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A BASS DIFUSSION MODEL ANALYSIS IN A MARKETING APPROACH ON THE MOBILE PHONE MARKET

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Abstract:
The idea in forecasting the adoption of new products is to serve the vision of what is likely to happen with the demand of new technologies on the mobile phone market. The purpose of this paper is to use one of Frank Bass' mathematical models showing the theory of diffusion of a new technology on the mobile phone market and to show how it can be applied to forecast the number of the new adopters, on the one hand, and how long it will take to achieve the peak adoption curve, on the other hand. This will be used to predict and track the technology life cycle and therefore the product life cycle. Through this research we try to find prompt answers to the question - "How many consumers will likely adopt the new technology and when?" The more persons adopt the new technology, the more the potential adopters see the increased value brought by the product and they also adopt it in their turn. The effects of consumers' interaction with each other ("word-of-mouth" type) depend on the time of adoption, being relatively strong during the early and late stages of the product life cycle. During the growth of the adoption period, the number of innovators decreases, while the number of imitators increases.

Keywords: technology diffusion, adopters, Bass diffusion model, innovators, imitators, marketing strategies

1. INTRODUCTION

Technology diffusion research aims at understanding the dissemination of innovations by modeling their entire life cycle also in terms of consumers' interaction. Diffusion modeling in the literature since 1990 tried to extend the Bass framework from reflecting the growing complexity of launching a new product to making forecasts regarding the potential market. Nowadays, in the business world there is a constant need for accurate predictions. For example, investment decisions and the ability to plan depend on the evolution of the product market. In practice, it often can be seen that managers are able to provide accurate estimates on the potential market of a product. However, the performance of the market of a new product and the time when the market is saturated remain unclear.

Technology diffusion theory has become an important area for marketing due to authors such as Rogers, Bass, Mahajan and Muller. The main objective of diffusion theory is to track the communication channels through which information on the new technology is transmitted within the social system, taking into account two distinct types of influence: an internal influence, of the word-of-mouth communication type, and an external influence represented by the mass media (Mahajan, Muller, Bass, 1990).

The purpose of this paper is to analyze the main changes in diffusion theory significantly marking the marketing management and, of course, to provide research proposals on the application of Bass model, which is based on both the research of diffusion technology and on marketing research. The objectives are:

- forecasting the number of those who adopt the products incorporating new technology;
- determining the time needed to adopt the new technology.

To develop this research we track the manner in which the mobile product category is distributed in the market. Information on consumers' attitudes to the introduction of new technology was obtained from the market in Baia Mare, Romania. The empirical results enable analogy and the further application of the model.

2. THE BASS MODEL OF TECHNOLOGY DIFFUSION AS A MODEL OF APPROACHING THE OVERLAP OF TECHNOLOGY DIFFUSION AND MARKETING MANAGEMENT

2.1. Marketing management and technology diffusion in terms of their interference

Technology becomes a competitive tool increasingly important for many organizations (Dovleac, 2011). A new technology takes time to gain economic importance. To begin, it must be introduced into the economy - innovation. Then it is gradually adopted by many users - diffusion (Mukoyama, 2003). An innovation strategy is applied more intensively with increasing uncertainty (Lobontiu, 2002). The adoption of a new product is a future event with an uncertain outcome (Castano & al., 2008). With regard to differentiation by marketing, significant relationships were established between the environment and the intensity of strategic behaviour (Lobontiu, 2002). Technological innovations such as the mobile phone, shopping on the internet, the digital TV have renewed the researchers' interest on the adoption of innovations (Sääksjärvi, 2003). The mobile phone market has changed from a purchase market to a replacement market when mature (Namkee & al., 2013).

