Information support for trade with the use of a conversion funnel

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Abstract. A contemporary tendency of providing commercial activity with ways of digital communication is related to solving the problem of online trade forecasting with the help of customers’ feedback. At the same time introduction of e-commerce and wide exploitation of information technologies led to transformation of traditional sales funnel. This work is devoted to the research of the conversion funnel as the next step of leading indicators system’s implementation to the trade activity. The results of elaborated formalized mathematical model are stated, an example of calculation is set. The results of research are aimed to provide managers of commercial enterprises with a convenient method of sales analysis and operating activity’s organization.

Introduction

The process of the commercial service must be investigated in dynamics. The CRM (Customer Relationship Management) systems are used to assess the economic indicators. The sales funnel had been one of the most convenient for many years. It is based that for business owner, a sales funnel is probably the most important marketing tool. In recent years, sales technology has changed significantly, primarily due to the growth of the online segment, e-commerce. Meanwhile, the structure of the sales funnel has changed. The most important difference is the ability to obtain real-time [1] conversion data during the transition between stages. In the theory of sales, a new term conversion funnel has appeared. This concept is derived from the area of e-commerce, the sale of products or services over the internet. It refers, for example, to a conversion of a visitor into a buyer.

Problem statement

The tasks of forecasting, optimization of trading activities, expert systems require a strictly formalized description of the processes when customers pass through the stages of commercial activities. A two-dimensional representation of the sales funnel, common in the literature, gives a purely schematic representation of the processes. Usually the movement from leads to cash is formally [2] described. Also, depending on the business segment, traditions and legislation, the stages may differ slightly, but the general principle remains. If we compare the main stages of interaction with consumers in the conditions of offline trade and e-commerce, we can reflect them in Table 1.

Table 1. Stages of interaction with consumers

| Stage      | Sales funnel                                      | Conversion funnel                                      |
|------------|---------------------------------------------------|-------------------------------------------------------|
| Awareness  | Prospecting. Unqualified leads.                   | Landing page, targeted page, blog posts,              |
| Discovery  | Qualifying leads, Initial meeting, Define         | Content, marketing, inbound marketing,                |
|            | prospects needs                                   | online ads. Opportunity size                          |
| Evaluation | Make an offer                                     | SEO search engine optimization, SEM                   |
|            |                                                   | Search Engine Marketing viral campaigns,              |


With conversions, the conversion rate can be measured. This is the percentage of all visitors who have eventually converted. The success of marketing activities is measured using the conversion rate of online shops. It should be noted that the conversion funnel reflects primarily not the behavior of the audience (consumers), but the technology of the marketer’s (or seller).

The task of this work is to develop a mathematical model [3] of conversion funnel processes in the conditions of market uncertainty. The result is an algorithm for predicting economic indicators of commercial activity.

The main formalisms

While studying economic objects, the problem of identifying processing parameters will allow a business to switch to leading indicators. The conversion characteristics of the conversion funnel stages should be determined, therefore, the evolution of the number of clients of a commercial enterprise is considered. Such an applied problem of economics is solved using mathematical models. In this case, there will be used equations with distributed parameters. Now, the task of transforming the customer base during the passage of all stages of interaction is being described (for example, from cold call to making the final payment). These models contain unknown quantitative characteristics reflecting the quality of the work of business units.

The solution is obtained by restoring [4] the processing parameters. This is possible using the apparatus of inverse problems of mathematical physics. Partial differential equations [5-6] give integral characteristics of the effectiveness of the organization of work within the relevant unit. In doing so, information obtained from a quantitative cross section of economic indicators in various services of a commercial structure is used.

To formalize the task, there is entered the axis $X$ of the process division into stages, the axis $Y$ on which the numerically measurable number of transactions are transferred (requests, customers, contracts, offers). In addition there is a time axis $t$.

To compile dynamic equations $W$ (wastage) is defined as intensity of potential customers dropping out (bounce rate) commercial service with gradual progress through the stages. There is $Q(x,t)$ - the quantity of clients (or intensity per time unit) at the moment $t$ on the stage $x$.

