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RESEARCH ARTICLE

The dynamics over the next few years of the Spanish mobile telecommunications market share: A mathematical modelling approach

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Taking into account available data from 2002–2009 about the market share percentages of the Spanish mobile telecommunications service providers, a dynamic diffusion model to study the evolution of the clients' change between the different companies during the period 2010–2016 is proposed. The constructed model provides a tool for forecasting short-term trends about the customers' preferences with respect to mobile network operators taking into account both, autonomous decisions due to direct marketing and advertising strategies, and also decisions adopted through interaction via social influence. The model can provide insights to companies for designing strategies in order to gain market share.

1. Introduction

Currently new technologies and especially the mobile telecommunications industry have become of interest due to the influence of direct and interactive environment: social networking, mobile payments, mobile marketing, mobile business, electronic and digital marketing, etc. According to [1], there is a worldwide explosion in the use of hand-held electronic communication devices such as mobile phones, digital music players and, hand-held Internet access devices. Certainly, daily activities like bank payments, updating your personal agenda, notification of discounts or promotions about items or offers, etc., are currently carried out by mobile devices. As a result, the number of subscriptions to mobile telecommunications services has grown worldwide at a compounded annual rate of 24% during the period 2000–

2008 with the number of mobile subscribers reaching 4 billion in December 2008 (International Telecommunication Union 2008) [2].

The mobile telecommunications market is characterised by a series of features among which are: high growth, importance of regulatory design in setting market structure, oligopolistic competition and rapid technological change or innovation [3]. Telecommunication services have existed as a legal monopoly nearly throughout its history. In 1998, telecom market liberalization was achieved across the EU (European Union) through the introduction of competition among telephone services. The process culminated in 2002 with the passing of four directives and a decision (the so-called *Telecom package* [4]), thereby establishing a new regulatory framework for the EU. Asymmetrical obligations were deemed necessary in order to compensate the market power of the former monopolist. Therefore the SMP (Significant Market Power) operators were imposed to provide access to its networks at reasonable prices and to all operators which demanded it. Since then and as a consequence of aggressive strategies and marketing campaigns, migrations of customers from one company to another have taken place over the last few years. Thus, the vast majority of mobile telecommunications service providers are very interested in predicting the evolution of these migrations over time since it would allow them to adopt successful strategies in order to retain the current customers and to attract new ones.

In Spain, the liberalisation process began in 1987 and it was completed by opening fixed telephony up to competition; this service was the cornerstone of the market in 1998 generated approximately 60% of the sectors revenues. Despite these efforts towards liberalisation, Telefonica de España (Telefonica) the former monopolist as the sole operator with 12 million clients, was able to use its de-facto monopoly position to deter any would-be competitors. Thus, the Spanish scenario can be considered a special case since the liberalisation of the telecommunication market consisted in the substitution of a legal monopoly by a regulated market, with a strong significant market power of the incumbent operator.

According to experts, a relevant feature that has promoted the change of mobile telecommunications service providers between Spanish customers has been the approval of the mobile number portability. MNP (Mobile number portability) is a process which enables mobile telephone users to keep their mobile telephone numbers when changing from one mobile network operator/provider to another. The international and European standard is for a customer wishing to port his/her number to contact the new provider (recipient) who will then arrange necessary process with the old provider (donor). This new regulation came into force in the year 2000 and it has encouraged the transfer of many customers from traditional mobile telecommunications service providers to the new providers. Specifically, from year 2000 until April 2007, over 9 million customers have changed their mobile operator. This represents the largest amount in the EU. Even more so, this trend increased at the end of this period, and 3,957,556 mobile lines, changed operator which represents 10% of the total [4].

2. Methods

Mathematical models are powerful tools to explain and predict the process of adoption of a new product or innovation over time and to attract new ones [5–8]. In this case, taking into account official data from CMT (Spanish Telecommunications Market Commission) [4], the Spanish mobile telecommunications market is divided into five main groups: Movistar–Telefonica, Vodafone, Orange, Yoigo and MVO (others Mobile Virtual Operators). The users of the mobile telecommunications

services can be classified into two main groups: the one (individuals) who make the decision to contract the service of a mobile telecommunications service provider because of advertising or marketing strategies through the media or other external factors regardless of the decision of others (imitators), and the other customers who will only contract the services of some telecommunications mobile companies due to the social interaction with satisfied customers and the influence by loyal customers, who contribute to service quality through their roles as promoters of the firm [9]. The effect of both, the individual and imitators in the market, is going to be taken into account in the modelling process which is going to be presented in this paper.

