

CHARACTERISTICS OF MOBILE COMMUNICATION DEMAND: THE CASE OF TURKEY

Mikail KAR*

MOBİL İLETİŞİM TALEBİNİN ÖZELLİKLERİ: TÜRKİYE ÖRNEĞİ

Abstract

In this study, different types of demand for mobile communications are discussed and price elasticity, income elasticity and cross-price elasticity of demand are analyzed for the case of Turkey. In the analysis, multiple linear regression approach is preferred and 68 quarterly time series between 2001 and 2017 are used. This study is the most comprehensive and up-to-date analysis of the Turkey Mobile Telecommunications Market and contributes to the empirical market analysis literature. The results obtained are as follows: The demand for access to network has (-1.4) price elasticity, (0.7) income elasticity and (-0.2) cross elasticity. The demand for network usage has (-0.2) price elasticity, (0.4) income elasticity and (0.4) cross elasticity. The demand for mobile diffusion has (-1.3) price elasticity, (0.6) income elasticity and (-0.2) cross elasticity.

Keywords: Mobile Communication Demand, Demand Elasticities, Access to Network, Network Usage, Diffusion Demand.

Öz

Bu çalışmada mobil iletişim için tanımlanan farklı talep tipleri tartışılarak talebin fiyat esnekliği, gelir esnekliği ve çapraz fiyat esnekliği Türkiye örneği için analiz edilmiştir. Çoklu doğrusal regresyon yaklaşımının tercih edildiği analizde 2001-2017 yılları arasındaki 68 çeyrek dönemlik zaman serileri kullanılmıştır. Bu çalışma, Türkiye Mobil Telekomünikasyon Piyasasının en kapsamlı ve güncel analizdir ve ampirik piyasa analizi literatürüne de katkı sağlamaktadır. Elde edilen sonuçlara göre talep esneklikleri talep türlerine göre şöyledir: Ağa katılma talebinin fiyat esnekliği (-1.4), gelir esnekliği (0.7) ve çapraz esneklik (-0.2)'dir. Ağı kullanma talebinin fiyat esnekliği (-0.2), gelir esnekliği (0.4) ve çapraz esneklik (0.4)'dür. Yayılma talebinin fiyat esnekliği (-1.3), gelir esnekliği (0.6) ve çapraz esneklik (-0.2)'dir.

Anahtar Kelimeler: Mobil İletişim Talebi, Talep Esneklikleri, Ağa Katılma, Ağı Kullanma, Yayılma Talebi.

* Dr. Arş. Gör., Bursa Uludağ Üniversitesi, İİBF, İktisat Bölümü, e-posta: mikailkar@uludag.edu.tr, <https://orcid.org/0000-0002-4036-7355>.

Makale Gönderim Tarihi: 01.04.2019 <https://dx.doi.org/10.11616/basbed.v19i47045.547585>

Makale Kabul Tarihi : 19.06.2019

1. Introduction

Elasticity, which has a very important place in demand structure analysis, refers to the sensitivity of an economic variable to change in another economic variable. The direction and degree of response of consumers to the changes in the factors that determine the demand direct the behavior of other actors in the market. The most important variables of consumer decision functions are price, income and related goods price. In case of a change in these factors, how demand will change is measured by price elasticity, income elasticity, and cross-price elasticity of demand. The price elasticity of demand is the percentage of change that the price change will create on demand. The income elasticity of demand is the percentage change of demand due to the change in consumer income. The cross-price elasticity of demand, also called cross-elasticity, is the percentage change that occurs in the demand of a good, with an increase in the price of another good associated with the good being analyzed. These elasticities, which are important determinants of the decisions that are effective in shaping the market structure, are among the most fundamental indicators of consumer behavior (Acemoglu et al., 2016: 105; Frank, 1991:112; McEachem, 1994: 70; McConnell et al., 1993: 122).

Telecommunications services meet the need for communication, and although demand has taken different forms, this demand has continuously increased over time. The demand for mobile telecommunications services also grew rapidly beyond expectations. This situation made the mobile telecommunications market one of the basic and strategic markets of economies. These markets, which directly or indirectly affect almost whole society, tend to develop by moving away from competitive structure with their unique characteristics. This situation provides important opportunities for operators. The regulatory authorities, however, also face many current and potential problems that need to be addressed and intervened. Operators are constantly developing new strategies with the effort to protect and increase their profits by evaluating the resulting opportunities. The regulatory authorities seek to produce policies to ensure and protect the productivity and efficiency of the market. These two actors of the market should carefully monitor and analyze consumer behaviors for success in the steps and decisions to be taken (Hausman and Ros, 2012: 38; Ahn and Lee, 1999: 297; Banerjee and Ros, 2004: 2; Madden and Neal, 2004: 519).

