Modeling Consumer Behavior in a Market Economy

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Abstract

The article deals with the current topic of modernity – modeling of consumer behavior. The instability of a complex socio-psychological system, such as consumers, which is virtually impossible to completely study and understand, increases in the context of a market economy. Making adequate decisions requires a deep, comprehensive assessment of the situation and a reliable forecast of the course of events. A firm that has managed to correctly predict the situation receives an additional profit compared to the one that refrained from forecasting. A firm that made the wrong forecast loses the most. The present work considers the main consumer behavior models, as well as factors influencing decision-making, and consumers/ preferences. The authors carried out a comparative analysis of the consumer behavior models. The approaches used in the work were the cognition method, retrospective and documentary analysis, as well as synthesis, generalization, and systematization.

Key-words: Model, Consumer, Consumer Behavior, Utility, Human Status, Decision-Making.

1. Introduction

Any economic phenomenon is an individual element of the economic relations system, different from others, however, at the same time, connected with them. The multiplicity of factors that determine the economic phenomenon makes it extremely difficult to study it. Today, economic and mathematical models are widely used to analyze economic phenomena. They represent a description of an economic phenomenon using mathematical formulas. Mathematical modeling makes the phenomenon quantifiable. By abstracting from reality, researchers have access to powerful

mathematical methods that allow looking further than the experience of previous years, predicting the object's behavior when changing any of the affecting factors [2, 3].

As an example of economic and mathematical models, one can cite supply and demand forecasting models, economic growth models, a model describing the formation and evaluation of an asset portfolio, a consumer choice formation model, etc.

Currently, given the market economy development, the orientation of producers and retailers to the consumer, high market competition, the issue of analyzing consumer behavior becomes particularly relevant. Simulation consumer behavior is the process of identifying the relationship that exists between the socio-psychological object (the buyer) and the opportunities, motives that drive a person when making a purchase [5, 6]. The more accurately and in detail, the above relationship is described, the greater the probability of predicting consumer behavior, and therefore the success of the company.

On this account, in the framework of the present work, the authors consider the model of consumer behavior, and the main related concepts, such as budget set, utility function, and marginal utility.

2. Methods

2.1 Budget set

Let's select a certain group with an arbitrary number of products. In this case, the product is understood as some good/service that is offered to the consumer. Let i be the type of product, and x be the quantity of the i-th product, then the selected group can be represented as X=(xi,..., xn). Essentially, the set X can be a consumer basket, where the goods can be found both in a single and in several copies. Let's denote the price of each product as p_i. Then the price of the selected products of the set can be denoted as P=(p_1,..., p_n), and the price of the entire consumer basket will be PX= p_1x_1+...+ p_nx.

The ability of the buyer to purchase a particular set of goods depends on his level of income. Let us denote Q as the monetary funds available to the consumer who wants to purchase goods. The set of goods at prices (p_1,..., p_n), whose total price (PX) does not exceed the available consumer's funds Q is called the budget set (B).

The budget set and its boundary can be defined using the usual inequalities and equalities:

$B(P,Q)=\{(x1,\ldots,xn): x1,\ldots,xn \geq 0, p1x1+\ldots+pnxn \leq Q\}$

$G(P,Q)=\{(x1,\ldots,xn): x1,\ldots,xn \geq 0, p1x1+\ldots+pnxn \quad Q\}$

as well as using vector inequalities and equalities:

$B(P,Q)=\{X:X \geq 0, PX \leq Q\}; G(P,Q)=\{X:X \geq 0, PX \quad Q\}.$

Thus, the budget set can be characterized as a set of benefits that an individual, participating in the economic system, can receive with a certain income available to him. As mentioned earlier, the consumer acts according to the axiom, which states that the decision to consume a certain set of goods is made by the buyer solely based on their specific preferences. In other words, the choice of what goods to consume depends on the personal tastes and desires of an individual, and exactly these factors affect the appropriate choice of the buyer [12, 15, 16].

The combination of sets of goods, whose total price is equal to Q, is the boundary of the budget set G.

If the consumer chooses between two products, the budget set of the buyer will consist of all the product sets lying in the shaded part of the graph shown in Figure 1.
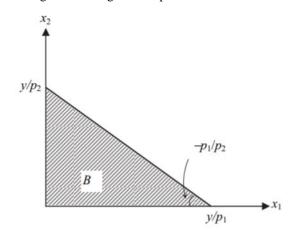
Figure 1 - Budget set of products x1 and x2.

