EC) regulatory framework. This approach provides some uniformity in terms of market definitions. In the broadband market, cable and fiber are included, but regulators remain suspicious on the inclusion of mobile networks. The broadness of the market is the core of the identification of firms with significant market power. The inclusion of mobile broadband in the relevant market definition can make a big difference in terms of regulatory structure and the competitiveness in the market.

The main set of rules governing the EU telecommunications industry were enacted in 2002 in a number of directives (most notably, 2002/21/EC) and revised in 2009 (2009/140/EC Directive). The wholesale broadband access (WBA) market was defined as a potential candidate for ex ante regulation in the 2003 EC Recommendation on relevant markets. As a result, the wholesale broadband market became subject to continuous regulations in the EU and regulated tightly after 2003. ERG, in a common position paper, found that cable services should also be included in the WBA market (ERG, 2008). As a result of similar developments many countries,, both DSL and cable began to be seen as competitors in markets where both were present.

The EU regulatory framework on WBA follows 'the ladder of investment' approach.[6] The following requirements were introduced as a result:

- Obligation of access to, and use of, specific network facilities,
- Assurance of a certain level of quality of service,
- Publication of appropriate reference offers,
- Fair and coherent access pricing to create efficient incentives to invest avoiding margin squeeze.

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[5] The increasing importance of price is a major indicator of whether two goods are in the same market.

[6] The investment ladder approach fits well with the natural monopoly origins of the regulation of the fixed-line networks. Recent advances in mobile technology made the investment ladder approach ineffective in many countries, as operators prefer not to invest into fixed-line infrastructure after FMS.

On the policy side, practices by member states have been less than uniform. Issues such as the appropriate form of regulation were discussed extensively and mostly ended in disagreement. The crucial factor is usually the market definition. How the precise geographical and product market definitions are to be made? The answer to this question is mostly empirical and the dearth of data and analysis make it difficult to offer clear-cut answers.

While cable is readily included in the WBA market, the EC has resisted to adding mobile broadband to the list. Even after the Austrian decision to expand the market definition to include mobile broadband, the EU holds the view that the Austrian case is an exception and originates from the unique characteristics of the Austrian broadband market.

3.2. The regulatory framework in Turkey

The liberalization of the Turkish telecommunications industry has begun in the 1990s. A major step was the privatization of Turk Telekom, the state-owned telecommunications company in 2005.[7] Turk Telekom was the incumbent operator for fixed-line telephony services, incumbent Internet service provider and the incumbent cable TV operator. As a result of the functional separation, Turk Telekom retained fixed-line telephony services. New companies were established for Internet services (TTNET) and cable TV (Turksat).

The broadband access infrastructure belonged to Turk Telekom before the privatization and then transferred to TTNET. The market share of TTNET was over 80 percent in fixed-line broadband services until recent years. While legally separate entities, the Turkish competition authority and the national regulatory agency take them as one company in terms of their competition policies.

The Information and Communications Technologies Agency (ICTA), the national regulatory agency, regulates the broadband access market in Turkey. The ICTA is responsible to provide a competitive environment, settle interconnection and access issues, approve tariffs, and manage the spectrum and other duties defined in the Electronic Communications Act (ECA), enacted in 2008.

The ECA's fourth article states that competition is the rule and regulation is the exception. The necessity to regulate prices in the industry is tied to the significant market power in the market. If any of the operators are found to have significant market power (SMP), then a number of obligations are imposed to eliminate monopolistic behavior. The existence of monopoly power is satisfactory to impose obligations. As opposed to competition law, the abuse of dominant position is not required.

Following the EU regulations, the investment ladder approach was accepted by the ICTA to provide a competitive environment in the market. As a result, Turk Telekom, as the wholesale broadband access provider, was asked to open its infrastructure to competitors via the methods of resale, bit stream access and local-loop unbundling.

Market definition is the starting point of any regulatory analysis of SMP. The ECA requires market analysis in order to determine the existence of monopoly power. The major variable to determine SMP is the market share of the firm. In addition to high market share a number of other variables are also considered before a firm is identified as having SMP. Among these variables technological advantages, non-duplicability, countervailing buying power, scope and scale economies and some other factors are mentioned in the Turkish regulations.[8]

4. FMS in the Turkish access market

In this section we examine whether fixed and mobile broadband services are substitutes in Turkey and evaluate market definition. We first examine the recent developments in the market conditions in the broadband market in Turkey. Subsequently, we examine FMS in the Turkish broadband market using an econometric model.