In mobile telecommunications markets, three types of demand can be mentioned: demand for access to network, demand for network usage and demand for mobile diffusion. In order to become a mobile subscriber of a

particular operator, the consumer bear a cost to participate in the operator's mobile network. Participation in the network makes the consumer accessible. However, another price needs to be paid to reach other people. Participation in the market by purchasing a line from an operator is defined as demand for access to network. The subscribers who have access to the network, bear a new cost to call and communicate with other subscribers and this is the demand for network usage. The demand for mobile diffusion is the redefinition of the demand for access to network by adding the country's population to the calculations. The ratio of the total number of mobile subscribers in the country's population is defined as the mobile penetration rate. This ratio shows the spread of access to mobile telecommunications network in a country. It is used as an important indicator in the analysis of mobile telecommunications markets as it incorporates the current and potential market size together in the calculations. Accordingly, the demand for access to network is measured by the total number of subscribers. The demand for network usage is measured by the monthly average call times (MoU) of mobile subscribers. Finally, the demand for mobile diffusion is measured by the mobile penetration rate (Waverman et al., 2016: 39; Dineen, 2000: 5; Hausman and Ros, 2012: 38; Hausman and Sidak, 2007: 387; Danaher, 2002: 119; Tishler et al., 2001: 1479; Ward and Woroch, 2009: 29; Grzybowski, 2004: 2).

In this study, the price, income and cross-price elasticities of demand for mobile communications in Turkey is estimated considering the above three types of demand with the help of 68 quarterly time series data between the years 2001 and 2017. This study is unique for the Turkish market by considering different types of demands when examining the demand characteristics of mobile communication in Turkey. In addition, it is the most comprehensive and up-to-date study analyzing the Turkish market by using the data from 2001 to 2017 and contributes to the literature by providing the analysis of Turkey Mobile Telecommunications Market. In the next part of the study, mobile communication services in Turkey is evaluated with the help of market data. Then a summary of empirical literature about demand analysis of mobile telecommunications markets is given. In the fourth part, the empirical analysis which prefers multiple linear regression (MLR) approach is performed and data, models, methods used and estimations are given. In the conclusion section, the information obtained from the estimation of three different models is evaluated by taking into consideration the market characteristics and expectations.

2. Mobile Communications in Turkey

In Turkey, mobile communications commenced in 1994, developed rapidly and prevailed in. Between the years 1994 and 2001 there were two operators (Turkcell and Telsim) providing service in Turkey's mobile telecommunications market. The number of operators increased to four (Turkcell, Telsim, Aria and Aycell) between the years 2001 and 2004 and after 2004 three operators (Turkcell, Telsim and Avea) continued to provide service. Vodafone bought Telsim in 2005 and serves on the market under the name "Vodafone" since then. Furthermore, Avea has been serving on the market with the "TT Mobil" brand since 2016. In other words, Turkcell, Vodafone and TT Mobile are the three operators currently provide mobile communication services in Turkey. In Turkey Mobile Telecommunications Market, the total number of subscribers reached 80.6 million and the penetration rate became 99.8% in the third quarter of 2018. 44.3% of the subscribers in the market use prepaid and 55.7% postpaid mobile communication services. 88.2% of these subscribers are individual and 11.8% are corporate subscribers. At the end of September 2018, the market share of operators in the market was 43.3% for Turkcell, 30.9% for Vodafone and 25.8% for TT Mobil. ARPU values, which represent the average revenue per user that operators get from for mobile communication, are 34,3 TL for Turkcell, 32,5 TL for Vodafone and 31 TL for TT Mobil in the third quarter of 2018. In this quarter, a total of 69 billion minutes of mobile traffic volume was realized in the market. Approximately 26 billion minutes of this mobile traffic was carried out by Turkcell subscribers, approximately 24 billion minutes by Vodafone subscribers and approximately 19 billion minutes by TT Mobil subscribers. As of September 2018, MoU values of subscribers showing monthly average mobile calls were 388 minutes for Turkcell, 493 minutes for Vodafone and 502 minutes for TT Mobil. Mobile subscribers made 50% of their calls in the network of the operator (on-net) they used. Approximately 46% of the calls were made out of the network to the subscribers of other operators (off-net) and approximately 4% of the calls to fixed line communication services (BTK, 2018: 58-78).

3. Empirical Literature

Studies addressing the demand characteristics of mobile communications started to take place in the literature in parallel with the spread of mobile communication. As one of the first studies, Hausman (1999) calculated the elasticity of demand for mobile communications in the United States. Using the number of subscribers as the quantity of demand, Hausman (1999) estimated the price elasticity of demand as (-0.50) and the income

elasticity of demand as 0.193 in the analysis made by the data between the years 1989 and 1993. Ingraham and Sidak (2004), who analyzed the same market using data for the years between 1999 and 2001, estimated the price elasticity of demand in the range between (-1.12) and (-1.29). Using data from 64 different countries, Ahn and Lee (1999) identified three different prices as a connection fee, monthly charge and a three-minute local call rate, and estimated the price elasticities of the demand, respectively as (-0.25), (-6.1) and (-30.62). Ahn and Lee (1999) calculated the income elasticity as (0.24). Okada and Hatta (1999) evaluated the first periods of Japan Mobile Telecommunications Market and calculated the price elasticity of demand for mobile communication as (-3.96) in the empirical analysis made with the data of years between 1992 and 1996.

