Iranian Economic Review, Vol.15, No.26, Spring 2010

Economic Factors in Determining the Penetration Coefficient of Mobile Phone in Iran

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Abstract

In this paper we have studied the adoption rate of mobile phone in Iran via the new technology diffusion models approach. The result show that its diffusion pattern has a S shaped curve which is consistent with logistic model. Effective factors in diffusion pattern are: population, GDP, digitalization of the telecommunication system, government expenditures on the telecommunication sector, price of mobile phone and the inflation rate. We have also found that the logistic model has a batter explanatory power than the time series models.

Keywords: Mobile Phone, Diffusion, ARMA model, Logistic model.

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1- Introduction

From the late 1980's the use of the services of mobile- phone has had a rapid growth in Iran; with two consequences: 1) fast increase in procuring the capabilities like telecommunication industries and its infrastructures, 2) remarkable reductions in the price of the set and service of the mobile phone.

Usually theories concerning the diffusion of a new technology has one common point; and that is penetration and diffusion of new technology in the society in time has a S shaped curve. That means at the outset of the introduction of a new technology its penetration is slow, then it become slow. The time process of diffusion of a new technology itself is affected by diffusion of information. That is at the outset there are a few number of people who accept the new technology and know its advantages, they then will convey these advantages to the others persuading them to use the new technology. In the later stage because there are more people who have used the new technology, diffusion of information will be at a wider dimension and finally a limited number of people will remain to accept using this new technology.

The pioneer in economic studies in the area of diffusion of new technology was Grilichez (1957). After him there were quit a number research in this area, in order to see the review of the literature one can see Geroski (2000), Frank (2004), Meade and Islam (2006) The first inter-countries study of the penetration rate of mobile phone belongs to De Kimpe at al, (1998). They have divided the effective factors on the penetration rate of mobile phone into exogenous and endogenous factors, which is a developed model of Bass's model. Gruber and Verboven (2001) have shown that the penetration of mobile in the society has a S shaped curve in which economical, technical, cultural and social factors were important. Frank (2004) has utilized the logistic model to study the pattern of mobile phone. According to his study the effective factors in the penetration coefficient of mobile phone in Finland were digitalization of the telecommunication system, population, GDP, and land- phone. Lee, M. & Cha, Y, (2007) have studied the effect of mobile- phone for the S. Korea. They have also done some forecasting in that regard. According to their findings the logistic models predict the penetration coefficient better than time service model and the explanatory factors which were used in Frank's model are also effective in Korea.

In Iran the demand for mobile phone has been accelerated in recant years. The number of subscribed has been increased from 0.5 million in 1995 to 16.7 million in 2006. In this paper we have stuelied the trend of penetration of mobile phone and the effective factors for its penetration.

The S Shaped models have been compared with time service model in their forecasting power.

2- The Models

a) Compertz (1825) has introduced the diffusion pattern of new technology with the following equation:

$$Y_t = K e^{-\alpha e^{-\beta t}} \tag{1}$$

If we use equation (1) for mobile, we will have Y_t as the number of subscribed mobile phone in time t, which K, α and β are parameters. In the above equation $Y_t \in [o, K]$; when t moves from -∞ to +∞ Y_t goes from o to K. α and β will determine the position of the S shaped curve.

b) Grilichez (1957) has also introduced the following equation for a S shaped curve, which also has been used by Frank (2004) for studying the diffusion pattern of mobile phone.

$$Y_{(t)} = \frac{y^*}{1+e^{-(a+bt)}} = \frac{y^*}{1+k\,e^{-bt}} \tag{2}$$

Equation (2) is the logistic equation of the diffusion of new technology. $Y_{(t)}$ is the number of subscribed mobile phone in time t, and y^* which is a function of population is the optimal number of the recipients of mobile phone; b is the speed of diffusion of mobile phone in the society.

