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To cite this article: Sergey Krasnov *et al* 2019 *IOP Conf. Ser.: Mater. Sci. Eng.* **497** 012032

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# Modelling of digital communication surfaces for products and services promotion

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**Abstract.** Development of information technologies at the present stage allows switching over to a higher level of interaction between business and clients. Worldwide trend in attempts to find a potential consumer is customization of marketing impact. This paper is dedicated to interactive communication modeling through evaluation of feedback to commercial brands promotion via all possible consumer preference influencing channels. The paper establishes formalisms, plots mathematical model of products promotion by means of digital platforms and gives calculation of optimized regimes. The paper shows results of investigations performed by means of elaborated mathematical model on a particular example. The paper substantiates efficiency of elaborated mathematical model employment (under the conditions of market uncertainty) for making managerial decisions in various products and services promotion areas and also for the purpose of short-term and long-term business planning.

## 1. Introduction

Extensive outspread of interactive communication tools in “client-supplier” segment and advancement of Customer Relationship Management (CRM) concept [1] allows to appropriately switch over to the closed-loop system regulating the flow of goods and services in continuous feedback paradigm. Operation of aforesaid systems is based on a number of basic constituents which gained momentum owing to mobile Internet, accessible smart phones and functional-rich digital technologies.

Firstly, this is on-line analysis of efficiency of omni-channel communication based on most advanced technologies. Namely the possibility to handle data bases of clients identified to the extent of particular individual and set of information not only about consumer preferences and history of purchase but also about age, location, relocation and other important business-information forms the basis for this type of information influencing exerted with the use of all possible as well as alternative channels [2]. At that, such software products as XaaS solutions, SIM solutions and active GPS/GLONASS user identification are being implemented.

Secondly, this is maximum implementation of search optimization entitled SEO (search engine optimization). Such comprehensive approach ensures not only good results of search systems, increase of number of potential clients and maximum profit. Main goal is associated with increase of profitability of investments into publicity – expensive and financially capacious cost item. Namely ROAS (Return On Ad Spend) is critical for the majority of business oriented on mass audience – first of all for network business. Importance of solving this issue is caused by wide spread of Brick and Mortar (B&M) format used for trade business organization. While physical presence (of shop or showroom) is based on well-



developed technologies of interaction with the consumer, e-Commerce requires ways of high conversion gaining to be sought for. There is a need for strategy which could enable control of communication with potential consumers' pool and provide maximum number of conversions with a definite level of investments profitability.

Thirdly, this is spreading of the concept entitled Fifth Party Logistics (5PL) which is defining steady development of modern commercial networks. These outsourcers are by maximum involved in current business activities of the client-company, are playing a coordinating role supporting physical and information flows [3] and acting in capacity of intermediaries releasing the enterprise from non-core activities.

5PL functioning is based on high-tech, specialized software and digital interfaces of communication with various companies based on information environment globalization; this is why IT units of all levels are paying primary attention to virtual digital contact surfaces aligning.

Formation of interactive communication structure is performed with consideration of dynamic and static external factors, functionality, with involvement of mathematic modeling, optimization methods; at that, all criteria are identified exclusively from economic view point – maximization of profit, capture of market and improvement of competitive strength.

Modern requirements put forward to commercial software development include, on one hand, multiplatform character and scalability, and, on the other hand, demand orientation mostly on mobile applications and implementation thereof requires storage in global network's cloud services. Transition to digital economy is putting forward practical tasks for the IT personnel; in order to solve them it is necessary to possess a wide range of available mathematical tools and to be able to integrate them into dynamically growing methods of interactive communication with widening range of information about goods and services as well as consumers with high degree of personification provided. It is essentially important to accept correct mathematical models [5] and solutions obtained with the use of optimization methods giving market participants a possibility to obtain economically substantiated competitive advantage as a basis for program algorithms [4].

## **2. Description of mathematical model's object region**

Modern business during recent decades displayed (in the segment of goods and services) main tendencies like increase of proportion of on-line sales and integrating in networks structures [6]. Since the major part of brand promotion budget is spent for marketing communications there is a demand for weighted estimation enabling optimized balance obtaining at the stage of media plans compilation. At that, it is necessary to make use of well-established system of measurable parameters characterizing efficiency of commercial activity [7].

Market demand and customer preferences are of stochastic nature; therefore for the purpose of formalized description we shall use machinery of theory of stochastic processes [8]. It should be mentioned that characteristics used by marketers have full compliance with parameters used in the theory of probability. Thus, function of probability distribution density in media planning is used under the term "Frequency" while cumulative distribution function is identified as "Reach f+".