Danaher (2002), who discussed the demand for mobile communications in New Zealand, estimated the price elasticity of the demand for access to network between (-0.06) to (-0.35) and the price elasticity of the demand for network usage between (-0.09) to (-0.71). Dewenter and Haucap (2004) took into account the Austrian market and predicted the price elasticity of demand with two different approaches: dynamic and static. In the study using monthly data belonging to the period between 1998 and 2002, the price elasticity of demand in the static model was calculated as (-0.56) and in the dynamic model as (-0.74). Rodini et al. (2002) estimated the price elasticity of mobile communications (-0.43) as a result of the US market survey for the years 2000 and 2001 and found that income elasticity decreased and approached to zero as income level decreased. Hazlett and Munoz (2009) analyzed the quarterly data for the 1999-2003 period of the country group consisting of 28 countries and calculated the price elasticity of the demand (-1.12). Hausman and Sidak (2007), who analyzed the U.K. and Ireland market, estimated the price elasticity of demand as (-0.84) and income elasticity of demand as (0.43). Growitsch et al. (2010) calculated the short-term and long-term price elasticities of the mobile communication demand respectively (-0.09) and (-0.60) by using the data between 2003 and 2008 of the 61 mobile service providers serving within the European Union. Hausman and Ros (2012) estimated the price elasticity of demand in the range between (-0.47) to (-0.59) and income elasticity (0.13) by analyzing the quarterly data for the 2004 and 2011 period from 17 different countries.

Haucap et al. (2010) looked at the initial developmental stages of the market and estimated the demand elasticities for the mobile communications market in Turkey using the monthly data between the years 2002 and 2006. Haucap et al. (2010) predicted the price elasticities

of demand separately for short and long term and considered network usage as the demand quantity. They obtained the price elasticity of the demand for using network in mobile communication for short-term (-0.27) and long-term (-0.45). In the study, the income elasticity of demand was obtained as (0.157) and the cross-price elasticity of the demand was found to be (0.26).

This study, it is separated from Haucap et al (2010) by taking into consideration different types of demands when examining the characteristics of mobile communication in Turkey. In addition, despite the Haucap et al (2010), which uses data from 2002-2006, this study is the most comprehensive and up-to-date study analyzing the Turkish Mobile Communication Market using data from 2001-2017 and contributes to the literature of market analysis with Turkey Mobile Communication Market analysis.

4. Empirical Analysis

This empirical analysis aims to estimate price, income and cross price elasticities of demand for mobile communication in Turkey by taking into account different demand definitions. For this purpose, MLR analysis is carried out by using 68 quarter-period time series from the first quarter of 2001 to the last quarter of 2017 and ordinary least squares (*OLS*) method is preferred in the estimations of three different models.

4.1. Data and Model

The models to be estimated in the analysis are based on the function (1) and this function is based on the adaptation of the function used by Taylor (1994: 241) for telecommunication demand to the mobile telecommunication markets.

$$Q_a = f(P_a, Y, P_b, X) \quad (1)$$

Here Q_a shows the quantity of demand, P_a service price, Y consumer income, P_b associated service price and X other variables. Based on this function, the following three different demand models will be estimated.

$$\text{Model I: } sub_t = arpu_t + gdp_t + farpu_t + con_t + u_t$$

$$\text{Model II: } mou_t = arpu_t + gdp_t + farpu_t + con_t + u_t \quad (2)$$

$$\text{Model III: } pen_t = arpu_t + gdp_t + farpu_t + con_t + u_t$$

In these models, sub_t shows the total number of subscribers, mou_t monthly average calling time per subscriber and pen_t mobile penetration

rate. sub_t , mou_t , and pen_t respectively represent demand for access to network, demand for network usage and demand for mobile diffusion. sub_t , mou_t , and pen_t are used following the study of Waverman et al. (2016: 20), Ward and Woroch (2009: 29), Hausman and Ros (2012: 23) and Dineen (2000: 5). The $arpu_t$ variable, which represents the average monthly revenue per subscriber on the market, is used as the price of mobile communications based on the studies of McCloughan and Lyons (2006: 70), Shi et al. (2006: 34) and Cho, et al. (2016: 11). The gdp_t variable, per capita gross domestic product in the country, is included in the model by considering McCloughan and Lyons (2006: 70), Hausman and Ros (2012: 25) and Dineen (2000: 5) as the consumer income. $farpu_t$ variable is used to represent the price of fixed line telephone services which is a related service of mobile communication service. This variable is the monthly revenue received per subscriber for fixed telephone services and is used in order to observe the cross-price elasticity in the study that is done by Ahn and Lee (1999: 302), Ward and Woroch (2009: 29). con_t variable which represents the market concentration is added to the model as a control variable considering the study of Lyons (2006: 12: 23), Hausman and Sidak (2007: 403). As a con_t variable, two values will be added separately to the model to make estimation. These values are the Herfindahl-Hirschman Index (HHI) which is square of the firms' shares in the market aggregated and the Concentration Ratio 1 ($CR1$) which is based on the market share of the largest firm in the market. In other words, three different estimations will be made for each model which are without control variable, with hhi_t variable and with $cr1_t$ variable. The monetary values in the series are all real values and since the main purpose of the study is to estimate the elasticities, the logarithmic transformation has been made for all variables. Details of the variables used in the study are shown in Table 1.