This paper provides a model to study the evolution dynamics of customers's change between the five main Spanish mobile telecommunications services providers previously annotated, over the next few years. This model is based on a nonlinear system of differential equations. It provides a tool for forecasting short-term trends about the customers' preferences with respect to mobile service providers taking into account both, autonomous decision, and also decisions adopted via social influence. Also, the model may provide insights to companies for designing strategies in order to gain market share.

2.1. *Mobile telecommunications services dynamic diffusion model*

In this study, the official data available from the CMT about the market share of the Spanish mobile telecommunications market during the period 2002–2009 [4] were considered. These data, classified by mobile telecommunications service providers, are shown in Table 1.

Table 1. Market share (%) of the Spanish mobile telecommunications market during 2002–2009. Companies like Yoigo and other Mobile Virtual Operators (MVO) entered the market in 2007.

Years	Movistar–Telefonica	Vodafone	Orange	Yoigo	MVO
2002	54.9	25.8	19.3	0.0	0.0
2003	52.8	25.3	21.9	0.0	0.0
2004	49.1	26.9	24.0	0.0	0.0
2005	46.6	29.3	24.1	0.0	0.0
2006	45.7	30.0	24.3	0.0	0.0
2007	45.1	30.5	22.5	0.9	1.0
2008	45.0	30.6	20.7	2.0	1.7
2009	43.6	30.4	20.4	2.5	3.1

Thus, a dynamic model to study the evolution of the market share of the Spanish mobile telecommunications market over the next few years will be built. First, let us define

- $T_1(t)$, the percentage of market share of the company Movistar–Telefonica, at time t.
- $T_2(t)$, the percentage of market share of Vodafone, at time t.
- $T_3(t)$, the percentage of market share of Orange, at time t.
- $T_4(t)$, the percentage of market share of Yoigo, at time t.
- $T_5(t)$, the percentage of market share of MVO, at time t.

Time variable t is measured in years. As it has been previously commented in the Introduction, the users of the mobile telecommunications services can be distinguished in two main groups: the individuals and the imitators. The individuals make decisions to contract the services of a mobile telecommunications provider because of advertising or marketing strategies through the media or other external factors regardless of the decision of others. The imitators will only contract the

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services of some telecommunications mobile providers due to the social interaction and influence by loyal customers of other companies. In connection with this, it should be pointed out that some mobile telecommunications service providers have already incorporated incentive marketing strategies addressed to loyal customers rewarding their loyalty and actions as promoters.

According to [4], it is assumed the vast majority of the population in Spain is a customer of one of the mentioned mobile telecommunications operators. Thus, the migration of customers among the companies is driven by one of two facts: 1) the individual personal decision or 2) imitation processes. This will be modelled by means of certain coefficients to be introduced in the following:

- The individual coefficients, A_1 for Movistar–Telefonica, A_2 for Vodafone, A_3 for Orange, A_4 for Yoigo and A_5 for MVO, measure the direct effect of marketing and advertising strategies on the customers of other companies and the means of gaining these customers. For instance, the means of gaining customers of Movistar from Vodafone is modelled by the linear term $A_1 T_2(t)$. Therefore, A_1 can be interpreted as the rate of gaining customers of Movistar from other companies due to advertising and direct marketing campaigns. An analogous interpretation can be made for $A_2, \ldots, A_5$. Hereinafter, A_i, $1 \le i \le 5$, will be referred to as direct marketing or advertising parameters.
- The imitation coefficients represent the persuasion effect of loyal customers satisfied with their providers and these are the best promoters when gaining customers from other companies. For instance, the peer-pressure of Movistar promoters on the customers of Vodafone can be modelled by the nonlinear term $\beta_{21} T_1(t) T_2(t)$. Therefore, β_{21} represents the migration rate of the customers from Vodafone to Movistar by interaction between Vodafone customers with Movistar promoters. An analogous interpretation can be made for β_{ij}, $1 \le i, j \le 5$, $i \ne j$ that in the following will be referred to as persuasion or peer-pressure parameters. It should be taken into account that the social mechanisms for which customers of one company persuade customers of other companies to migrate from the former company are all embedded in the parameters β_{ij}.