Out of other summary indicators used for problem formalization we shall use gross rating points (GPR), target rating points (TRP), in reference to targeted public, Coverage and Index T/U (Target/Universe). In order to shape optimization criteria we shall use the below economic indicators: CPT (Cost Per Thousand), CPP (cost per point).

In order to obtain data required for the mathematical model [9] it is necessary to use first of all entire feedback tools integrated in web sites and portals beginning from Web 3.0. Here we shall combine two basic data systems. For traffic itemization we used processing of server logs containing information enabling assessment and analysis of sites and visitors' statistics acquisition.

Since Feed information flows already generate info sets of web crawlers and have integrated data communication about already done purchases, it is only required to perform processing thereof to obtain summary indicators; besides, these resources enable the users to perform targeted point cuts as per gender, interests, age, geo-targeting and financial well-being. Since access logs already contain a set of

any possible information about the visitors, it means that upon referring the traffic with time scale and processing thereof it is possible to build-up statistics of customer preferences. Google Analytics (GA) or similar metrics serves in capacity of alternative system. Since this service is synchronized with Google Ad Words, information contained therein about visitors' geography, visit duration and site conversion allows to use these data as a basis for optimization of both multi-channel and omni-channel communication with consumers pool [10].

For the purpose of task substantiation, let us set up a number of mathematical formalisms (MFs) [11] and define the set of required constraints. Under consideration is commercial network activity; at that, this is understood as expansion of this category of market subjects. Apart from traditionally used concept of enterprises group operating under one and the same brand, centralized management, coordinated distribution and marketing let us take into account intrusion into social networks and communication with search portals and software clients of mobile communication of "Google+" type. This allows interlinking company economic indicators with market demands in the mode close to on-line. Such effect is achieved namely owing to integration into the system of landing pages, consumer leads collection, formation of targeted leads. Referring to these data it is possible to calculate brand loyalty, marketing tags, conversion. Tools like RLSA (Remarketing Lists for Search Ads) from Google search service, re-targeting and others, implemented in popular search services, are representing the entire set of indicators required for optimization of commercial network company profit.

### 3. Elaboration of mathematical model of products promotion by means of digital platforms

To plot a mathematical model let us define a set of market condition assessment of  $M$  dimensionality. These may be (i) either absolute quantitative measurable indicators represented by scope of demand or scope of sales or (ii) relative (in reference to previous periods or to general parameters) indicators in this particular segment of commercial activities.

Let us introduce stochastic matrix of transition  $P^0 = \{p_{ij}^0\}$ ,  $i, j = 1, \dots, M$  formed out of marketers' data [12] provided that there are no promotion costs. At that, indicators will have the below meaning: probability of transition from state  $i$  to state  $j$  is equal to  $p_{ij}^0$ . Accordingly, the lines contain full groups of events and the matrix  $P^0$  is stochastic on its right hand (RH) side. From analysis of commercial networks profits it is possible to calculate matrix of profit  $R^0 = \{r_{ij}^0\}$ ,  $i, j = 1, \dots, M$ .

Further, let us introduce value  $K$  - number of types of communication with consumers' pool. Here belong: publicity, marketing, leads involvement, brand promotion, expositions, landing pages, media planning and other ways of exerting influence on consumer demand. Accordingly, let us define the set of transition matrices  $P_1, P_2, \dots, P_k, \dots, P_K$ , where  $P_k = \{pk_{ij}\}$ , at that  $k = 1, \dots, K$ , and indices obtain the below values:  $i, j = 1, \dots, M$ .

Let us introduce costs associated with any type of promotion as  $\Omega_k$   $k = 1, \dots, K$ .

Links between market activity and economic activity indicators is implemented through calculation of profit matrices  $R_1, R_2, \dots, R_k, \dots, R_K$ , where  $R_k = \{rk_{ij}\}$ , at that:  $k = 1, \dots, K$ ;  $i, j = 1, \dots, M$ . Values of elements of matrix  $R_k$  have been obtained by solving a N/A equation (Nerlove–Arrow), linking promotion activity  $q(t)$ , customers interest  $\Lambda(t)$  and  $\mathcal{Q}$  – quality of product promotion measures:

$\frac{d\Lambda(t)}{dt} = \mathcal{Q}q(t) - k\Lambda(t)$ . Here, we take into account reduction of profit due to costs  $\Omega_k$ . Accordingly,

elements of profit matrices  $rk_{ij}$ , are in their turn, the functions of these arguments:  $rk_{ij}(q, \Lambda, \mathcal{Q}, t)$ .