4.1. The current situation in the Turkish broadband market

Turkey is an important case to see FMS in broadband because the numbers of both broadband Internet subscriptions, in general, and mobile Internet subscriptions have increased substantially. However, the growth rate of the number of mobile Internet subscriptions is much higher. To put this in perspective, Fig. 1 shows total number of subscriptions for broadband Internet and the number of subscriptions for mobile Internet separately. Both of these series are expressed in natural logarithm in order to see the rapid growth better. In Turkey, mobile Internet subscriptions increased by 62 percent in 2010, 47.9 percent in 2011, and 22.1 percent in 2012. The corresponding growth rates for fixed broadband Internet subscriptions are 0.4 percent, 0.2 percent, and 0 percent, respectively. The recent rapid growth of the mobile Internet subscriptions in the Turkish telecommunications market is more visible when compared to the European market in Fig. 2, which is drawn in a similar fashion as Fig. 1. While the trend for the total number of fixed broadband subscriptions has a flat shape for both Turkey and Europe, total mobile broadband subscriptions exhibit a secular increasing trend but much faster in Turkey.

Fig. 3 shows the substantial expansion in the Turkish retail broadband market expanded substantially in recent years (see Fig. 3). The number of broadband Internet subscribers reached 40 million in the third quarter of 2014 (ICTA, 2014). In other words, almost all of the total individual Internet users use broadband services. Around 75 percent of broadband users use broadband services from mobile phones and around 15 percent use xDSL (see Fig. 4).

According to the ICTA market statistics, the subscribers for broadband Internet have increased remarkably from only 18.6 thousand in 2003 to 1.6 million in 2005, 4.6 million in 2007, 6.0 million in 2008, and 14.3 million in 2010. However, Turkey's broadband growth rate fell behind the OECD area during the period up to 2010. In 2010, specifically, the growth rate of broadband services in Turkey was only 0.83 percent whereas the OECD average was 1.72 percent. When compared to major developing economies, Turkish broadband growth was considerably lower. For instance, according to OECD broadband statistics, the broadband capacity in
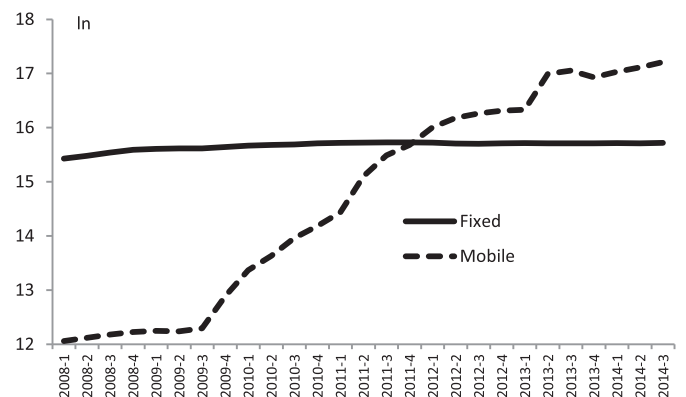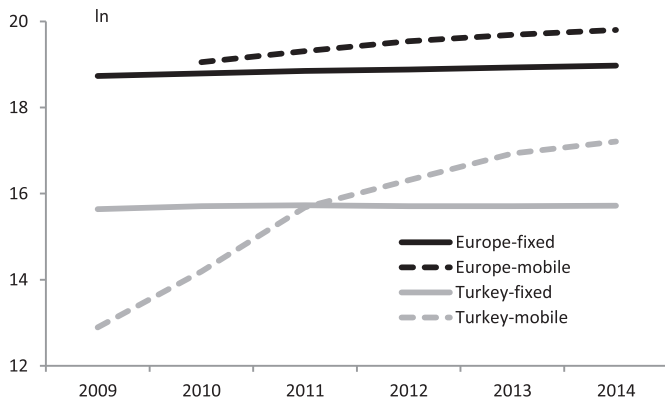

Fig. 1. Fixed-broadband and mobile-broadband subscriptions in Turkey (unit: natural logarithm). Source: ICTA market reports, various issues.