c) Along with logistic models, the autoregressive moving average models ARMA (p, q) have also been used for forecasting of diffusion of new technology. In these models P is the rank of auto regression and q is the moving average term. Auto regression model AR(p) is

$$Y_t = \mu + \gamma_1 y_{t-1} + \gamma_2 y_{t-2} + ... + \gamma_p y_{t-p} + \varepsilon_t$$

And moving average MA(q) is written as

$$Y_t = \mu + \varepsilon_t - \theta_1 \varepsilon_{t-1} - ..... - \theta_q \varepsilon_{t-q} \qquad (4)$$

The general model of ARMA (p,q) is the combination of (3) & (4):

$$Y_t = \mu + \gamma_1 y_{t-1} + ... + \gamma_p y_{t-p} + \varepsilon_t - \theta_1 \varepsilon_{t-1} - ...... - \theta_q \varepsilon_{t-q} \qquad (5)$$

One can find p and q by autocorrelation function (ACF) and partial autocorrelation function (PACF).

In this article we have utilized the Frank's model which can be explained as follows:

According to equation (2) we had:

$$Y_t = \frac{y_t^*}{1 + e^{-(a+bt)}} \qquad (6)$$

Where Y_t^* is the potential recipients of mobile phones; b, the relative growth rate of diffusion which varies in time. Y_t^* Can be defined as

$$Y_t^* = \gamma\, POP_t \qquad (7)$$

In (7), y^* is the total potential recipients of mobile phone and γ is the penetration coefficient in the society. Frank has defined b_t as the following relation:

$$b_t = \beta_a + \beta_g\, GDP_t + \beta_d\, DIG_t + \beta_T TEL_t \qquad (8)$$

In which GDP, DIG and TEL are gross domestic product, digitalization of telecommunication system and the number of land phones, respectively.

In our study we have modified (8) to (9)

$$b_t = \beta_\alpha + \beta_g GDP_t + \beta_d DIG_t + \beta_T TEL_t + \beta_f INF_t + \beta_p PS_t + \beta_{go} GOV_t + (q)\varepsilon_t \qquad (9)$$

INF is inflation rate; PS price of mobile phone and GOV is the government expenditures at telecommunication section.

The first derivative of (6) will give us the speed of diffusion of mobile phone, or the number new mobile phone at time t. The second derivative shows the change in the number of new mobile phones at time t. From equation (6) we have:

$$\frac{Y_t}{Y^*} = \frac{1}{1+e^{-(a+bt)}} \Rightarrow \frac{Y^*}{Y_t} = 1+e^{-(a+bt)}$$

Using equation (10) we get:

$$Y_t' = \frac{bY_t(Y^* - Y_t)}{Y^*}$$

$$Y_t'' = \frac{bY^* Y_t' - 2bY_t'}{Y^*}$$

One can substitute (7) and (9) in to (6) and use NLS estimation method.

3- Variables and Data

Digitalization of the telecommunication system of Iran started in 1989, after that, the penetration rate of land phone and mobile phone increased dramatically. This variable has been entered into equation (9) as a dummy variable which has the value of zero for the years 1986-1988 and one for the years after, Data of land phone and mobile phone and their prices were collected from Iran Telecommunication Company (ITC). Other data were collected from the Iran Statistic Centre and the Central Bank of Iran.

Stationarity of the data were checked with the Augmented Dicki Fuller test. The results are presented in table (1).

Table 1: Test of Stationarity of the Data

Variable	ADF Statistic	10% critical level
γ_t	-3.2	- 2.98
Pop	-3.05	-3.39
GDP	-3.74	-2.81
Tel	-4.51	-3.55
P_s	-3.07	-2.92
Inf	-5.01	-3.38
Gov	-4.46	-3.48

All the variables are stationary at α= 10%

4- Estimation of the Models

4-1- Logistic Model

In table (2) we have presented the results by using the Frank's logistic model. According to the table, β_T is negative, but not signification. Negative β_T means mobile phone is a substitute for land phone and positive β_T means that they are complement to each other.