Accounting of time factor in these calculations is crucially important. This is stipulated by the fact that, on one hand, planning is performed for a considerably extended horizon [13], on the other hand, the market situation is changing rather rapidly and, apart from this, promotion actuality is falling due to

participation of competitors presence in this part of the market segment (this fact is taken into account in N/A equation of the dynamic model). As a presumption in this investigation it has been accepted that indicators calculation is performed periodically, with some span or discrete  $\Delta t$ , for instance on a weekly basis.

Having plotted the mathematical model it is required to apply methods of optimization theory and retrieve maximum profit with implementation of products and services promotion activities on the planning horizon which consists of  $N$  periods with  $\Delta t$  duration.

Solution method. Let us begin optimization, according to Bellman's principle, from the last  $N$  period. Let us note down the optimization equation  $G_n(i)$ , where  $n$  – serial number of the current stage,  $i$  – random index of market condition defining consumers preferences. Since the profit is composed of products of transition probabilities by corresponding elements of profit matrices  $\sum_{j=1}^m pk_{ij} rk_{ij}$  and products of probability of transition into already known optimized solution  $\sum_{j=1}^m pk_{ij} G_{n+1}(j)$ , we obtain an expression for retrieving the optimized value maximizing by  $k$ -interaction as shown below:

$$G_n(i) = \max_k \left\{ \sum_{j=1}^m pk_{ij} \left( rk_{ij} + G_{n+1}(j) \right) \right\}. \quad (1)$$

It should be noted that this formula gives a possibility to plot a recurrent algorithm useful for programming by the computer [14]. For this purpose, it is enough just to introduce at a current step  $n$  of planning horizon not only the value of optimized profit  $G_n(i)$ , but also an expression for summation variable as per corresponding  $i$  lines of the matrices:  $\lambda k_i = \sum_{j=1}^m pk_{ij} rk_{ij}$ . Therefore, we can finally obtain an expression suitable for expert programs plotting:

$$G_n(i) = \max_k \left\{ \lambda k_i + \sum_{j=1}^m pk_{ij} + G_{n+1}(j) \right\} \quad (2)$$

for zone  $n \in [1, N-1]$ , at false boundary condition, where  $G_{N+1}(i) = 0$  with any  $i = 1, \dots, M$ .

#### 4. Elaborated model employment for the purpose of investigation conduct.

In order to illustrate the proposed methodology of mathematical modeling and retrieve optimized solution we took (on the planning horizon provisionally divided into  $N = 3$  stages) actual data submitted by “Mobyco” company specialized in residential sector supplying with mass-market products. Since this segment is characterized by (i) considerable number of competitive parties and (ii) strong volatility of demand, sales performance monitoring is carried out twice every month enabling the players to promptly respond to market behavior. According to marketers' data, we plotted the transition probability matrices:

$$P^0 = \begin{vmatrix} 0.15 & 0.54 & 0.31 \\ 0.12 & 0.5 & 0.38 \\ 0.05 & 0.05 & 0.9 \end{vmatrix} \quad P1 = \begin{vmatrix} 0.4 & 0.5 & 0.1 \\ 0.05 & 0.44 & 0.51 \\ 0.1 & 0.31 & 0.59 \end{vmatrix} \quad (3)$$

Proceeding from “Mobyco” company performance indicators the profit matrices, with consideration of promotion costs, were calculated (K Euro):

$$R^0 = \begin{vmatrix} 9350 & 6420 & 2100 \\ 7580 & 5540 & 1250 \\ 5150 & 3270 & -1008 \end{vmatrix} \quad R1 = \begin{vmatrix} 6730 & 4150 & 770 \\ 7220 & 3420 & 400 \\ 4970 & 2350 & -1800 \end{vmatrix} \quad (4)$$

Thus, if we apply formula presented above, we can obtain (i) values of profit vectors and, accordingly, (ii) type of promotion  $k$ , giving optimized output:

$$G_3 = (5520.3; 4154.6; 163.5) \quad k_3 = (1, 1, 2) \quad (5)$$

$$G_2 = (9145.7; 6956.5; 2099.9) \quad k_2 = (2, 1, 2) \quad (6)$$

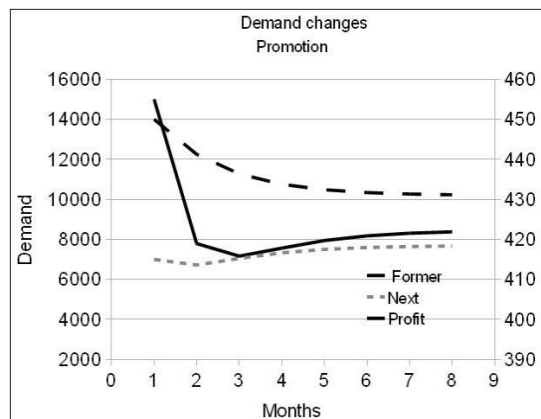
$$G_1 = (12190.5; 9528.3; 4473.5) \quad k_1 = (2, 1, 2). \quad (7)$$

It follows here from that for first month, depending on assessment of market demand status  $m = 1, 2, 3$  active expenses for promotion are expedient in cases 1 and 3, while in the first half of the second month investing in publicity is expedient in case 3. At that, obtained values of maximum profit are equal to corresponding vector elements  $G_n(i)$  at  $n = 1, 2, 3$ .