Note: The reported figures are end-year subscription numbers.
Source: ICTA market reports, ITU

Fig. 2. Fixed and mobile broadband Internet subscriptions in Turkey and Europe (unit: natural logarithm). Note: The reported figures are end-year subscription numbers. Source: ICTA market reports, ITU.
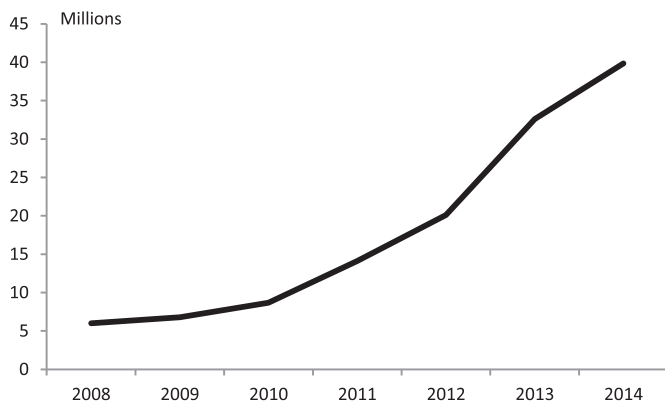

Fig. 3. The number of broadband subscribers in Turkey, 2008–2013. Source: ICTA market reports.

India grew remarkably by 62 percent in 2010.

Largest increases in broadband subscriptions were most visible after 2010. The number of subscriptions increased rapidly from 14.3 million in 2010 to 22.3 million in 2011, 27.6 million in 2012, 32.6 million in 2013 and 39.83 million in the third quarter of 2014 (ICTA, 2014). The average annual growth rate of broadband subscriptions during 2010–2014 is a remarkable 78 percent. Mobile
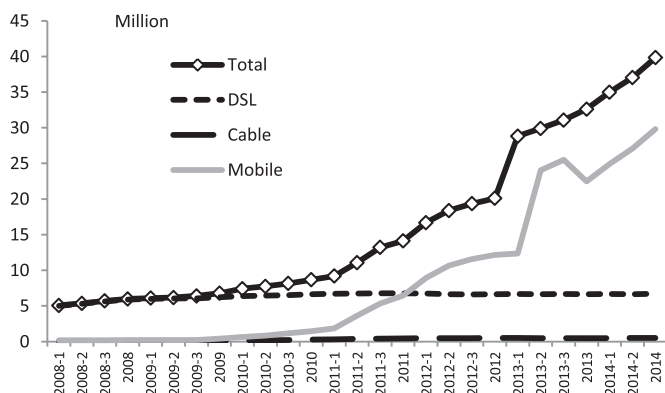

Fig. 4. Broadband subscriptions in Turkey by source. Data source: ICTA market reports.
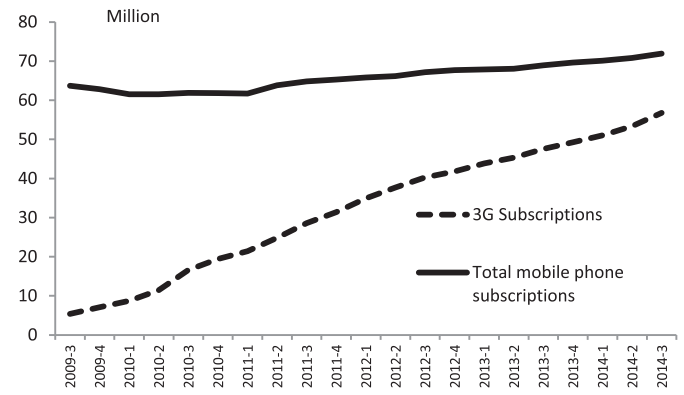

Fig. 5. Mobile phone and 3G subscriptions in Turkey. Data source: ICTA market reports.

broadband accounts for most of the recent growth in subscriptions after 2010 whereas the subscriptions of fixed-line xDSL (i.e., ADSL, G.SHDSL, and VDSL) subscriptions remained stagnant around 6.7 million after 2011. Turkey's relatively well-developed mobile network has a high penetration level and provides another means for broadband access. Wireless broadband has exhibited a significant expansion following the decision of the Turkish government to issue 3G licenses after 2008. This decision made the broadband market more attractive for investors. Since then, 3G mobile Internet services using data cards have grown rapidly, already reaching 15 million subscriptions in 2010 (see Fig. 5).[9] As a result, we conclude that mobile broadband has grown much more rapidly than fixed broadband services in Turkey (Telli, 2011). Other means of broadband services, such as cable and fiber, have relatively smaller shares in total subscriptions. However, despite the secular rising trend, the share of fiber in total subscriptions was only 3.4 percent in 2014.