Figure 1 shows that the boundary line of the budget set has a negative slope. This fact indicates the possibility of the consumer to purchase more than one product only by refusing a certain number of other products which occurs due to the limited funds of the buyer.

Thus, the consumer's choice is determined by the means at his disposal and the prices set for the goods. In real conditions, in addition to the above factors, consumer preferences have a key influence on the formation of the consumer basket [9, 10].

2.2 Utility function

In economic theory, there were two approaches to defining the concept of utility – cardinal (quantitative) and ordinal (ordinal). The adherents of the first approach (U. Jevons, K. Menger, L. Walras) [17-19] believed that it is possible to measure the exact amount of utility of a good extracted by the consumer, using the util as a measurement unit. However, it was later proved that this is impossible since the product can be of great value to one consumer, while for another be useless. Then the quantitative approach was replaced by the ordinal approach, which is today the most common. Ordinalists (F. Edgeworth, V. Pareto, I. Fischer, R. Allen, and J. Hicks) [20-22] believed that the utility of individual goods cannot be measured independently, while the order of preference of sets of goods can be measured. The consumer systematizes the choice of a set of goods according to the level of satisfaction. For example, he gets the most satisfaction from the first set, less satisfaction – from the second set, and even less – from the third.

The consumer preference system can be described employing several axioms, which together reflect the idea that the consumer can make consistent choices.

The completeness axiom states that for any x1 and x2 of the set X, x1 is not worse than x2, or x2 is not worse than x1. The axiom implies that the consumer has sufficient information about the product, distinguishes it, and can compare it.

The axiom of transitivity states: for any x1, x2, and x3 if x1 is not worse than x2, and x2 is not worse than x3, it follows that x1 is not worse than x3. The axiom notes the consistency of consumer choice and implies that the consumer always compares only two products. Even though at first glance, this axiom reflects quite natural things, it is quite controversial. Studies have shown that in practice, the conditions of transitivity are not always met, and the buyer is capable of unexpected actions driven by factors known only to him.

The axiom of insatiable needs states that consumers always prefer a larger amount of any good to a smaller one. However, this axiom does not apply to goods with negative utility, since they lower the level of well-being of a given consumer. Thus, environmental pollution, high noise levels reduce consumer utility.

Thus, it follows from the above axioms that the consumer can independently evaluate the goods and order them according to their increasing utility [1, 4].

To summarize the information about the relationship of customer preferences, the authors introduce the utility function. Imagine that a certain number u(x) corresponds to each product set x, reflecting the degree of its usefulness. Then the following conditions hold:

$u(x_1) <= u(x_2)$, if and only if when $x_1 <= x_2$;

$u(x_1) < u(x_2)$, if and only if when $x_1 < x_2$;

$u(x_1) = u(x_2)$, if and only if when $x_1 = x_2$.

The main properties of the utility function are:

- $\dfrac{du}{dx} > 0$, the utility of goods for the consumer increases with the growth of the consumed goods;

- $\dfrac{\lim\limits_{x_i \to 0} du}{dx_1} = \infty$, in the case of the initial absence of a good, even a small increase in the consumed goods contributes to a significant increase in utility;

- $\dfrac{d^2u}{dx_i^2} < 0$, an increase in the consumption of a good leads to a slowdown in the growth of utility. For example, by eating the first sandwich, a hungry customer gets more benefit from it than from each subsequent sandwich bought and eaten.

- $\dfrac{\lim\limits_{x_i \to \infty} du}{dx_i} = 0$, if there is a very large amount of good, its growth does not lead to an increase in utility. In the veracity of this property, you can be convinced by observing how a person evaluates water and gold. Water is irreplaceable for a person, but since it is available, it is cheaper than gold, without which it is possible to do.

Marginal utility is the increase in total utility that occurs due to an increase in the consumption of a good by one more than the previous level of consumption. [13, 14]. The marginal utility of a commodity is nothing more than the limit of the ratio of the increment of utility to the increment of the purchased commodity that causes the growth in question

$$\dfrac{\lim\limits_{\Delta x_i \to 0} \Delta du}{\Delta dx_i} = \dfrac{du}{dx_1}.$$

Most goods have the property of decreasing marginal utility, according to which the greater the consumption of a certain good, the smaller the increment of utility obtained from a single increment of consumption of this good. This explains why the demand curve for these goods has a

negative slope. For a hungry person, the usefulness of the first slice of bread consumed is very high, however as his appetite is satiated, each subsequent slice of bread brings less and less satisfaction.