Under the above assumptions, a dynamic model for the market share of the Spanish mobile telecommunications market is introduced in (1). Figure 1 shows a graphical representation of this model.

$$
\begin{aligned}
T_i'(t) = A_i \sum_{j=1,j\ne i}^{5} T_j(t) + T_i(t) \sum_{j=1,j\ne i}^{5} \beta_{ji} T_j(t) \\
- T_i(t) \left(\sum_{j=1,j\ne i}^{5} A_j + \sum_{j=1,j\ne i}^{5} \beta_{ij} T_j(t) \right), \quad 1 \le i \le 5.
\end{aligned}
\tag{1}
$$

3.   Results

3.1.   *Model fitting*

The goal of this subsection is to find out the best values of direct marketing or advertising A_i, $i = 1, \ldots, 5$, and persuasion or peer-pressure parameters $\beta_{i,j}$, $i, j = 1, \ldots, 5$, $i \ne j$, in order to fit the model with the data. Taking into account data from Table 1 corresponding to the market share percentage of the Spanish mobile
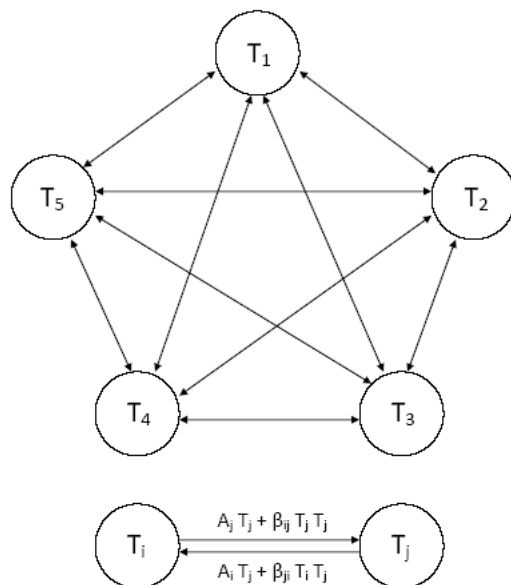
Figure 1. Diagram of the compartmental dynamic model for the Spanish mobile telecommunications market (1). T_1, T_2, T_3, T_4 and T_5 denote the percentage of market share of the companies Movistar–Telefonica, Vodafone, Orange, Yoigo and MVO at time t, respectively. The arrows represent the customer (autonomous or imitation) migration between companies.

telecommunications service providers during the period 2002–2009, the data were fitted according to the model (1). The data corresponding to year 2002 have been taken as the initial conditions of this model. In order to compute the best fitting in the least square sense, *Mathematica* software was used to carry out computations [10]. Thus, the nonnegative values of A_i, β_{ij} with $1 \leq i, j \leq 5$, $i \neq j$, given in Tables 2 and 3, where obtained respectively. Figure 2 shows the fitting of model (1) to the data from Table 1.

Table 2. Values of the direct marketing or advertising parameters A_i, $i = 1, \ldots, 5$ obtained by fitting the model (1) to the data from Table 1.

$\mathbf{A_1}$	$\mathbf{A_2}$	$\mathbf{A_3}$	$\mathbf{A_4}$	$\mathbf{A_5}$
0.0907692	0.0761403	0.0626275	0.0165038	0.00660914

The results for the parameters of direct marketing or advertising A_i provide crucial information about the effectiveness of direct marketing or advertising strategies of these companies. From Table 2, it should be noticed that big companies have associated greater direct marketing and advertising coefficients which entails more effective marketing strategies. In the case-study, the obtained direct marketing and advertising parameters can be explained by their greater ability in advertising investment as well as their situation of Significant Market Power (SMP) of these big companies [11].

Table 3. Values of the persuasion parameters β_{ij}, $1 \leq i, j \leq 5$, $i \neq j$, obtained by fitting the model (1) to the data from Table 1.

$\beta_{i,j}$	$j = 1$	$j = 2$	$j = 3$	$j = 4$	$j = 5$
$i = 1$	-	0.0624995	0.0124441	0.0527110	0.0745537
$i = 2$	0.0694217	-	0.0454117	0.0405594	0.0633758
$i = 3$	0.0043526	0.0598186	-	0.0912634	0.0404809
$i = 4$	0.0580532	0.0630378	0.0633421	-	0.0425000
$i = 5$	0.0678221	0.0375226	0.0657689	0.0507095	-