The abovementioned statistics reflect the change of tides in the broadband market. There is a tendency of subscribers to switch to mobile broadband, as evident from the increasing use of smart phones and tablet computers. Mobile Internet has been adopted very rapidly and widely in Turkey. As of the end of 2013, 30 percent of mobile subscribers use 3G in Europe, while in Turkey the corresponding figure is around 60 percent. In 2013, mobile broadband was the most popular broadband platform. In addition, the penetration rate for mobile subscriptions was as high as 89.1 percent in 2012.

4.2. The model

The extent of substitution among services is widely used to describe the boundaries of the market (Carlton, 2007). In the broadband access market, the inclusion of mobile broadband is the most controversial issue. While fixed-line (copper and fiber lines) and cable Internet are widely accepted to be of the same market, mobile broadband is still treated as a different market by most regulatory agencies and in academic studies.

The national regulatory authority in Turkey holds this view as well. According to its market analysis (ICTA, 2013), mobile broadband is not included in the WBA market. This decision, however, is not based on an empirical study. The lack of empirical studies allows speculative assessments to take a primary role over market definition issues. Our study provides a first estimation for the Turkish telecommunications market. We develop a simple model to

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[9] ICTA (2014) reports that total 3G subscriptions reached 56 million in 2014.

examine whether fixed line broadband services are complements or substitutes to mobile broadband services. For this purpose, we adopt and modify the empirical model in Barth and Heimeshoff (2012). We estimate cross price elasticities to examine complementarity and substitutability relationships between fixed-line and mobile broadband services. To estimate the cross price elasticity, we assume, in accordance with the theory, that the amount of subscriptions of fixed-line broadband subscription (SUB_f) is a function of the price of mobile broadband services (P_m), the price of fixed-line broadband services (P_f), and a set of socio-demographic variables (X) as follows:

$$SUB_f = f\left(P_m, P_f, X\right) \tag{1}$$

Likewise, we assume that the amount of subscriptions of mobile broadband subscription (SUB_m) is a function of the price of mobile broadband services (P_m), the price of fixed-line broadband services (P_f), and a set of socio-demographic variables (X) as follows:

$$SUB_m = f\left(P_m, P_f, X\right) \tag{2}$$

The substitution relation between mobile and fixed-line broadband services is derived from the relation between P_m and SUB_f and between P_f and SUB_m.

The data on the number of broadband subscriptions are obtained from ICTA market reports which are available online. Prices of fixed broadband services are available from various issues of *OECD Communications Outlook* and *OECD Internet Economy Outlook*. Due to large amount of services offered, there are statistics for various prices. On the other hand, although service prices of different service types (e.g., 500 MB−1 GB, 1 GB−2 GB, unlimited, etc.) are available, the numbers of subscribers for different services or their shares in total are not available. Therefore, it is not possible to compute a weighted price for fixed broadband services. The number of subscribers is available only at the aggregate level. For this reason, we use the price of the most widely used type of subscription for fixed broadband, 4 GB data download limit and a speed of 1 MB per second. Prices of mobile broadband are available for each year from the relevant websites of the three service providers in the market. The data on subscriptions for each service providers are available from ICTA market reports. We use these data and calculate a weighted price for the most widely used type of subscription. All prices are then normalized by the specific price index for telecommunications services in the consumer price index published by the Turkish Statistical Institute.

Socio-demographic variables for the subscribers are not available from ICTA reports or the service providers. Therefore, we used the level of income (quarterly real GDP per capita) and total number of households in Turkey, which is available from by the Turkish Statistical Institute. To avoid a severe degrees of freedom problem, we are not able to include more demographic characteristics such as age and education composition of the population and the type and structure of households, all of which are available at annual frequency. On the other hand, such data can be included in the future when longer time series become available. Summary statistics of the variables used in the analysis are presented in Table 1.

Empirical studies examining FMS in broadband mostly use survey data as FMS is a recent phenomenon and there are not sufficiently long time series data for time series econometric analysis. Survey data allow researchers to estimate price elasticities. In similar other studies, researchers mostly employ monthly data. In the case of Turkey, ICTA publishes mobile broadband data

only at the quarterly frequency and they start from the first quarter of 2008. In this study we are bound by such data limitation.[10] We use quarterly data spanning the period from the first quarter of 2008 to the third quarter of 2014. Therefore, we have data for 27 quarters. We remind that the mobile broadband services started in Turkey only very recently in 2008.

