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COMPUTER CONSUMER BEHAVIOR MODELING: MULTICRITERIA MODEL FOR CHOOSING IONIZERS

Liudmyla DOROKHOVA[1], **Oleksandr DOROKHOV**[2]

Abstract

The object of the research in this article is the development of approaches, tools and instruments for computer modeling to predict the behavior of consumers (potential buyers and users) in the process of their implementation of consumer choice of technically complex household goods under circumstances of broad supply in the retail market. Accordingly, the subject of this study was to consider the problem of multi-criteria choice of domestic appliances available on the Ukrainian home appliances market for monitoring and maintaining indoor air condition. The formulation and realization of relevant tasks with the subsequent development of applied program models were among the main goals of this work. As main methods we consistently used expert surveys of potential consumers, collection, processing, systematization and analysis of information about the models of ionizers of air on the domestic market. Approaches to multi-criteria modeling of the process of consumer choice on a set of alternatives and their computer implementation in a specialized software product have also been taken into consideration. Computer simulation has confirmed the hypothesis that the approaches proposed makes it possible to obtain mathematically grounded generalized comparative estimates of the household appliances considered. This, in turn, allows consumers to make their choice more consciously, while manufacturers and sellers of such equipment are enabled to make a multi-criteria comparison between the products produced and sold by them.

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Key words: consumers behavior computer modeling, choosing household ionizers, products evaluation by buyers, multicriteria customers choice

1 Introduction

In the context of the globalization of the world economy and the entry of the countries of the former post-Soviet political and economic space into the international trade system, the supply of various goods (of different producers and

[1]National Pharmaceutical University, Ukraine, e-mail: liudmyladorokhova@gmail.com
[2]Kharkiv National University of Economics, Ukraine, e-mail: aleks.dorokhov@meta.ua

countries) has increased considerably. This fully applies to Ukraine, in particular, to its market of complicated household appliances.

At the same time, the general development of consumer self-awareness in Ukrainian buyers leads to a more conscious choice of the goods they buy. Therefore, there is a need for one or another analytical analysis that can be used to solve such problems as for forecasting consumer behavior, and for a comparative multiparameter analysis of goods on the market (similar in terms of basic user characteristics) of goods.

On the other hand, such models allow manufacturers, distributors, sellers of complex domestic appliances to compare different models of the same type but different by characteristics, price, manufacturers, brands etc. This makes it possible to select and recommend potential customers the most specific models of complex home appliances that meet their individual preferences and requirements.

2 The study of consumer behavior

As a scientific direction, the study of consumer behavior occurred in economic science in the middle of the previous century, as a composition of several different scientific paradigms. So, in research [10] consumer behavior is defined as "the acquisition, consumption, and distribution of goods, services, time and ideas with the use of decision-making."

At the same time, [5] focuses on internal decision-making processes in the definition of this concept: "consumer behavior is the action of persons directly involved in the acquisition and use of economic goods and services including the decision-making processes that precede and determine these actions."

In [16], consumer behavior is defined as "processes associated with situations when individuals or groups select, buy, use or sell products, services, ideas or experiences to meet needs and desires." At the same time, [7] focuses on "the study of individuals, groups or organizations and processes they use to select, secure, use and dispose of goods, services, experiences or ideas to meet needs and consequences which these processes have for the consumers and society."

From the point of view of marketing, according to [1, 8], this concept is distinguished by the "dynamic interaction of effect and cognition, behavior, and the environment through which people carry out the exchange aspects of their lives." The essence of this definition is confirmed in [12], where the authors focus on the main stages of consumption - information retrieval, decision making, use, and disposal.

It can be concluded that the above definitions reflect the dynamics of a change in the understanding of the concept in time. So each definition is representative of the time interval in which it was developed. Thus, the evolutionary development of these definitions under the influence of the expansion of relevant knowledge illustrates the progress of studying and understanding consumer behavior as a field of study.

If in the beginning consumers' behavior was perceived as a closed set of certain

facts (factors), then modern research represents the process of making decisions about buying and consuming goods much wider, longer and deeper than simply, directly the act of buying.