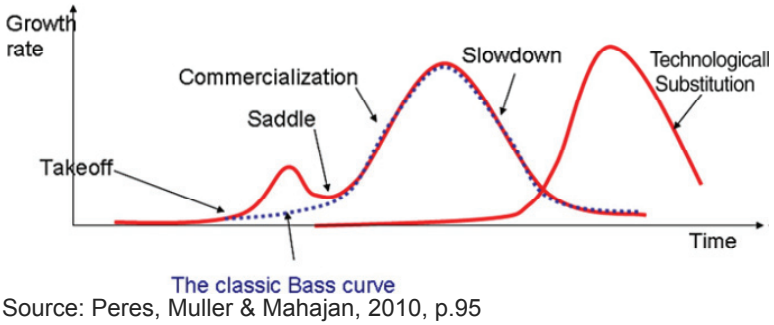
A consumer's attitude towards innovation was also identified as an important personal trait influencing the person's intention to adopt a new product or new technology (Hirschman, 1980). In his book, Rogers (2003) briefly mentioned why a mobile phone has been successfully adopted by consumers. He attributed value to successful adoption as the advantages of cordless telephones, of mobile phones, which ensures compatibility with the existing systems, with ease of use, testing and observation.

2.2. The description of the bass new technologies diffusion model

The Bass diffusion model was developed in 1960 by Frank Bass to study the distribution of different types of new products and services. The model is based on a mathematized presentation of the technology diffusion phenomenon and describes the process by which new products are adopted in a population. The basic principle is that adopters can be classified as innovators and imitators. The rate and timing of adoption depends on the degree of innovation or imitation among the adopters. The Bass model is a very useful tool for predicting the adoption (first purchase) of an innovation (more generally, of a new product) for which there are no competing alternatives on the market. A key feature of the model is that it incorporates a process of contagion to characterize the dissemination word-of-mouth between those who adopted the innovation and those who have not yet adopted the innovation (Balahrishnan, 2010).

In the last decade, a wave of research approached the examining of turning points in the life cycle of the product, which are not included in the classical curve of adoption (figure 1). Some researchers have focused on the research dealing with two turning points in the life cycle of the product: the launch, taking place at the beginning, and the saddle point, which appears during the growth phase of the product (Peres, Muller & Mahajan, 2010).

Figure 1: Turning points in the product life cycle



Source: Peres, Muller & Mahajan, 2010, p.95

The Bass classic model begins with the spontaneous adoption by an initial group of adopters, but offers no explanation for the mechanisms that lead to the initial adoption or launch. Studies on the launch focus on this initial stage and explore the market behavior and the interface between adoption and early communication interactions (Peres, Muller & Mahajan, 2010, p.95).

Bass considered that the adopters of innovation include two different groups. The first group adopts innovation independently of the decisions of other people in a social system and is influenced solely by communicating with the media (external influence). Bass has defined this group as innovators. This segment represents the lovers of novelty, influenced by the characteristics of the product (Firth, Lawrence & Clouse, 2006). The second group of adopters is influenced by the pressure of the social system, by oral communication (internal influence); it has a strong imitation behavior and was named the group of imitators. They are influenced in terms of innovation adoption by the decisions of other members of the social system. The internal influence implies that buyers are subject to a contagion effect as a result of interpersonal contacts (Noratikah & Ismail, 2013). For innovators and imitators it estimates different rates of adoption of new technologies (Vasiľová, 2012).

The main theorem of the Bass diffusion model is as follows (Mahajan, Muller & Bass, 1995): *The period of adoption at the given time t since no initial purchase has been made = p + q * the cumulative fraction of adopters at time t*, where *p* is the innovation coefficient and *q* the imitation coefficient.

If *f(t)* is the probability of adopting at time t and *F(t)* is the cumulative fraction of real adopters at time t, the principle of Bass model is given by the mathematical expression (Mahajan, Muller & Bass, 1995):

$$\frac{f(t)}{1-F(t)} = p + q * F(t) \qquad (1)$$

If we take the Bass equation (1) and multiply it with M, where M is the potential market, by the following equations, the result is the equation (2):

$$\frac{f(t)}{1-F(t)} = p + q * F(t) \Leftrightarrow$$
$$\Leftrightarrow f(t) = [p + q * F(t)] * [1 - F(t)] \quad * M \Leftrightarrow$$
$$\Leftrightarrow M * f(t) = [p + q * F(t)] * M * [1 - F(t)] \Leftrightarrow$$
$$\Leftrightarrow M * f(t) = [p + q * F(t)] * [M - M * F(t)] \Leftrightarrow$$
$$\Leftrightarrow M * f(t) = \left[p + q * \frac{M * F(t)}{M} \right] * [M - M * F(t)] \quad (2)$$

Vasiľová (2012) uses the following mathematical notation:

- ✓ *M * f(t) = n(t)*, representing the number of new adoptions at the time t,
- ✓ *M * F(t) = N(t)*, representing the cumulative number of adopters at the time t.