Mathematical model

In the area from $x_1$ to $x_2$ at some point in time $t$, there can be written the following:

$$W = \frac{Q(x_2,t) - Q(x_1,t)}{x_2 - x_1}.$$ Moving [6] on to the limit: $\lim_{x_2 \to 0} W = -\frac{\partial Q}{\partial x} \bigg|_{x=x_2}$. In that $W$ is seen as value proportional to bounce rate during the progression on the axis $X$. Accordingly, the bigger $W$ - the steeper conversion funnel narrows. At the entrance the $\frac{\partial Q}{\partial x} \bigg|_{x=x_2} \Delta t$ clients goes through $x_1$ at considering area for the time $\Delta t$, and at the exit from $x_2$ the $\frac{\partial Q}{\partial x} \bigg|_{x=x_2} \Delta t$ clients goes out. Thus, total loss on the area from $x_1$ to $x_2$ for the time $\Delta t$ equals:

$$(W(x_1) - W(x_2))\Delta t = -\frac{\partial Q}{\partial x} \bigg|_{x=x_1} \Delta t - \left( -\frac{\partial Q}{\partial x} \bigg|_{x=x_2} \Delta t \right).$$
Now, there is indicator \( g(x) \), (grade of service) which represents work effectiveness of commercial service on stage \( x \). In that the professional qualities of enterprise managers are considered. The function \( g(x) \) - is integral effectiveness indicator \([7-8]\) of the organization inside according unit which is in contact with client on this stage. The higher \( g(x) \) - the more organized is work of the unit. Conversion rate is calculated via formula:

\[
g(x)^{-1} \Delta x(Q(x,t_2) - Q(x,t_1)) = g(x)^{-1} \Delta x \Delta Q.
\]

Moreover, the work of the commercial service can be influenced by the external market environment. For example, the withdrawal of some customers to competitors as a result of aggressive policies, changes in legislation (for example, opening a foreign market or vice versa sanctions), conditions (inflation, crisis, etc.). Also, random factors \([9]\) influence the client's decision (for example, a change of fashion, the refusal of a transaction due to too large time delays).

It is required to foresee possibility of accounting this influence. The functional dependency \( D(x,t) \) (Disbenefits) is necessary to be introduced. This function shows the level of influence of market uncertainty on the bounce rate of customers over the past one stage. The total quantity of loss equals: \( g(x)^{-1} \Delta x \Delta Q - g(x)^{-1} D(x,t) \Delta x \Delta t \). Equating the left and right sides:

\[
-\frac{\partial Q}{\partial x} \bigg|_{x=x_1} \Delta t - \left( -\frac{\partial Q}{\partial x} \bigg|_{x=x_2} \right) \Delta t = g(x)^{-1} \Delta x \Delta Q - g(x)^{-1} D(x,t) \Delta x \Delta t.
\]

Remarking, the separation of stages along the axis \( x \) implies finding customers at each stage in the scope of one service activity. Meanwhile, all employees have the same authority, qualifications, use the same type of hardware and software. Inside of the stage number \( n \) value \( g(x) \) is constant and equal to \( g(x) = g_n \). Writing again the equation there is one for the stage \( n \):

\[
-\frac{\partial Q}{\partial x} \bigg|_{x=x_1} \Delta t - \left( -\frac{\partial Q}{\partial x} \bigg|_{x=x_2} \right) \Delta t = g_n^{-1} \Delta x \Delta Q - D(x,t) \Delta x \Delta t.
\]

Taking out \( \Delta t \) and as \( \Delta x = x_2 - x_1 \), the Lagrange theorem is applied. The result is differential [10] equation:

\[
g_n \frac{\partial^2 Q}{\partial t^2} + D(x,t) = \frac{\partial Q}{\partial t}.
\]

Now the type of dependencies will be \( g(x) \) and \( D(x,t) \). The methods of queuing theory are used to do that. As noted above, at each stage managers have the same skill level. Denote their performance by \( \mu_n \), where \( n \) - the number of stage. There is introduced \( \lambda_n \) - customer flow density from the previous stage, \( m \) - quantity of managers working with clients, \( D \) - maximum quantity of them waiting for transition to the next stage. Than to calculate \( g(x) \), the formula for determining the conversion rate is used in the following form:

\[
g_n = 1 - \frac{\lambda_n^{m+D}}{m D \mu_n^{m+D} m!} \left[ \sum_{k=0}^{m} \frac{\lambda_n^k}{k! \mu_n^k} + \frac{\lambda_n^{m+1}}{m! \mu_n^{m+1}} \left( 1 - \frac{\lambda_n}{m \mu_n} \right)^D \right]^{-1}.
\]
For modeling $D(x,t)$ (Disbenefits) parameter $v(t)$ is used as an indicator of the intensity of withdrawal of potential consumers due to the uncertainty [11] of the market situation. Then, denoting $\alpha_n = \lambda_n / \mu_n$ follows the next equation:

$$D(x,t) = 1 - \frac{v(t)}{\lambda} \left[ \sum_{i=0}^{m} \frac{\alpha_n^i}{k!} + \frac{\alpha_n^m}{m!} \sum_{i=0}^{\infty} \frac{\alpha_n^i}{\left( m + k \frac{v(t)}{\mu} \right)} \right]^{-1} \sum_{i=0}^{\infty} \frac{\alpha_n^i}{\left( m + k \frac{v(t)}{\mu} \right)}$$

As a result, a complete set of formulas for a mathematical model [11-12] of processes in conversion funnel is obtained.