The concept of the utility function is closely related to the concept of the indifference curve. The indifference curve is a curve that graphically reflects alternative sets of two types of goods (taken in different or the same quantity), of which each is equally useful to the consumer.

In Figure 2, the indifference curve goes down from left to right. If the indifference curve would be directed upwards, from point A towards D, it would contradict the assumption that the more consumer goods, the better. Since set D contains more of both goods than set A, set D is preferable to set A, and thus cannot be on the same indifference curve as A. Any set of goods located above and to the right of the indifference curve U_1 in Figure 2 is preferable to any set on curve U_1.
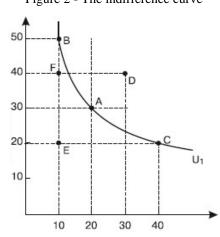
Figure 2 - The indifference curve

Indifference curves are characterized by the following properties.

- The indifference curve, which is located to the right and above the other curve, reflects the sets of goods most preferred for the consumer.
- The indifference curves are characterized by a negative slope since the consumer is rational and prefers a larger amount of any set to a smaller one, which is reflected in the axiom of insatiable.
- Since the marginal substitution rates decrease with saturation, the curves have a concave shape.
- The indifference curves never intersect and usually illustrate the decreasing marginal rates of substitution of one product for another.

- Sets of goods located at more distant coordinates from the origin are more preferable than those located closer to the coordinate axes.

The ordered indifference curves form the indifference map, which graphically describes the increase in consumer benefit as passing through each subsequent indifference curve from the coordinate origin. The map of indifference curves gives an idea of the preferences of a particular consumer since it illustrates the rate of replacement of two goods at any level of consumption of these goods. When talking about the fact that the preferences of consumers are known, means that the entire map of the indifference curves is known, rather than the current ratio of units of two goods. On a map of indifference curves, each curve combines points with the same utility. The intersection of the indifference curves is impossible because it would mean that the buyer is acting irrationally. The indifference map is shown in Figure 3.
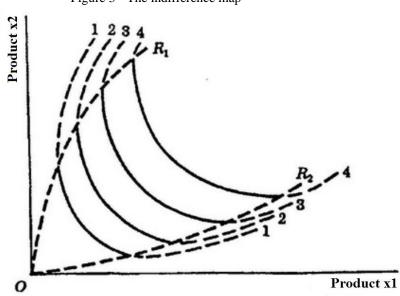
Figure 3 - The indifference map

The indifference curves can be represented as curves 1-4 shown in Figure 3, however, only the sections of the curves marked with a solid line and bounded by lines R1 and R2 can be considered realistic. This is because the buyer is satisfied with the utility of the product X1 as soon as the indifference curve becomes horizontal, and the utility of the product X2 as soon as the curve becomes vertical.

Thus, in the current situation, the consumer will no longer seek to saturate the utility of these goods, and therefore will not be ready to give up a few units of X2 in favor of X1 or a few units of X1 in favor of X2.

2.3 The task of maximizing utility

When making a purchase, the consumer seeks to maximize the utility or satisfaction of spending the funds available to him [7, 8].

If the indifference curve shows what the buyer would like to buy, while the budget line indicated what the consumer can afford within their budget, then together these curves could answer the question of how to achieve maximum satisfaction from the purchase in the context of limited resources. A graphical solution to the problem of maximizing the utility of the consumer is presented in Figure 4 and represents a touchpoint at which the budget line only touches, but does not intersect the indifference curve that is farthest from the coordinate origin.
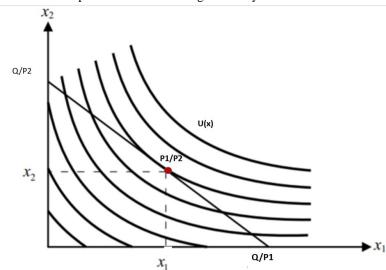
Figure 4 - Graphical solution of the problem of maximizing the utility of the consumer basket

Thus, the optimal set of consumer goods must meet two conditions, namely, be located on the budget line and provide the consumer with the most preferred combination of the two goods.