Our sample with limited data for 27 quarters is not sufficient to run time series analysis as such an analysis will suffer from over-parameterization and low degrees of freedom. Therefore, we employ the Bayesian Vector Auto Regression (BVAR) method. We abstain from the technical details here as it can be found elsewhere (e.g., see Karlsson (2013) for a comprehensive review). BVAR uses the Bayesian approach to estimate a VAR and shrinks the number of parameters via restrictions on the model parameters using the priors. BVAR models require prior specifications for the distribution of the model parameters. We use the popular Minnesota random-walk priors developed by Doan et al. (1984).[11] Specifically, to use the BVAR language, we set the values of the required parameters in Minnesota prior using the conventional BVAR notation as follows: the AR(1) coefficient $\mu = 0$, the level of tightness $\lambda_1 = 0.10$, the cross variable weight $\lambda_2 = 0.99$, and the lag decay $\lambda_3 = 1$, and the initial residual covariance is based on univariate AR estimates.

Specifically, denoting the vector of endogenous variables in our VAR models as Y, our VAR model is as follows:

$$Y_t = \alpha + \sum_{i=1}^{p} \beta_i Y_{t-i} + u_t \tag{3}$$

where α is the constant term, u_t is the error term, and β_i are the coefficients to be estimated.

We use the first differences of the price, subscription amount, and socioeconomic variables in natural logarithm. All variables are seasonally adjusted. We specifically use two BVAR models. In Model 1, we examine FMS using equation (1). In the VAR model, we specify the endogenous variables as SUB_f, P_m, and P_f, and the socioeconomic variables X are set as exogenous. In Model 2, we examine FMS using equation (2). The endogenous variables in the VAR models are SUB_m, P_m, and P_f, and the socioeconomic variables X are exogenous.

To compute cross price elasticities, we use an indirect approach. We calculate the impulse response functions and use the accumulated responses. Specifically, to calculate the FMS from mobile broadband to fixed broadband in Model (1), we give one unit (one percent) shock to P_m and calculate the accumulated impulse response of SUB_f over the appropriate lag period. Similarly in Model (2), we give one unit (one percent) shock to P_f and calculate the accumulated impulse response of SUB_m.

4.3. Findings

To estimate the BVAR models, we first determine the appropriate lag lengths. We use Schwartz information criterion for this purpose. The lag length criteria suggests four lags, which is also supported by intuition.

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[10] On the other hand, ICTA has conducted a large-scale survey in 2013 with more than 3000 respondents and examined whether there is FMS in voice and broadband services. The details of this survey are available online: http://tk.gov.tr/kutuphane_ve_veribankasi/raporlar/arastirma_raporlari/dosyalar/sabitmobilikamesi.pdf (accessed March 29, 2014). However, these data are not available to the public and are not shared with the public. ICTA did not conduct an econometric analysis but rather relied on answers given to hypothetical questions about the respondents' intended responses to given changes in prices, as usual in such surveys.

[11] We run our analysis using Eviews v. 8.

Table 1
Descriptive statistics.

Variable	Mean	Median	Minimum	Maximum	Standard deviation
DSL subscribers	15.667	15.709	15.427	15.729	0.079
Mobil broadband subscribers	14.724	15.105	12.062	17.211	1.938
Price of DSL	3.144	3.219	2.916	3.319	0.131
Price of mobile broadband	3.378	3.230	3.139	3.907	0.256
Income	15.117	15.126	14.871	15.291	0.097
Number of households	16.620	16.618	16.592	16.644	0.018

Note: All variables are expressed in natural logarithm.

The BVAR model results are not reported since they are not of interest. We report the impulse responses of the variables of interest in Fig. 6. We use the impulse responses to indirectly derive the cross price elasticities. In Model 1, the dependent variable is the DSL fixed line subscribers (SUB_f) and to compute the cross price elasticity, we look at the response of SUB_f to unitary (1 percent) shock given to the price of mobile broadband services. We name this "Mobile to fixed" in Fig. 6. The results show that the response of fixed line subscriptions to the change in mobile broadband price is negligibly small, stabilizing around −0.007 percent after the fifth period. We evaluate this estimate of cross price elasticity very low. Therefore, there is no strong support for substitution relation from mobile broadband services to fixed DSL services.