Table 1: Variable Definitions and Summary Statistics

<i>Variable</i>	<i>Source</i>	<i>Definition</i>	<i>Mea.</i>	<i>Std. D</i>	<i>Min</i>	<i>Max</i>
<i>sub_t</i>	BTK	Total number of mobile subscribers	1.700	0.198	1.213	1.892
<i>mou_t</i>	BTK	Monthly average calling time per subscriber	2.181	0.345	1.672	2.669
<i>pen_t</i>	BTK	The ratio of the total number of subscribers in the population	1.840	0.182	1.387	1.991
<i>arpu_t</i>	BTK	Average monthly revenue per subscriber	1.341	0.138	1.198	1.717
<i>gdp_t</i>	TCMB	Per capita GDP	4.211	0.091	3.995	4.380
<i>farpu_t</i>	BTK	ARPU of fixed line telephone services	1.355	0.121	1.154	1.667
<i>hhi_t</i>	BTK	Total square of the mobile operators' shares in the market	3.628	0.060	3.544	3.743
<i>cr1_t</i>	BTK	Market share of the largest firm in the market	1.747	0.060	1.640	1.833

As a result of the model estimates, the expectations for the coefficients in the models are as follows;

- The coefficient of the price variable (*arpu_t*), which shows the price elasticity of the demand, is expected to be negative (-) in accordance with the demand law.

- It is expected that the coefficient of income variable (*gdp_t*) showing income elasticity of demand will be positive (+) in accordance with normal goods.

- The coefficient of the price of fixed line service price (*farpu_t*) which indicates the cross price elasticity, can be obtained negative (-) or positive (+). If (-) comes out, there is a substitution relationship between the two services and if it is (+), then it will be interpreted as having a complementary relationship between the two services. Since three different demand quantities are defined, it is possible that this coefficient may differ between models.

4.2. Econometric Methodology

The three multiple linear regression (*MLR*) models proposed above will be estimated separately by the ordinary least squares (*OLS*) method. However, since time series are used, it is necessary to check the stationarity of the series before the estimation process is started. If the unit root is encountered in the series, it is necessary to ensure the stationarity of the series by taking the difference of the series. After

checking the stationarity of the series, the correlation matrix should be established and the degree of the relationship between the explanatory variables should be observed. A high level of correlation should be avoided. After the models are estimated, it should be tested whether the assumptions such as multicollinearity, heteroskedasticity and normality are ensured, whether the model is generally (F) and the coefficients separately (t) are statistically significant. Then, by looking at the adjusted R^2 value, it should be evaluated how successful the independent variables are in explaining the dependent variable. After all these steps, the coefficients obtained from the estimation can be interpreted. Here, the MLR model and the OLS method are briefly discussed with their features and assumptions.

Multiple Linear Regression (MLR): MLR is an important and powerful method to establish the interaction between a dependent variable like y_i and a series of explanatory variable like $x_i=(x_{i0}, x_{i1}, \dots, x_{iK})$. Its basic assumption is the fact that the relationship between the explanatory variables and the dependent variable is linear. As it is simple and useful, it is widely preferred in empirical analysis. MLR models are generally estimated using the OLS method. This method is based on minimizing the square differences between the observed values and the estimated values obtained from the model. When a number of basic assumptions are provided in the estimation of MLR models, the OLS estimator has statistical characteristics that yield highly successful results (Wooldridge, 2012: 168; Stock and Watson, 2015: 228; Cameron and Trivedi, 2005: 70; Stevens, 2009: 63; Osborne and Water, 2002: 3; Kennedy, 2008: 41).

The basic MLR model can be expressed as follows;

$$y_i = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \dots + \beta_k x_{ik} + u_i \quad i = 1, 2, 3, \dots, N \quad (3)$$

In model (3), y_i indicates the i^{th} observation of the dependent variable. x_{ik} is the i^{th} observation of the explanatory variable x_{ik} , x_k ($k=1, 2, \dots, K$). The β_0 constant term, the $\beta_1, \beta_2, \dots, \beta_k$ slope coefficients. Finally, u_i represents the i^{th} error term.

The matrix representation of the model makes it easier to understand. MLR model with k variable can be written with matrix notation as in equation (4);

$$y = X\beta + u \quad (4)$$

Here y represents dependent variable vector with $(N \times 1)$ dimensions. X indicates the explanatory variable matrix with $[N \times (K+1)]$ dimensions. β

is the slope parameters vector with $[(K + 1) \times 1]$ dimensions. u shows $(N \times 1)$ error vector.

The matrix number (4) can be written explicitly as follows;

$$\begin{matrix} \begin{bmatrix} y_1 \\ y_2 \\ y_3 \\ \vdots \\ y_N \end{bmatrix} \\ Nx1 \end{matrix} = \begin{matrix} \begin{bmatrix} 1 & x_{11} & \vdots & x_{1K} \\ 1 & x_{21} & \vdots & x_{2K} \\ 1 & x_{31} & \vdots & x_{3K} \\ \vdots & \vdots & \ddots & \vdots \\ 1 & x_{N1} & \vdots & x_{NK} \end{bmatrix} \\ Nx(K+1) \end{matrix} \begin{matrix} \begin{bmatrix} \beta_0 \\ \beta_1 \\ \beta_2 \\ \vdots \\ \beta_K \end{bmatrix} \\ (K+1)x1 \end{matrix} + \begin{matrix} \begin{bmatrix} u_1 \\ u_2 \\ u_3 \\ \vdots \\ u_N \end{bmatrix} \\ Nx1 \end{matrix} \tag{5}$$

The basic MLR model mentioned above can be estimated and β coefficients can be obtained by OLS method when the necessary assumptions are provided. These basic assumptions can be expressed in 5 different headings as follows.

Linearity: The most basic assumption of the MLR model is the existence of a linear relationship between the dependent variable (y) and the set of independent variables (x_i). In other words, the functional relationship between the dependent and explanatory variables is assumed to be linear in the parameters. According to this assumption, dependent and explanatory variables do not have to be linear as assumption is entirely related to coefficients.