Moreover, less obvious concomitant and underlying conditioning processes, such as causality, environmental impact, social determination, etc., are included in the actual analysis of consumer behavior and are not considered only as external, separated, isolated and secondary factors that are inherent only in the beginning of purchases.

In general, there are two main aspects that are common to all of these definitions. First of all, the consumer is perceived as the main actor acting on the market scene. However, consumer interact with other types of agents in the decision-making process, by subjects that can influence their buying behavior.

For example, the potential consumer (user) of the purchase and the person who made the purchase are often two different people. It is not difficult to see that earlier definition called *consumer behavior research* is not really a consumption study, but a consumer purchase.

At this moment the scientific literature of the last years has significantly clarified, explaining the difference between what is called *buyer behavior* and *consumer behavior* or *behavior of user*. However, the commonality of these definitions is the recognition of the dynamic and multidimensional nature of decisions and judgments that precede and follow the act of buying a particular product, service and goods.

This process begins as soon as an individual identifies its own need, as a result of the influence of internal or external stimuli. This forces him to act to find information about the means to meet this need in an active, passive, conscious or unconscious manner [17].

The next natural step is to evaluate alternatives and process information that can lead to a purchase. However, the results of the interaction between assessments and incentives that significantly affect the search process and its results are not always amenable to direct forecasting [11].

Acquisition and consumption often generate new incentives and relationships. They, in turn, can serve as prerequisites for other purchases made by the same person or may affect the perception and behavior of other people. It should be noted that there are cases when the transfer of experience between people or processes occurring in the memory of one person are beyond the reach of what can be observed or controlled [15].

Typically, the consumer goes through certain standard stages of decision making at each purchase. In the case of some permanent, regular acquisitions (such as for example, conventional purchases), consumers often miss some of these stages.

The complexity of internal (external) factors, as well as controlled (uncontrolled) processes associated with the decision-making process and behavior immediately upon acquisition (after purchase), makes direct observation an inadequate means of understanding and predicting consumer behavior. As a consequence, it becomes necessary to use more sophisticated research tools [3, 4].

Often these tools are borrowed from other disciplines. In chastity, the study of consumer behavior largely depends on research in economics, psychology, anthropology, and sociology, having an applied dimension. This interdisciplinary nature provides a marketing framework for studying consumer behavior as a distinct, clearly defined area of modern economic research. The economic practice also confirms the importance of studying consumer behavior as a field of marketing research, without which successful activities in modern competitive globalized markets are impossible.

Recently, the main focus is on identifying the characteristics of consumer behavior from different points of view. Researchers are trying to understand and analyze the behavior of consumers from different groups and segments of the population, as an organic component of economic interaction in a society in which consumers exist and operate. For this, theoretical approaches of social psychology, anthropology, and even linguistics are widely used. After all, there is no clear dichotomy between strategic material, social and spiritual interests in consumer behavior.

The study of consumer behavior as an important component of marketing research leads to a more rational use of marketing resources and the development of more effective solutions to marketing problems. To understand and predict the behavior of consumers, marketers should undertake the task of using various tools for analyzing both external influences [14] and potential responses to various external and internal stimuli.

At the same time, customer-oriented management [13] uses only a posteriori behavior analysis or, at best, the diagnosis of consumer reactions tested in laboratories. Recently, however, it has been proved that the study of consumers and interaction with them should not be aimed only at developing effective strategies for companies, but at the same time at explaining to consumers how they themselves decide to purchase goods, services and distribute their resources [6].

Summarizing the above, we note that the study of consumers and their relationship to purchases and decision-making on them is an extremely topical scientific and theoretical and practical task in the process of improving the economic activities of commercial enterprises in the production and distribution of goods, the provision of services and benefits in a competitive, globalized world market.

3 Behavioral features of consumers of medical goods

As indicated in the literature, the behavior of consumers on the market, including pharmaceutical, is determined by personal, cultural social and psychological factors. This circumstance determines the importance of socio-psychological research in explaining the phenomena and specific features that arise in this particular sphere of consumption. It is necessary to clarify and specify the specific factors that affect consumer behavior and the effect of the psychological mechanisms underlying the behavior of consumers in the market for pharmaceutical products and services.