In Model 2, the dependent variable is mobile broadband subscribers (SUB_m). The impulse response obtained from Model 2 named "Fixed to mobile" in Fig. 6 measures the response of mobile broadband subscriptions to unit change (1 percent) in the price of fixed DSL broadband services. The results show a strong substitution relationship from fixed broadband to mobile broadband DSL services in Turkey. The effect of 1 percent shock given to the price of fixed broadband stabilizes around 0.33 after four periods. Therefore, we conclude that mobile broadband is a substitute for fixed broadband services.

The empirical findings above point to a substitution relationship from DSL to mobile broadband but not the other way around. Therefore, we argue that the relevant market for broadband Internet in Turkey should be redefined accordingly to include mobile broadband market. This finding has further important implications for the policymakers and for the firms in the relevant markets. Our findings confirm the conclusion of the ICTA's above-mentioned survey in 2013 on fixed-mobile substitution in

broadband services, which was based on the respondents' answers to survey questions.

Following the findings of this study, an important issue to take into consideration is the relative cost of switching between fixed, cable, and mobile broadband services. These costs have been falling during recent years as demand and supply increase, and technology advances. In addition, the use of dongles and other technologies have reduced switching costs substantially. Customers do not see a difference in quality of service among different service providers. Young costumers are particularly more inclined to use mobile broadband as they do not have the historical connection with fixed broadband (Oğuz, 2013).

Another important issue to consider is the pricing of broadband services. In many countries, including Turkey, the prices of mobile broadband are comparable to fixed networks. Consumers are sensitive to price changes and tend to choose which service to use based on relative prices. The pressure from cable services in the past constrained the pricing of DSL considerably (Cardona et al., 2009a,b). A similar pressure is coming from mobile broadband especially after technological advances in mobile networks such as long-term evolution (LTE) and femtocell increased their quality and reduced the costs. Thus, mobile broadband becomes part of the same market with the cable and fixed-line broadband for the retail customer.

As mobile markets mature and operators recover their sunk costs, prices fall toward the levels of marginal cost. This also accelerates intermodal competition in broadband Internet. In the end, the bottleneck monopoly of fixed broadband infrastructure does not provide monopoly power to Turk Telekom, the fixed-line incumbent, to increase prices. In this environment, mobile operators try to keep fixed-line market tightly regulated by denying the existence of FMS. On the other hand, they try to reach fixed-line broadband customers by offering similar services with similar prices.

All mobile operators in Turkey compete with the fixed-line incumbent operator, TTNET. They offer services similar to TTNET and advertise as substitutes of TTNET services. To illustrate, Table 2 compares information about connection types and prices for fixed broadband services of TTNET and mobile broadband services of the three mobile broadband service providers, Avea, Turkcell, and Vodafone as of the end of 2014. Their services are priced similarly in terms of quotas, speed and prices.

5. Conclusions

In this paper we provide evidence in favor of FMS in broadband services and reiterate the need for a reconsideration of regulatory framework in broadband in Turkey. We showed that that fixed and mobile broadband services in Turkey are substitutes and the regulatory environment of the fixed and mobile broadband markets should be reconsidered. FMS in broadband is here to stay and a lesson learned from FMS in voice is such that consumers can change their preferences very quickly with respect to fixed and

Note: "Mobile to fixed" refers to the response of fixed broadband subscriptions to the price of mobile broadband. "Fixed to mobile" refers to the response of mobile broadband subscriptions to the price of fixed broadband.

Fig. 6. Impulse responses in BVAR models. Note: "Mobile to fixed" refers to the response of fixed broadband subscriptions to the price of mobile broadband. "Fixed to mobile" refers to the response of mobile broadband subscriptions to the price of fixed broadband.

Table 2
Selected broadband services offered by fixed and mobile broadband service providers (2014).