Mathematically, the problem can be represented as follows:

$$\begin{cases} u(x_1, x_2) \to max \\ p_1 x_1 + p_2 x_2 \leq Q \\ x_1 \geq 0, x_2 \geq 0 \end{cases}$$

It is necessary to find such a set of products $(x_1,...,x_n)$ that would satisfy the condition of a limited budget $p_1x_1+...+p_nx \leq Q$ and at the same time maximize the utility of the basket in general $u=(x_1,...,x_n)$. The solution of the problem is reduced to the solution of the following system of equations:

$$\begin{cases} \dfrac{u_1'}{u_2'} = \dfrac{p_1}{p_2} \\ p_1x_1 + p_2x_2 = Q \end{cases}$$

The budget set B is nonempty and is a compact subset of the set R^n. The utility function $u(x)$ is real-valued, continuous, and concave, which indicates the existence of only one set of goods that will meet the specified requirements in terms of price and utility.

Thus, one can conclude that there is only one set of products that can provide maximum utility for a given budget. The only point of intersection of the utility function $u(x)$ (the indifference curve) with the boundary of the budget set is called the demand point or the consumer equilibrium point.

Let us consider the specific task of maximizing the utility of the consumer basket. Suppose a consumer wants to buy oranges and chocolate bars for 540 rubles. At that, the utility function of oranges for him is $u1 = 3x_1^2 + 17$, while chocolate bars – $u2 = 6x_2^2 + 24$. One kg of oranges costs 120 rubles, while one chocolate bar – 60 rubles. The question is how many kilograms of oranges and how many pieces of chocolate bars the buyer needs to buy to get the greatest benefit from their purchase.

The problem is solved by solving a system of equations:

$$\begin{cases} \dfrac{u_1'}{u_2'} = \dfrac{p_1}{p_2} \\ p_1x_1 + p_2x_2 = Q \end{cases} => \begin{cases} \dfrac{\left(3x_1^2 + 17\right)'}{\left[\left(6x_2^2 + 24\right)\right]'} = \dfrac{120}{60} \\ 120x_1 + 60x_2 = 540 \end{cases} => \begin{cases} \dfrac{6x_1}{12x_2} = 2 \\ x_2 = 9 - 2x_1 \end{cases} =>$$

Thus, based on the given utility functions of the consumer, it can be concluded that to get the maximum utility from the purchase, the consumer needs to buy four kg of oranges and one chocolate bar.

3. Results

The study of the consumer in the marketing system aims at establishing the full scope of the motivating factors that the buyer follows when choosing products. Factors of this kind are by nature social, psychological, and economic, namely, are dependent on demography, income, prices, traditions, group interests, motivation, etc. [11, 23]. In general, modeling customer behavior makes it possible to understand, on the one hand, the response of consumers to the motivating factors of marketing, while on the other – what exactly is a significant competitive advantage for the enterprise. At that, it is extremely important to establish the conditions influencing consumer's decision-making, as well as to study the segments of consumers, and to choose the type of model which will serve the basis for building the marketing policy of a particular enterprise. Simulating consumer behavior provides an increase in the effectiveness of an advertising campaign and commitment to a particular brand.

In today's environment, it is extremely important to have an idea of what a potential consumer might want. Behavioral simulation is a fairly useful analytical solution that can help to cope with this problem. However, such a solution cannot serve as a full-fledged alternative to a good manager. On the other hand, this tool can significantly increase the effectiveness and forecasting capabilities.

Consumer behavior is influenced by several important factors. The first of them is the preferences of a particular consumer, i.e. which set of goods will best meet their needs. Second, the consumer determines the best set of benefits based on their budget constraints. In such conditions, the best consumption plan for each particular consumer is determined by taking into account the fact that the consumer wants to get the greatest utility from a set of goods.

4. Conclusion

The model of consumer behavior and the main related concepts were considered, such as budget set, utility function, indifference curve, and marginal utility. It is revealed that the main guide when choosing products for the consumer is the utility of the purchase and its cost. Consumer behavior simulation is carried out assuming that the consumer has sufficient information about the product, can compare two products, and does not make a choice that contradicts common sense. The utility of goods for the consumer increases with the growth of the consumed goods. In the case of the initial absence of a good, even a small increase in the consumed good contributes to a significant

increase in utility. An increase in the consumption of goods leads to a slowdown in utility growth. The growth of a very large amount of goods does not lead to an increase in utility.

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