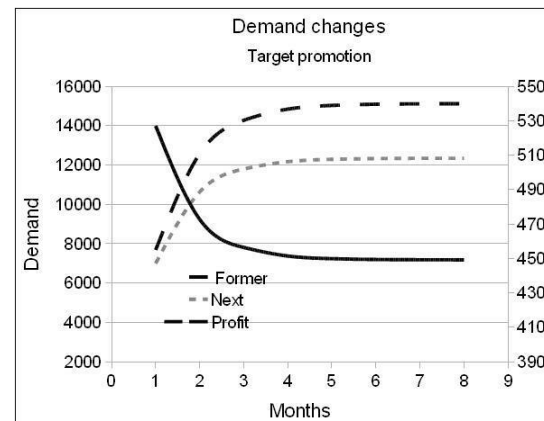
More interesting is employment of this methodology for the selection of optimized production program where innovative products are about to enter the market. Since next generation of any product is normally appearing on the counter simultaneously with previous generation it is the task for managers to find a balance between ramp-down of previous generation product release ramp-up of the next generation product manufacturing. And that is particularly true of gadgets because upgrade in this segment is rushing and expenses associated with new design are so huge that any company failing to perform thorough economic calculation under the condition of fierce competition will fail to achieve the required rate of return.

In such case, in order to solve the problem, it may be possible to further expand the proposed methodology taking into account peculiarities of each specified task. Let us plot the matrix of preferences  $P = \{p_{ij}\}$  and vector of current demand  $\bar{C}_0 = \{c_{0k}\}$  whose elements are reflecting level of demand for previous (Former) product, level of demand for innovative (Next) product and rejection of product fabricated by this manufacturer. In this case, after scheduled interval of  $T$  periods, vector of demand levels will be equal to  $\bar{C}_T = \bar{C}_0 \times P^T$ . Let us plot the same for preferences which changed upon products promotion.

Figure 1 shows graphs of demand change in respect of previous (Former) and innovative (Next) products and dynamics of income (Profit) under conventional promotion. Change of market promotion tactics is causing principal change of the general view (figure 2). It can be viewed that unlike provisional variant, there is a steady profit growth, and targeted promotion is causing innovative products sales growth.



**Figure 1.** Sales-profit dependency for Former/Next.



**Figure 2.** Targeted promotion impact on profit.

This example shows that even with limited dimensionality it is required to employ serious mathematical models [15] and computer-based calculations. This can be explained by the fact that under the condition of market uncertainty only stochastic process investigation machinery provides the manager with appropriate tool allowing to take correct managerial solutions.

## 5. Conclusion

By linking data derived from the proposed model with a set of economic indicators characterizing company activities we can obtain an efficient financial tool enabling determination of ROI (return on investment) or ROR (rate of return) which makes it possible to exercise planning (in the mode close to on-line) of current and long-range activities on the basis of customer feedback. Ability to update plans in dynamic mode means transition to leading indicators. As a result, it is possible to achieve optimization of expenses associated with products and services promotion – a most important cost item affecting the budget savings. Increase of on-line sales, transition to virtual platforms caused fiercer competition in the sphere of large network business. Maximum efficient employment of available client communication tools is the first priority task of the managers. Liability of economic environment, level of consumers' well-being, proportion of their profit intended for spending, changing preferences and general macroeconomic background volatility make planning even for 2-3 years' horizon a rather serious task.

It should be mentioned that two-dimensional problem from the sphere of marketing (known as TM Problem) [16], is a specific instance of aforesaid mathematical model. Employment of findings gained hereunder is not limited by the sphere of material products materialization. Practical implementation range may be expanded by means of services provision [17] including those pertaining to medical sphere, information, technical maintenance, show business and entertainment industry. It is possible to particularly mention an important (for large cities and resort areas) tourism segment [18] including hotels, air and railway tickets booking. Monitoring during peak season shall be maintained minimum twice a week. Most advanced direction in using this type of models – emerging and constantly growing segment of on-line sales in 5PL paradigm (Fifth Party Logistics) [19].

Namely using this digital technology-based network communication between consumer, supplier and manufacturer it is possible to realize fullest potential of scientific methods used by managers in the process of planning and management.

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