	Connection type	Speed (Mbps)	Monthly quota	Monthly price (TL)
TTNET − Fixed				
NET4	ADSL	Up to 8	4 GB	32
NET6	ADSL	Up to 8	6 GB	35
NET12	ADSL	Up to 8	12 GB	47
NET-Unlimited	ADSL	Up to 8	Unlimited	67
NET-Unlimited Plus	ADSL	Up to 8	Unlimited	97
8-Unlimited	ADSL	8	Unlimited	123
Ultranet6	ADSL	Up to 16	6 GB	39
Ultranet-Unlimited	ADSL	Up to 16	Unlimited	73
Hipernet4	VDSL2	Up to 24	4 GB	37
Hipernet6	VDSL2	Up to 24	6 GB	40
Hipernet12	VDSL2	Up to 24	12 GB	48
Hipernet	VDSL2	Up to 24	Unlimited	71
Hipernet	VDSL2	Up to 24	Unlimited	78
Hipernet	VDSL2	Up to 35	Unlimited	87
Hipernet	VDSL2	Up to 50	Unlimited	107
Hipernet	VDSL2	Up to 100	Unlimited	127
Turkcell − Mobile				
250 MB Pack	3G	Up to 43.2	250 MB	19
250 MB Pack	3G	Up to 7.2	250 MB	14
500 MB Pack	3G	Up to 43.2	500 MB	24
500 MB Pack	3G	Up to 7.2	500 MB	19
1 GB Pack	3G	Up to 43.2	1 GB	30
1 GB Pack	3G	Up to 7.2	1 GB	25
2 GB Pack	3G	Up to 43.2	2 GB	35
2 GB Pack	3G	Up to 7.2	2 GB	30
4 GB Pack	3G	Up to 43.2	4 GB	45
4 GB Pack	3G	Up to 7.2	4 GB	40
Vodafone − Mobile				
250 MB Pack	3G		250 MB	12
500 MB Pack	3G		250 MB	16
1 GB Pack	3G		1 GB	22
2 GB Pack	3G		2 GB	30
Avea − Mobile				
250 MB Pack	3G	Up to 43.2	250 MB	14
250 MB Pack	3G	Up to 7.2	250 MB	12
1 GB Pack	3G	Up to 43.2	1 GB	21
1 GB Pack	3G	Up to 7.2	1 GB	19
2 GB Pack	3G	Up to 43.2	2 GB	33
2 GB Pack	3G	Up to 7.2	2 GB	29
4 GB Pack	3G	Up to 43.2	4 GB	43
4 GB Pack	3G	Up to 7.2	4 GB	39

Source: Respective webpages of the service providers.

mobile services. Especially, the recent advances in smartphones and tablet computers institutionalize the use of mobile broadband. Substitution will follow naturally in the broadband access market.

The lack of studies estimating demand price elasticities for different types of broadband access is a major constraint to analyze FMS. It is noteworthy that the rapidly changing environment is not easy to capture with an econometric model, as it has a tendency to smooth out extreme changes. However, a lot has changed in broadband markets since the earliest studies such as Cardona et al. (2009a,b). The availability of 3G and 4G networks increased FMS. For most costumers the distinction between fixed and mobile networks has lost its relevance. More customer-oriented studies are needed to empirically show the situation in the market.

Given the intermodal substitution between fixed and mobile broadband services, asymmetric regulation of them is expected to reduce competition and consumer welfare in Turkey. More importantly, it creates a path for wealth transfers from fixed to mobile networks. While fixed broadband is tightly regulated, there is very limited regulation of mobile broadband. This approach was an extension of the investment-ladder model. As a consequence of FMS, the fixed broadband operator faces competition from the mobile operators. However, it cannot efficiently compete with them because of the tight regulation of the wholesale market.

An interesting comparison would be the rate of substitution between mobile broadband and DSL and the rate of substitution between cable/fiber and DSL. In some countries, the degree of substitution in the former might already be bigger than the latter. Since DSL and fiber/cable are easily accepted at the beginning in the same relevant market, this comparison may reflect the effect of perceptions over facts.

FMS is a recent phenomenon and we do not have a sufficiently long time series for statistical analysis of FMS and lack of sufficient data is a major constraint. We believe that the limited availability of data is a major obstacle. Econometric studies have a tendency to mitigate the effect of FMS, as they tend to average out extreme changes in recent times. In addition, if the customer-level data such as those from consumer surveys are made publicly available, more reliable estimations can be made. In particular, survey data make possible the use of discrete choice models such as logit and probit as in Srinuan et al. (2012).

Econometric findings in a fast-changing environment would also make it difficult to see a major policy issue. As in the case of FMS in voice services, regulators will not have the chance to adopt competitive policies proactively. It is well established that the existence of scientific evidence comes after FMS. This would create some social welfare costs, as the wealth transfers from asymmetric regulation would have already institutionalized the existing preferences. Fixed services will lose their ability to compete with

mobile networks. This may be a political preference. However, it should not be advocated based on economic efficiency.

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