**Calculations and results.**

Formulas were programmed with the application of Mathcad software package on the basis of developed mathematical model. There formulas connect following indexes: $Q(x,t)$ - amount of clients in $t$ point of time on the $x$ stage; $g(x)$ - grade of service; $\alpha_n$ - disbenefits; $\mu_n$ - productivity; $\lambda_n$ - traffic dencity and $W$ - bounce rate. The data used has been granted by “Mobyco” company that undertakes commercial activity on the basis of B&M business model. 3-D diagrams of conversion funnel modeling were resulted (illustration 1). In so doing time data (Time) and number of stage (Stage) are indicated on the plane XoY. Number of transactions (requests, customers, contracts, offers) are indicated on the Z axis.

**Figure 1** Three-dimensional diagram of the conversion funnel

From the analysis of the data given on the figure 1 it can be delivered that any of sections of this histogram will give a classical view of sales funnel. It will let to calculate the most efficient variant of commercial activity organization on the overall costs minimization basis. As a result the diagram of the most optimal work realization in terms of initial data can be built (figure 2).
The most profitable result can be acquired according to the calculation of best performance with measuring data of each stage (illustration 3). It became possible due to the fact that conversion level had become steadier on every level. As a result it lets to gain the best economical performance.

As 3-D interpretation of calculation result is quite convenient, analysis of graphic representation of mathematical modeling results with the usage of computer leads to conclusion that optimal progression in terms of conversion funnel represents a track on XoY plane. In conformity a manager can use projections of Q level to form optimal commercial decisions.

**Application of results**

For practical results, it is important to obtain expressions for calculating the amount of profit from the activity for a certain period of time. In addition, the management of an enterprise can influence the
values \( g_n \) through organizational and personnel interventions, as well as the implementing of various technologies. Accordingly [13-14], it is necessary to obtain recommendations for achieving the maximum profit for the planned period by choosing the optimal values \( g_n \).

As an example of the use of the proposed method, consider the link of conversion funnel with the widely used [15-16] logistic curve economists. There is denoted \( Q_0(t) \) as the number of clients at the initial stage, value \( \Omega - \) customer pool capacity (potential customers). Then according to Verhulst equation:

\[
\frac{dQ(t)}{dt} = \theta Q(t)\left(1 - \frac{Q(t)}{\Omega}\right),
\]

where parameter \( \theta \) is a rate of change of preferences. The exact solution to the equation is the S-logistic function:

\[
Q(t) = \frac{\Omega e^{\theta t}}{\Omega + \Omega e^{\theta t}}.
\]

Remarkably, the starting value differs from zero, since there was an initial pool of pre-orders for this product. The first derivative gives an estimate of the intensity of the change in the number of clients entering the conversion funnel. It is calculated this way:

\[
Q'(t) = \frac{\theta \Omega Q(t) e^{\theta t} (\Omega - Q(t))}{\Omega + \Omega e^{\theta t}}.
\]

Since in reality there is discreteness, the Feigenbaum logistic map is usually used. Sales funnels are right for businesses that rely on a high degree of prospect interaction and engagement to make sales or close deals. Their sales process may be long and complex or they may be selling a high-ticket item that requires a lot of consideration by the customer. Both B2B and B2C businesses use sales funnels.

Conversion tracking is used both by web masters and affiliate networks to review performance. The latter use conversions made in the affiliate program as a basis for their payments to publisher. Creating a conversion funnel helps teams identify sales and marketing activities that will help to build trust and increase customer engagement. Once created these tasks can be built into CRM tools, helping teams, manage leads, stay on task, and prioritize their follow up efforts.

**Conclusions**

The interpretation of work results can be considered as a tool for the commercial service manager. Using the set of restored function values \( g(x) \) it is possible to evaluate the results of activities at all stages in dynamics, and make decisions about the redistribution of the load. A precise analysis of all relevant phases of the funnel can provide information about possible problems. Usability tests can also make weaknesses in the ordering process known. To increase the likelihood of purchase, various optimization approaches can be applied. The recognition of customers is according to this study of great value and can motivate them to buy. Through this, trust signals such as high usability and performance of the website can increase the chance of a conversion. Another equally important result is the ability to predict both the volume of secondary demand and related terms. Thus, investment planning will be made on the basis of a weighted analysis, which will allow assessing risks and provides an additional justification for the possibility of attracting credit funds.

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