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Table 3 contains the estimation for persuasion coefficients β_{ij}. In general, the obtained values are very similar, whereas the sum of the columns of Table 3 can be interpreted as the global peer-pressure of the loyal customers of each company, therefore it can be noticed that the values associated to company Yoigo (0.235243), which correspond to the sum of column $j = 4$, are slightly higher than the sum of the other columns, followed by Vodafone (0.222879), MVO (0.220909), Movistar (0.19965) and finally, Orange (0.186967). Hence, the customers satisfied with Yoigo company exert a more effective persuasion on customers from other companies through their peer-pressure.
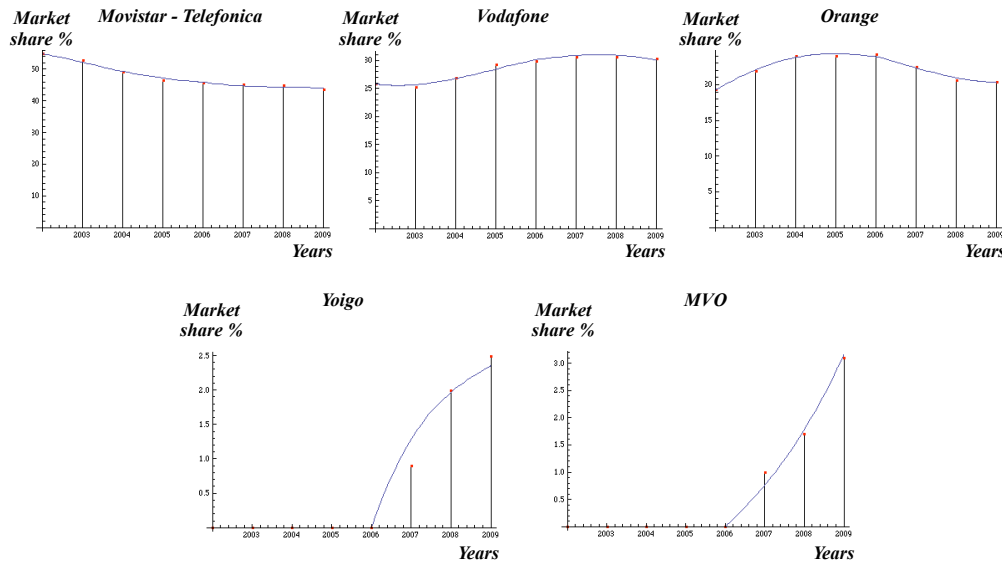

Figure 2.   Model fitting for period 2002–2009. The points represent data from Table 1 and the continuous lines represent the results of the model. The values show the percentages of market share.

3.2.   Short-term prediction over the next five years

In the previous subsection, the values of the parameters that provide the best fitting (in the least square sense) of the nonlinear system (1) for the data from CMT about the market share percentage of the Spanish mobile telecommunications services during the period 2002–2009 have been determined. Considering the general situation of the mobile telecommunications market will not change over the next few years and by using the model, the trends of market share percentage of Spanish mobile telecommunications service can be forecasted. Table 4 collects the numerical model predicted results. Figure 3 shows these predictions graphically.

Table 4.   Short-term numerical forecasting for the percentage of market share of the companies Movistar–Telefonica, Vodafone, Orange, Yoigo and MVO over the period 2010–2016.

%	2010	2011	2012	2013	2014	2015	2016
Movistar	43.18	41.47	39.10	36.60	34.44	32.92	31.98
Vodafone	28.67	27.14	26.05	25.71	26.05	26.72	27.27
Orange	20.64	21.75	23.29	24.65	25.35	25.30	24.83
Yoigo	2.64	2.98	3.44	4.00	4.59	5.09	5.43
MVO	4.87	6.66	8.12	9.04	9.57	9.97	10.49