Normality: Secondly, in the MLR model studies, it is assumed that the expected values of the error terms that represent the difference between the values of the observations and the values predicted by the model have a normal distribution. In other words, the expected value of the error terms is zero.

$$E(u_i | X_{1i}, X_{2i}, \dots, X_{ki}) = 0 \tag{6}$$

Independency: One of the most important assumptions while making estimations with MLR models is that the error terms are independent of each other. The terms u_i and u_j are independent from each other while $i \neq j$. Basically, this indicates that the value of an error term has no effect on the value of another error term. The violation of this assumption is known as autocorrelation.

$$Cov(u_i, u_j) = 0 \tag{7}$$

Homoscedasticity: The homoscedasticity assumption says that the variance of errors is equal and constant at each level of the variables. When the variance of errors changes in the different values of the independent variables, a heteroscedasticity occurs. According to this assumption, for each value of x_i , the variance of the error term (u_i) is a fixed number equal to σ^2 . This also means that the variance of y for each x_i value is constant.

$$\text{Var} (u_i | X_i) = \sigma^2 \tag{8}$$

Multicollinearity: It is assumed that in MLR models with many explanatory variables there is no linear relationship between these explanatory variables. Multicollinearity is the name of the situation when this assumption is not valid. The most ideal situation is to have no relation between independent variables, in other words the correlation value of independent variables by twos to be zero. However, this situation is very rare and up to certain levels relation between independent variables is acceptable. However, when this relationship is complete and almost complete, the OLS method is not used and it is impossible to calculate the parameters.

OLS method for estimating MLR models is a method that is frequently used and gives successful results. OLS is an approach that minimizes squares of differences in observed and estimated dependent variables. This approach can generally be expressed as in equality (9).

$$S(\beta) = \sum_{i=1}^N (y_i - x_i' \beta)^2 = (y - X \beta)' (y - X \beta) \rightarrow \min_{\beta} \tag{9}$$

β value resulting from OLS estimator;

$$\hat{\beta} = (X' X)^{-1} X' y \tag{10}$$

Considering the structure of the OLS estimator, the dependent variable is estimated by equation (11).

$$\hat{y}_i = x_i' \hat{\beta} \tag{11}$$

Error terms can be obtained with equation (12).

$$\hat{u}_i = y_i - x_i' \hat{\beta} \tag{12}$$

Various hypotheses can be tested after the MLR model is estimated. With the F test, the hypothesis H_0 is tested in which the dependent variable cannot be explained by independent variables and the model is not

generally statistically significant. The t test is used to test the statistical significance of the β parameters one by one showing the relationships between the dependent variable and the independent variables against the null hypothesis in which the related parameter is not significantly different from zero. The F test therefore tests whether the dependent variable is linearly dependent on all of the explanatory variables. Also the t test is used to test the relationships between independent variables and the dependent variable one by one.

4.3. Empirical Analysis Results

Since the time series are used, first of all the stationarity of the variables was tested by Dickey-Fuller unit root test. It tests the stationarity of the variables against the H_0 hypothesis established on the unit root content of the series.

Table 2: Dickey-Fuller Unit Root Test Results

	Variable:	Test Statistic	lag	Critical Value (%1)	p- value
<i>Level</i>	<i>sub_t</i>	-3.636	2	-2.918	0.005
	<i>mou_t</i>	0.359	2	-2.918	0.979
	<i>pen_t</i>	-3.179	2	-2.918	0.021
	<i>arpu_t</i>	-4.371	2	-2.918	0.000
	<i>gdp_t</i>	-0.543	2	-2.918	0.883
	<i>farpu_t</i>	-0.956	2	-2.918	0.769
	<i>hhi_t</i>	-1.199	2	-2.918	0.674
	<i>crI_t</i>	0.306	2	-2.918	0.977
<i>First Difference</i>	<i>mou_t</i>	-5.283	2	-2.919	0.000
	<i>gdp_t</i>	-17.783	2	-2.919	0.000
	<i>farpu_t</i>	-3.562	2	-2.919	0.006
	<i>hhi_t</i>	-4.415	2	-2.919	0.000
	<i>crI_t</i>	-3.797	2	-2.919	0.002

According to the results on Table 2, at 0.05 significance level the series *sub_t*, *pen_t*, and *arpu_t* are stationary at the level, in other words they are determined to be $I(0)$. It is observed that *mou_t*, *gdp_t*, *farpu_t*, *hhi_t* and *crI_t* series which contain unit root at the level, become stationary when their first difference is taken, therefore they are determined to be $I(1)$. After this stage, the stationary series at level are used in the same way as they are, and the series containing the unit root at the level are used after the first differences are taken.

After the stationarity of the series is maintained, the correlation matrix is established and it is ensured that there is not a high level of correlation between the explanatory variables. The correlation matrix is created and

the results are shown in Table 3. Since the correlation between the explanatory variables is the same in each model only the correlation matrix between the independent variables is shared in the Table 3. When the relations between explanatory variables are examined carefully, there is a very strong relationship only between hhi_t and crI_t series. As a matter of fact, these variables are an alternative to each other and will be included separately. In this respect, the high correlation between them is an indication of the correct selection of these two variables as alternative variables. Apart from that there is not any relation demonstrating high correlation level. However, after the model estimates are made, *VIF* (variance inflation factor) will be still calculated and multicollinearity will be tested.