At the same time, consumer behavior should be considered in the context of the whole life activity of individuals included in the society. So, consumer behavior in the field of health is expedient to study, going beyond the limits of directly consuming processes in the context of the problem of health behavior and diseases in general [8].

In recent years, stable negative trends in the state of public health and people's attitudes toward its preservation have been outlined in Ukraine. On the one hand, health is an integral part of the quality of life. On the other hand, against the background of increased mortality and a reduction in life expectancy, the level of care of the Ukrainian population about their own health is extremely low. Along with this, there is the problem of general dissatisfaction of the population with the quality of medical care and low confidence in official medicine.

The problem of an individual's personal responsibility for his own health, which is extremely urgent in the conditions of reforming the social condition of society and Ukraine as a whole, is becoming increasingly acute. After all, in a globalized information society, the end user is more active than before . At the same time, his responsibility for the decisions made is also increasing. Models of communication between the pharmacist and the buyer also develop and receive new connotations [2, 9].

Such trends lead to the need for a deeper study and understanding of the features of the interaction in the *pharmacist-client* system, which require an explanation and, if possible, prediction . It seems to us that one of the most promising avenues for analyzing this problem is to consider it in the context of studying the psychology of consumer behavior of individuals in the field of health.

An important aspect of the consumer behavior of individuals in the pharmaceutical market is the situation when the intermediary, doctors, and pharmacists, are included in the decision-making process, for which a high degree of involvement in the decision-making process in the consumer choice is characteristic in this case.

The study of the socio-psychological aspects of the behavior of people in the field of health in the pharmaceutical science was developed only in recent times. So, certain issues of the social psychology of health have theoretical coverage and some empirical development in the works of a number of scientists. However, despite deep theoretical ideas and interesting empirical findings, these works often remain fragmentary and isolated.

An important circumstance that must be taken into account when studying the consumption of medical products, in general, is that they refer to goods with *hidden* qualities. That is, the most important characteristics (health, curative effect) are manifested only after the sale when used. Therefore, consumers often lack information (or it is distorted, incomplete, contradictory, incorrect and incomprehensible) about the functional characteristics of technically complex medical and health products (characteristics related to utility, that is, a positive effect on health).

Often the determining factors for choice are the so-called *added characteristics*.

These are properties (quality of goods, medical product), which are not directly related to the curative effect, but affect the choice. The characteristics added may include, for example, the producer country, the manufacturing company, the price, the design and the like. In general, it is clear that providing the population with quality medical care in full implies the availability of high-quality medical products.

An important feature is that often consumers tend to view medical products as a necessary purchase, rather than as a desirable product. Therefore, as a rule, purchase, and consumption are carried out under the pressure of symptoms of the disease or at a feeling of deviation from the normal state of health.

A sick person (a patient) buys a medical device not as such, but as a means (tools) to regain health (or save it) and eliminate the state of discomfort caused by the state of ill health. That is, there is a somewhat different set of motives, needs, and other values, compared with other consumer goods.

Finally, another feature is related to the lack of awareness of the end user about which type of device (from many samples available on the market) he or she needs to choose. These features should be taken into account when conducting and planning research on the modeling of consumer behavior in the market for complex technical goods for health.

It should be noted that, according to the generally accepted opinion, consumer behavior as a subject of research includes two main blocks: models of the process of consumer choice and factors that influence consumer behavior. We will dwell on the analysis of these blocks in relation to end-users in the market for complex medical products to improve the state of the environment (air ionizers for residential premises).

Today in Ukraine, the social psychology of health and the resulting studies of consumer behavior in the pharmaceutical market are only being approved as a new trend in pharmaceutical marketing. Therefore, issues that were traditionally considered to be a sphere of medicine (including pharmaceuticals and marketing in health care) receive a new content.

The content of such research can be defined as a combination of socio - psychological (i.e., conditioned by the direct social interaction of individuals) phenomena (structural aspect) and processes (dynamic aspect), *surrounding* health and diseases.