A decreasing trend in Movistar-Telefonica due to the gains made by MVO and Yoigo can be observed. Vodafone and Orange, with some fluctuations, maintain their market share. Thus, a sharp rise in the number of customers to these small
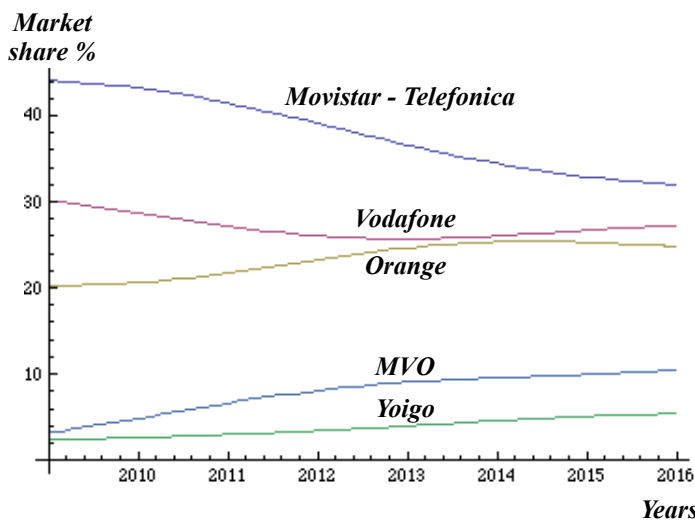
Figure 3.   Evolution of the market share from 2009 until 2016. An increase of Yoigo and MVO at expense of Movistar can be observed. Vodafone and Orange, with some fluctuations, more or less maintain their market share.
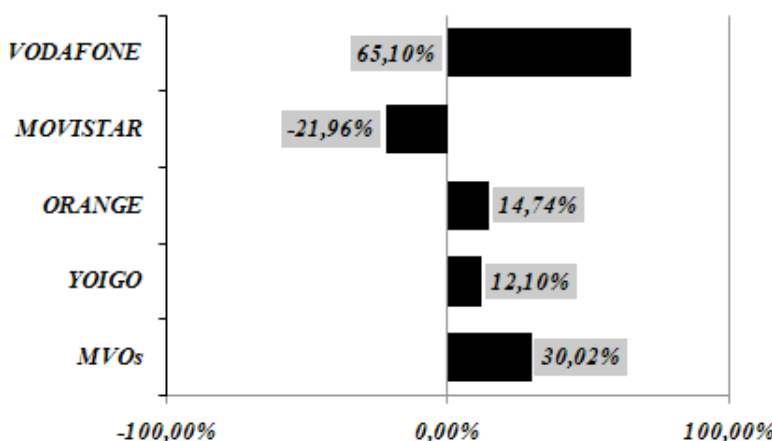

Figure 4.   MNP customers migration between Spanish mobile telecommunications providers 2008–2009. Source CMT [4].

companies, Yoigo and MVO, is expected at the expense of Movistar-Telefonica. This fact is in keeping with recent reports of mobile portability numbers of CMT [4] (see Figure 4).

Recently, CMT has reported data corresponding to 2010 in CMT [4] : Movistar (41.80); Vodafone (29.40); Orange (20.10); Yoigo (3.90); MOV (4.80). As it can been noticed these values fit the model predictions of 2010: Movistar (43.18); Vodafone (28.67); Orange (20.64); Yoigo (2.64); MOV (4.87) (see Table 4). These trends state the current process in the context of global crisis. Therefore, it can be assumed that global crisis (which started in 2008) does not seem to have a direct effect over the companies share market, since market share is a percentage value.

The trends forecasted by the model may allow the companies to adapt their strategies, design new ones and simulate them in the model in order to see if they will be effective to get a higher market share in the future.

4.   Discussion

Mathematical models are emerging as powerful tools to understand and predict trends over time in different areas, such as sciences and technologies. In this paper, the dynamic model (1) has been put forward, whose direct marketing/advertising and persuasion/peer-pressure coefficients A_i and β_{ij}, respectively, have been computed by fitting this model to the available data (collected in Table 1). This allows to predict the evolution of the market share of the Spanish mobile telecommunications services market in the next few years. In particular, it has been shown that large companies have a much higher direct marketing or advertising coefficient, which entails a greater power to attract new customers. This feature can be explained by the greater investment capacity of the biggest companies. Also, the obtained persuasion coefficients are quite similar.

The evolution of the market share shown in Figure 3 predicts an upward trend of Yoigo and MVO in the next five years at the expense of Movistar–Telefonica. This forecasted behavior agrees with reports issued by CMT in 2010 [4]. Since 2000, the approval of the mobile number portability in the Spanish market, has encouraged the transfer of many of the customers from traditional mobile telecommunications service providers to new firms such as Yoigo and MVO, which have also entered the market with attractive discounts and promotions. According to experts, this could explain in the near future, the increase of the number of customers of Yoigo and MVO at the expense of Movistar–Telefonica. The model also predicts that Vodafone and Orange will maintain their market share, with small fluctuations.

It should be emphasised that models allow to simulate and generate different scenarios of interest for companies in order to develop new strategies as well as to predict their share of the market.

Finally, we would like to point out that as the only official available data are those ones collected in Table 1, while we were building our model we assumed that both model parameters A_i (individual coefficients) and β_{ij} (imitation coefficients) embed specific factors which determine the customer flow among Spanish telecommunication companies. In the future and if more data and/or metadata were available, the proposed model would enable the disaggregation of both model parameters in other subparameters related to specific factors such as, the offer of tariff plans, special promotions or social culture aspects, for instance. This approach has been recently and successfully adopted by some of the authors when dealing with the modelling of another problem [12].

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