Table 3: Correlation Matrix for Independent Variables

	$arpu_t$	gdp_t	$farpu_t$	hhi_t	crI_t
$arpu_t$	1.000				
gdp_t	0.185	1.000			
$farpu_t$	-0.205	0.192	1.000		
hhi_t	-0.167	0.154	0.186	1.000	
crI_t	0.136	0.157	0.090	0.888	1.000

Model I, which analyzes the demand for access to the network, is estimated in three different forms and the results are shown in Table 4. Before the results are interpreted, multicollinearity, heteroskedasticity and normality are checked and make sure whether the assumptions are fulfilled for each estimation. The assumptions of the analysis are fulfilled in all three estimates. When the results of demand for access to the network models are considered, for all three models the coefficients are both altogether (*F*) and individually (*t*) statistically significant at 0.05 significance level and also their signs are consistent with the economical expectations. According to the *adjusted R²* values, it can be said that the models used in all three estimations explain 93% of the demand for access to the network. The coefficient indicating the price elasticity of the demand is obtained (-1.4) in all three estimates. This means that an increase of 1% in price will reduce the demand for access to the network by 1.4%. The coefficient, which shows the income elasticity of demand, is obtained positive as expected and close to each other; (0.68), (0.72) and (0.71). In other words, 1% increase in income will increase the demand for access to the network by 0.7%. The coefficient indicating the cross-price elasticity of demand is obtained negative. This shows that there is a complementary relation between the demand for access to network in mobile telecommunications and fixed line telecommunication services. The coefficients indicating market concentration are obtained negative.

This shows that moving away from the competitive market structure discourage some consumers from subscription.

Table 4: Model I Estimation Results

		<i>sub_t</i>	<i>con_t</i>	<i>arpu_t</i>	<i>gdp_t</i>	<i>farpu_t</i>	<i>hhi_t</i>	<i>cr1_t</i>	<i>F</i>	<i>R²_{adj}</i>	<i>VIF</i>
<i>Model Ia</i>	<i>sub_t</i>	3.61 (0.00)	-1.43 (0.00)	0.68 (0.00)	-0.25 (0.03)	-----	-----	-----	296.67 (0.00)	0.930	1.10
<i>Model Ib</i>	<i>sub_t</i>	3.63 (0.00)	-1.45 (0.00)	0.72 (0.00)	-0.19 (0.04)	-2.75 (0.03)	-----	-----	237.05 (0.00)	0.934	1.12
<i>Model Ic</i>	<i>sub_t</i>	3.58 (0.00)	-1.41 (0.00)	0.71 (0.00)	-0.19 (0.04)	-----	-3.08 (0.01)	-----	245.40 (0.00)	0.936	1.10

Note: the values in () are probability (p) values.

Model II, which addresses the demand for network usage in mobile communication, is estimated in three different forms and the results are shown in Table 5. The assumptions of the analysis, multicollinearity, heteroskedasticity and normality are fulfilled in all three estimates. In the three versions of the model, the estimated coefficients are statistically significant both together (*F*) and individually (*t*) at the significance level of 0.05. Also their signs are in accordance with economic expectations. It can be said from the *R²* values that the explanatory variables explain more than 40% of the demand for network usage.

Table 5: Model II Estimation Results

		<i>mou_t</i>	<i>con_t</i>	<i>arpu_t</i>	<i>gdp_t</i>	<i>farpu_t</i>	<i>hhi_t</i>	<i>cr1_t</i>	<i>F</i>	<i>R²_{adj}</i>	<i>VIF</i>
<i>Model IIa</i>	<i>mou_t</i>	0.08 (0.05)	-0.26 (0.01)	0.40 (0.00)	0.37 (0.03)	-----	-----	-----	15.77 (0.00)	0.401	1.08
<i>Model IIb</i>	<i>mou_t</i>	0.04 (0.31)	-0.24 (0.02)	0.42 (0.00)	0.43 (0.04)	-1.60 (0.02)	-----	-----	13.97 (0.00)	0.440	1.08
<i>Model IIc</i>	<i>mou_t</i>	0.04 (0.30)	-0.26 (0.01)	0.42 (0.00)	0.40 (0.03)	-----	-1.43 (0.03)	-----	13.71 (0.00)	0.435	1.07

Note: the values in () are probability (p) values.

The coefficient, which shows the price elasticity of demand, is obtained (-0.2) in all three estimates. According to this coefficient which is suitable to the demand law, a 1% increase in price will reduce the demand for network usage by 0.2%. The coefficient showing the income elasticity of demand is also obtained compatible with the expectations and according to that a 1% increase in income will increase the demand of network usage in mobile communications approximately 0.4%. The coefficient indicating the cross-price elasticity of demand is obtained positive. This means that there is a substitute relationship between the demand for network usage in mobile communications and the demand for fixed line telecommunications services. The coefficients of *hhi_t* and *cr1_t* are shows that market concentration discourage consumers from usage.