The equation (2) becomes (Vasiľová, 2012):

$$n(t) = \left[p + q * \frac{N(t)}{M} \right] * [M - N(t)] \quad (3)$$

For the practical application of the model, one must take into account that the cumulative number of buyers becomes known to us at time t-1. Thus, the equation (3) becomes (Firth, Lawrence & Clouse, 2006):

$$\mathrm{n(t)} = \mathrm{p} * [\mathrm{M} - \mathrm{N(t-1)}] + \frac{\mathrm{q}}{\mathrm{M}} * \mathrm{N(t-1)} * [\mathrm{M} - \mathrm{N(t-1)}] \quad (4)$$

Where n(t) is the number of the new buyers of the product or service in question at the time t; N(t - 1), the cumulative number of buyers at time t - 1; M, the potential market, i.e., the total number of potential buyers of the final product that should be set when launched; p, the coefficient of innovation or the external influence that characterizes the probability that a person who has not yet used the product begins to use it due to external influence in the process of dissemination: advertising, price, product awareness in the media, personal needs, ease of use; q, the coefficient of imitation or internal influence that characterizes the probability that a person who has not yet used the product begins to use it due to the influence of those who are already using the product.

The Bass model is by far the diffusion model most commonly used in marketing, and it is a mixed model in terms of capturing both the innovative and the imitative effects.

3. RESEARCH METHODOLOGY

3.1. The research method

The chosen research method is the survey and non-random sampling, based on affordability. The chosen research instrument is the questionnaire. The survey focuses on tracking the dissemination of the new technologies on the market of mobile phones. The questionnaire, which we drafted, provides information about the consumers' behavior on the market of mobile phones. The questions are closed identification, opinion, knowledge and factual questions. We have also introduced filter questions, because not everyone can or should answer to all the questions. The questionnaire was administrated and implemented by the authors. The implementation period was between March 1, 2014 and August 31, 2014. The target group is represented by consumers in the mobile phones market in Baia Mare, Romania.

3.2. Research results

Based on the questionnaire applied on the diffusion of technology for mobile products we used the Bass model in order to determine the number of new adopters of mobile products by category of sex and the time required for adoption, obtaining the results enlisted below. To estimate the parameters p and q we used the data collected from respondents regarding the influence of internal and external factors on the adoption of new technologies. Since it is the diffusion of new technology in mobile telephony, the number of previous buyers is 0 (N(t-1) = 0). We considered all 328 respondents as potential adopters. The table below presents the estimates of the potential market (M), the coefficients of innovation (p) and imitation coefficients (q) for the situation under analysis.

Table 1: Estimating the potential market M, the innovation coefficient p and the imitation coefficient q

Potential Adopters	M	p	q
Women	148	0.07	0.54
Men	180	0.12	0.42

Substituting these coefficients in equation (4), we constructed a mathematical model of technology diffusion for the entire population surveyed, separately for potential female adopters and potential male adopters, as will be seen in the tables and figures below.

The estimates for the application of the mathematical model are as follows: for the potential market M = 148 women, respectively M = 180 men, for the rate of innovation p = 0.07 for women, respectively p = 0.12 for men, q = 0. 54 the coefficient of imitation for women, and q = 0.42 for men. The values of the q and p coefficients were determined based on the answers given by the respondents to question 12 of the questionnaire - *If you were interested in purchasing a mobile phone what information sources would you use?* Depending on the internal and external influence sources marked by the respondents, we have identified the type of adopter that includes the 328 respondents, innovators and imitators.