The estimation for γ is 45% which gives the maximum penetration rate of the first operator which has been the subject of this study. The coefficient of GDP is positive, that is as income improves diffusion of mobile phone increases. The coefficient of DIG is consistent with the theory; improvement and penetration of digitalization in the telecommunication system makes the expansion of mobile phone more possible. The price of mobile phone has had a negative effected on its diffusion. As the government expenditures on the telecommunication goes up, so does the diffusion of mobile phone. Finally inflation has had a negative effect.

Table 2: The Results of the Estimation of Logistic Model with NLS Method

Coefficient	Estimate	t		
a	-20.2	-2.56		
β_a	1.98	3.482		
β_y	0.967	4.829		
β_d	0.8173	3.012		
β_T	-0.00173	-0.00026		
γ	0.45	3.0097		
β_{inf}	-0.86	-3.23		
β_p	-0.92	-2.95		
β_{go}	0.78	3.028		
R^2=0.72	$\overline{R}^2 = 0.65$	D.w = 1.82	N= 20	F= 7.28

4-2- ARMA Model

By using ACF and PACF the rank of AR was found to be P= 2; and the rank of MA, q= 1.

$$Y_t = \mu + \gamma_1 Y_{t-1} + \gamma_2 Y_{t-2} + \varepsilon_t - \theta_1 \varepsilon_{t-1} \tag{13}$$

The results of the estimation of equation (13) are presented in table (3):

Table 3: The Results of the Estimation of E q. (2)

Variable	Coefficient	SE	t
γ_1	1.4597	0.3805	6.24
γ_2	-0.54162	0.28376	-1.42
μ	82656.1	21814.3	4.06
θ_1	0.6478	0.54713	1.45
R^2=0.62	$\bar{R}^2 = 0.58$	D.w = 2.01	

As can be seen from table (3) the variables in ARMA (2, 1) are significant and we can say the autocorrelation moving average model along with Frank's logistic model are good predictors.

4-3- Comparison of Logistic and ARMA Models

In figure (1) we have drawn the ARMA and logistic models. The cumulative number of mobile phones are on the vertical axis. The logistic model has a S shape and the ARMA model oscillates. According to the literature the diffusion of new technology has a S shaped curve, which in our case the logistic model is a better fit.

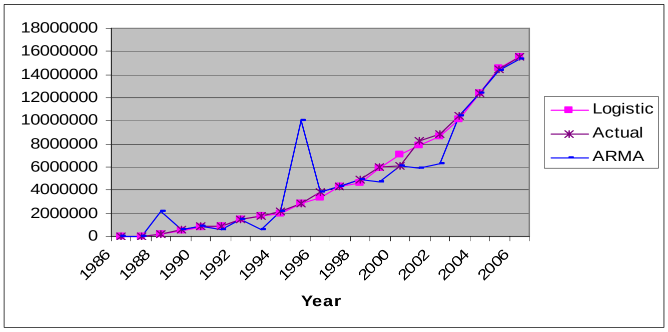

Fig 1: Comparison of Logistic, ARMA with Actual DATA

In table (4) the perdition power of these two models with the residual sum of square (RSS) and mean square of errors (MSE) criteria are shown. According to table 4 the logistic model can predict diffusion of mobile phone in Iran better than ARMA model.

Table 4: Compassion of Logistic and ARMA Models in Terms RSS and MSE

Criteria	Logistic Model	ARMA Model
RSS	6.42 E +09	5.43E + 11
MSE	1.86 E + 07	1.89 E+ 07

5- Summary and Conclusion

The literatures on the diffusion of new technology models have shown that the pattern of diffusion through time has a S shaped curve. By using these models it can be shown that at each point in time how much is the penetration coefficient, and consequently what should be the proper policy.

We have considered mobile phone as a new technology to Iranian society and have seen that its pattern of diffusion has had a S shaped curve. According to our finding GDP, digitalization of the telecommunication system, population, government expenditures on telecommunication sector have had positive effects on the diffusion of mobile phone in Iran, while its price and inflation have had a negative effect.

Comparing logistic model with time series model shows that the logistic model explains the role of effective factor in the penetration of mobile phone and also will give us a better predication than the time service model.

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