The *Model III* which addresses the demand for diffusion and indicates the spread of mobile communication within the population, is estimated and the results are shown in Table 6. The estimated models fulfill the assumptions of multicollinearity, heteroskedasticity and normality. It is seen that the obtained coefficients are statistically significant both together (*F*) and individually (*t*) at the 0.05 significance level, also the signs are in line with the economic expectations. The independent variables that are preferred in the model explain more than 90% of the demand for diffusion. The coefficient, which indicates the price elasticity of the demand, means that a 1% increase in price will reduce the demand for diffusion by approximately 1.3%. According to the coefficient of income elasticity of demand, 1% increase in income will increase the demand for diffusion by 0.6% in all three estimates. If the demand for diffusion is taken into consideration, it is concluded that there is a complementary relation between the fixed line telecommunication service and mobile communication service as the coefficient for cross price elasticity of demand is negative. The coefficients indicating market concentration means that market concentration put off some consumers from consumption.

Table 6: Model III Estimation Results

	<i>pen_t</i>	<i>con_t</i>	<i>arpu_t</i>	<i>gdp_t</i>	<i>farpu_t</i>	<i>hhi_t</i>	<i>cr1_t</i>	<i>F</i>	<i>R²_{adj}</i>	<i>VIF</i>
<i>Model IIIa</i>	<i>pen_t</i>	3.57 (0.00)	-1.30 (0.00)	0.60 (0.00)	-0.24 (0.04)	-----	-----	208.08 (0.00)	0.904	1.10
<i>Model IIIb</i>	<i>pen_t</i>	3.59 (0.00)	-1.31 (0.00)	0.65 (0.00)	-0.18 (0.05)	-2.96 (0.03)	-----	166.52 (0.00)	0.909	1.12
<i>Model IIIc</i>	<i>pen_t</i>	3.54 (0.00)	-1.27 (0.00)	0.64 (0.00)	-0.18 (0.05)	-----	-3.09 (0.01)	169.63 (0.00)	0.910	1.10

Note: the values in () are probability (p) values.

The results obtained from the estimates can be evaluated considering the Haucap et al. (2010) results. If coefficients of price elasticity of demand compared with the results obtained in the study of Haucap et al. (2010) it can be said that the demand for mobile communications in Turkey became more elastic. It can be seen that the income elasticity of demand increased in time. In the study of Haucap et al. (2010:9-13), which is based on the network usage to represent the quantity of demand, the cross - price elasticity of the demand is obtained positive and a substitution relationship is found. On the other hand, in this study for the demand for access to network and demand for diffusion a complementary relationship found and for the demand for network usage a substitution relationship determined.

5. Conclusion

In this study different types of demand for mobile communications is discussed and the price elasticity, income elasticity and cross-price elasticity of demand is analyzed for the case of Turkey. Demand for access to network, demand for network usage and demand for mobile diffusion are estimated using the price, income and related service price series. In Turkey the mobile communications price elasticities of demand are obtained as follows: for access to network (-1.4), for network usage (-0.2) and for mobile diffusion (-1.3). That indicates while operators have a more elastic demand when getting subscribers, the subscribers' demand for network usage is relatively inelastic. If we look at the coefficients of income elasticity of demand, which reveal how the change in consumer income affects the demand for mobile communication, the income elasticity of the demand for access to network and diffusion is between (0.6) and (0.7) and the income elasticity of the demand for the network usage is approximately (0.4). That means according to the income elasticity of demand coefficient, mobile communications in Turkey is classified as a necessity good by the subscribers. The results obtained from the estimates of the cross-price elasticity coefficient of the demand indicating the relationship between fixed line communication service prices and the amount of mobile communication demand are noteworthy. When the demand for access to network and demand for diffusion is examined, it is seen that there is a complementary relationship between these two services, but when the demand for network usage is considered, the relationship is a substitution relationship. That suggests consumers can choose one of those two services to meet the need for communication, while the two services complement each other in terms of the growth of network and spread of it among the population. The coefficients indicating market concentration are obtained (-). This shows that moving away from the competitive market structure discourage some consumers from consumption.

The results are very important in terms of strategies to be developed and policies to be implemented. However, since the market is faced with a lot of state regulation as of the period analyzed, the study can be developed by structural break analysis which taking these regulations into account.

References

Acemoglu, D., Laibson, D. and List A. J. (2016), *Mikroekonomi*, Istanbul: Beta Basım Yayım.

- Ahn, H. and Lee, M. H. (1999), An Econometric Analysis of the Demand for Access to Mobile Telephone Networks, *Information Economics and Policy*, (11), p.297-305.
- Banerjee, A. and Ros, J. A. (2004), *Drivers of Demand Growth for Mobile Telecommunications Services: Evidence from International Panel Data*, Cambridge: National Economic Research Associates.
- BTK (2018), Türkiye Elektronik Haberleşme Sektörü Pazar Verileri Raporu, <https://www.btk.gov.tr/uploads/pages/pazar-verileri/2018-2ceyrekraporu.pdf> (13.01.2019)
- Cameron, A. C. and Pravin K. T. (2005), *Microeconometrics: Methods and Applications*, Cambridge: Cambridge University Press.
- Cho, D., Ferreira, P. and Telang, R. (2016), The Impact of Mobile Number Portability on Price, Competition and Consumer Welfare, SSRN: <https://ssrn.com/abstract=2265104>
- Danaher, P. (2002), Optimal Pricing of New Subscription Services: Analysis of a Market Experiment, *Marketing Science*, 21(2), p.119-138.
- Dewenter, R. and Haucap, J. (2004), Demand Elasticities for Mobile Telecommunications in Austria, *University of the Federal Armed Forces Hamburg Discussion Paper*, 33, p.49-63.
- Dineen, C. (2000), Demand Analysis and Penetration Forecasts for the Mobile Telephone Market in the U.K., *Telecommunications: The Bridge to Globalization in the Information Society, XIII Conferencia de la Sociedad Internacional de Telecomunicaciones (ITS)*, Buenos Aires – Argentina, 2 - 5 Julio.
- Frank, R. (1991), *Microeconomics and Behavior*, New York: McGraw-Hill, Inc.
- Growitsch, C., Marcus, J. S. and Wernick, C. (2010), The Effects of Lower Termination Rates (MTRs) on Retail Price and Demand, *Communications & Strategies*, 80(4thQ), p.119–140.
- Grzybowski, L. (2004), The Competitiveness of Mobile Telecommunications Industry Across the European Union, *Discussion Paper*, Munich Graduate School of Economics, July 2004.
- Haucap, J., Heimeshoff, U. and Karaçuka, M. (2010), Competition in the Turkish Mobile Telecommunications Market: Price Elasticities and Network Substitution, *Discussion Paper*, 12, p.1-23.