Table 2: The percentage of target market held by women adopters, respectively men at time t

t	Women					Men				
	M - N(t-1) %	N(t-1) %	Innovators %	Imitators %	n(t) %	M - N(t-1) %	N(t-1) %	Innovators %	Imitators %	n(t) %
0	100.00	0.00				100.00	0.00			
1	93.00	7.00	7.00	0.00	7.00	88.00	12.00	12.00	0.00	12.00
2	82.97	17.03	6.51	3.52	10.03	73.00	27.00	10.56	4.44	15.00
3	69.54	30.46	5.81	7.63	13.44	55.97	44.03	8.76	8.28	17.04
4	53.23	46.77	4.87	11.44	16.31	38.90	61.10	6.72	10.35	17.07
5	36.06	63.94	3.73	13.44	17.17	24.25	75.75	4.67	9.98	14.65
6	21.09	78.91	2.52	12.45	14.98	13.62	86.38	2.91	7.72	10.63
7	10.62	89.38	1.48	8.99	10.46	7.05	92.95	1.63	4.94	6.58
8	4.75	95.25	0.74	5.13	5.87	3.45	96.55	0.85	2.75	3.60
9	1.98	98.02	0.33	2.44	2.78	1.64	98.36	0.41	1.40	1.81
10	0.79	99.21	0.14	1.05	1.18	0.76	99.24	0.20	0.68	0.87
11	0.31	99.69	0.06	0.42	0.48	0.35	99.65	0.09	0.32	0.41
12	0.12	99.88	0.02	0.17	0.19	0.16	99.84	0.04	0.15	0.19
13	0.05	99.95	0.01	0.07	0.07	0.08	99.92	0.02	0.07	0.09
14	0.02	99.98	0.00	0.03	0.03	0.03	99.97	0.01	0.03	0.04
15	0.01	99.99	0.00	0.01	0.01	0.02	99.98	0.00	0.01	0.02
16	0.00	100.00	0.00	0.00	0.00	0.01	99.99	0.00	0.01	0.01
17	0.00	100.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00
18	0.00	100.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00
19	0.00	100.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00
20	0.00	100.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00

In the M-N(t) column in Table 2 the percentage at each time t represents the percentage of the potential market that has not adopted the new technology. In the column N(t-1) one may notice the percentage of the target market, at any time t, which adopted the new technology. In the Innovators column, it is calculated the market share taken by innovators and in the Imitators column, the market share taken by imitators. At t = 0, since this is a new technology and its diffusion process is still under observation, therefore it has not yet been launched on the market, and the number of buyers N(t-1) = 0.

Table 3: Determining the number of new adopters, men and women, at the time t

t	Women					Men				
	M - N(t-1)	N(t-1)	Innovators	Imitators	n(t)	M - N(t-1)	N(t-1)	Innovators	Imitators	n(t)
0	148	0				180	0			
1	138	10	10	0	10	158	22	22	0	22
2	123	25	10	5	15	131	49	19	8	27
3	103	45	9	11	20	101	79	16	15	31
4	79	69	7	17	24	70	110	12	19	31
5	53	95	6	20	25	44	136	8	18	26
6	31	117	4	18	22	25	155	5	14	19
7	16	132	2	13	15	13	167	3	9	12
8	7	141	1	8	9	6	174	2	5	6
9	3	145	0	4	4	3	177	1	3	3
10	1	147	0	2	2	1	179	0	1	2
11	0	148	0	1	1	1	179	0	1	1
12	0	148	0	0	0	0	180	0	0	0

For all the respondents, 148 women and 180 men, to adopt the new technology on the mobile phone market it is required a number of 11 weeks for both women and men, as shown by the results in Table 3. In the same table we may see that of all 328 potential adopters at time t = 1, we have a total of 10 new women adopters and 22 new men adopters, representing the innovators. At t = 2 we have a number of 15 new adopters of which 10 are innovators and 5 imitators, representing women, i.e. a total of 27 new adopters of which 19 are innovators and 8 imitators, representing men. As one may see from the data given in the tables above, in the adoption period, initially we only have innovators, and only external influence factors on the potential adopters are present. Once the new technology was brought to the attention of the potential adopters by innovators, imitators appear and thus along the diffusion process of the new technology the number of innovators gradually decreases and the number of imitators increases.