- Hausman, A. J. and Ros. A. J. (2012), Correcting the OECD's Erroneous Assessment of Telecommunications Competition in Mexico, *CPI Antitrust Chronicle, Competition Policy International*, June 2012.
- Hausman, A. and Sidak, G. (2007), Evaluating Market Power Using Competitive Benchmark Prices Rather Than the Hirschman-Herfindahl Index, *Antitrust Law Journal*, 74(2), p.387-407.
- Hausman, A. J. (1999), Cellular Telephone, New Products, and the CPI, *Journal of Business and Economic Statistics*, 17, p.288-194.
- Hazlett, W. T. and Munoz, E. R. (2009), A Welfare Analysis of Spectrum Allocation Policies, *RAND Journal of Economics*, 40(3), p.424-454.
- Ingraham, A. and Sidak, J. G. (2004), Do States Tax Wireless Services Inefficiently? Evidence on the Price Elasticity of Demand, *Mimeo, American Enterprise Institute for Public Policy Research*, 2004.
- Kennedy, P. (2008), *A Guide to Econometrics*, 6ed., Malden: Wiley-Blackwell.
- Lyons, S. (2006), Measuring the Benefits of Mobile Number Portability, *Working Paper*, Trinity College, Dublin.
- Madden, G. and Neal, G. C. (2004), Economic Determinants of Global Mobile Telephony Growth, *Information and Economics Policy*, 16, p.519-534.
- McCloughan, P. and Lyons, S. (2006), Accounting for ARPU: New Evidence from International Panel Data, *Telecommunications Policy*, 30(10-11), p.521-532.
- McConnell, C. and Stanley, L. B. (1993), *Microeconomics*, New York: McGraw-Hill Publishing Company.
- McEachem, W. A. (1994), *Economics*, Cincinnati, Ohio: South-Western Publishing Co.
- Okada, Y. and Hatta, K. (1999), The Interdependent Telecommunications Demand and Efficient Price Structure, *Journal of the Japanese and International Economies*, 13, p.311-355.
- Osborne, W. J. and Waters, E. (2002), Four Assumptions of Multiple Regression That Researchers Should Always Test, *Practical Assessment, Research & Evaluation*, 8(2), p.1-5.

- Rodini, M., Ward, M. R. and Woroch, G. (2002), Going Mobile: Substitutability Between Fixed and Mobile Access, *Telecommunications Policy*, (27), p.457-476.
- Shi, M., Chiang J. and Rhee, B. (2006), Price Competition with Reduced Consumer Switching Costs: The Case of 'Wireless Number Portability' In the Cellular Phone Industry, *Management Science*, 52(1), p.27–38.
- Stevens, P. J. (2009), *Applied Multivariate Statistics for The Social Sciences*, 5th ed., New York: Routledge.
- Stock, J. and Mark W. (2015), *Introduction to Econometrics*, 3rd ed., Pearson Addison-Wesley.
- Tabachnick, B. and Fidell, L. (2006), *Cleaning up Your Act Screening Data Prior to Analysis Using Multivariate Analysis*, 5th ed., Needham Heights, MA: Allyn & Bacon.
- Taylor, L. D. (1994), *Telecommunications Demand in Theory and Practice*, Dordrecht, Netherlands: Kluwer Academic Publishers.
- Tishler, A., Ventura R. and Watters, J. (2001), Cellular Telephones in The Israeli Market: The Demand, The Choice of Provider and Potential Revenues, *Applied Economics*, 33(11), p.1479-1492.
- Ward, M. R. and Woroch, G. (2009), The Effect of Prices on Fixed and Mobile Telephone Penetration: Using Price Subsidies as Natural Experiments, *Information Economics and Policy*, 22(1), p.18-32.
- Waverman, L., Dasgupta K., James, N. and Bethany, K. (2016), Consumer Surplus and The Impact of Competition for Telecommunications Services in Bahrain: An Empirical Study and Literature Review, *Public Version, Berkley Research Group*. <http://www.tra.org.bh/media/document/Consumer%20Surplus%20and%20the%20Impact%20of%20Competition-ENG1.pdf> (16.01.2019)
- Wooldridge, J. M. (2012), *Introductory Econometrics: A Modern Approach*, 5th edition, Mason, OH: South-Western Cengage Learning.