In the figures 2 and 3, we plotted the cumulative adoption of the new technology in time and the adoption period necessary to the 328 respondents to adopt the new technology.

Figure 2: Cumulative adoptions at time t for women, respectively for men

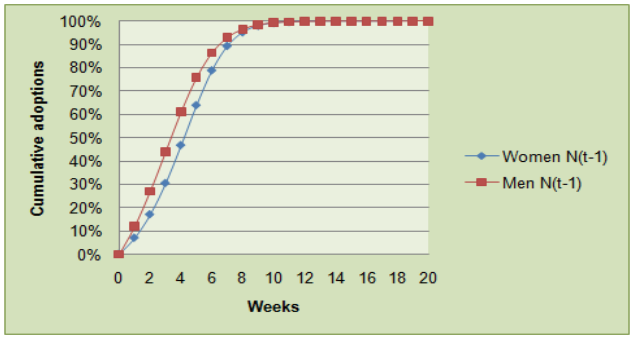
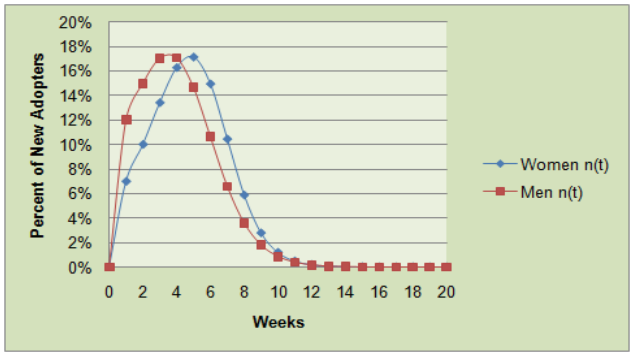


Figure 3: The adoption period for women, respectively for men



It can be seen that men need less time to start the adoption process. This is because the number of innovators is higher in men than in women leading to the innovation coefficient estimate of 0.12 in men and 0.07 in women. Also the number of imitators is higher among women, the coefficient of imitation is q = 0.54 to 0.42 in men. Regarding the number of new adopters n(t) at time t = 1, it is 10 for women to 22 for men adopters.

4. CONCLUSIONS

According to the conducted research and the results obtained, the conclusions are as follows:

1. The interaction between those who have adopted the new technology and the potential adopters has a direct influence on the rate of adoption. The more people adopt, the more the prospective adopters see the increased value of the product and adopt at their turn.
2. The number of new buyers in the innovators category is maximum at first and then decreases steadily.
3. The number of imitators is zero at first, and then rapidly increases to reach a maximum, followed by a decrease.
4. The innovation coefficient is higher in men than in women, which shows that on the mobile phone market the potential male adopters are more open to new than the potential female adopters.
5. The imitation coefficient is higher in women, which shows that on the mobile phone market women are significantly influenced by the others in taking the decision to adopt.
6. The adopting time for both women and men is the same, even if the potential market (M) of men is higher than women. This is due to the larger number of potential male adopters among the innovators.
7. The influence of external and internal factors is manifested in the values of the innovation coefficient (p) and the imitation coefficient (q), which are determinants of the technology diffusion speed.

Besides technical findings, the paper is important for presenting the technology diffusion Bass model in correlation with marketing strategies. The Bass model, applied on the mobile phone market, integrates the issue of marketing management. Sex differentiation of new technology adopters enables an adaptation of differentiated marketing strategies with effects given by the magnitude of the differences in adopters' behavior.

5. IDENTIFIED RESEARCH DIRECTIONS

According to the empirical study, we have identified as new research directions the following:

1. The review of the possibility that the speed of technology diffusion is captured by the innovation (p) and imitation (q) coefficients.
2. Studying the variation coefficients of innovation (p) and imitation (q) depending on the product and the area where the launch of the new product is intended.

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