It should be noted that socio-psychological phenomena and processes (determining the state of health and the corresponding behavior of the individual) operate in two main ways: when they are included in the structure of factors of the social etiology of the disease; and regulating behavior related to health and disease. Next, we will consider the second component, in particular, consumer behavior in the sphere of consumption of medical devices.

In the classical sense, the health-related behavior is any personal activity based on the belief that such activity serves the purpose of health, preventing disease or detecting the disease at the symptomatic stage of the course. In the context of consumption, this may be due to the prophylactic passage of medical examina-

tions, the use of certain preventive medicines and, of course, various sophisticated household medical devices. Behavior associated with the disease - is any activity that leads to illness, the behavior associated with health risks, as well as being in a living environment that is harmful to health.

Finally, behavior in the role of the patient, this is one of the possible facets of the individual's behavior in the disease. It is the activity and actions of a person who feels like a patient and directs his efforts towards achieving recovery. This pattern of behavior differs from the ones above and is determined by the fact that a person consciously assumes the role of a patient and acts on the basis of the goal of recovery.

For today in Ukraine, two tendencies with respect to people's health and its components are observed. On the one hand (mainly for economic and social reasons), people pay insufficient attention to their health, it occupies a relatively low position in the system of consumer values (which is correlated with the results of expert studies of end users).

On the other hand, people's desire for a healthier lifestyle is increasing, and measures are being taken to preserve health. Consumers are increasingly eager to maintain their health status; which is realized in pharmacies and medical equipment stores in the form of buying vitamins, biologically active additives, as well as so-called *health products*, including various complex technical devices and apparatus.

4 Necessity and peculiarities of household appliances used to improve air quality

Specialists have investigated and established the extraordinary usefulness and beneficial effect of air ionizer devices on humans. Ionization of indoor air significantly improves the conditions of human existence and health, in particular: it normalizes the work of the cardiovascular system, reduces fatigue, normalizes sleep, strengthens the protective functions of the body, activates the work of the brain, improves appetite, slows down the aging process of the body, reduces the likelihood of acute respiratory infections and other viral infections, facilitates breathing, eliminates the factors that cause allergic reactions. It is also a preventive tool and prevents the appearance of malignant tumors, reduces the electrostatic voltage from the included TVs and monitors, increases the general tone of the body and improves performance.

Ionizer effectively cleans air from harmful components: viruses, bacteria, allergens, dust and saturates the air in the room with a large number of negative air ions. Therefore, this device is particularly useful and vital for the following population categories: children and adolescents, people suffering from diseases of the respiratory system, old people, people suffering from other chronic diseases, the entire population during the epidemics of influenza and the spread of acute respiratory diseases, all persons who actively use a computer, tablet, smartphone, other electronic gadgets at home, those who watch television more than two hours

a day, people who, for one reason or another, spend most of their time in enclosed spaces (during work, school, rest, treatment, weather conditions in winter, etc.) and employees actively working with computer monitors. However, it should be noted that there are also some contraindications for using these devices for health reasons.

5 Determination of the main criteria in customers' choice of household ionizers

If the consumer decides that he needs an air ionizer, he faces the question of how to choose it. Analysis of various sources of information found that when selecting it is worthwhile to pay attention to some of the characteristics listed below.

Area of the room. One of the main parameters of choice is the area (volume) of the room that will be serviced. The power of the device and its price depend significantly on the service area.

Humidification. There are ionizers with air humidification and without it. It must be remembered that in winter when heating systems work, the atmosphere in the apartment often dries up, and the humidifier can easily fix it. In addition (in the presence of such a function) much less dust is retained in the moist air.

Types of filters. Different filters perform different tasks. Some of them get rid of dust, others destroy harmful impurities, fight smells. Different models of devices have different in functionality filter kits.

Hydrostat. That is a humidity level sensor in the house. As soon as the humidity drops to the critical level, it includes moistening.

Remote Control. The remote control helps to quickly and conveniently change the operating modes of the device. For example, if necessary, urgently switch the ionizer into a mode of cleaning the air of odors, after smoking guests, in case of cooking and the like.

Timer. If it is necessary for the device to refresh and humidify the air in a certain period of time, then it is necessary to choose a model with a timer.

The ultraviolet lamp. By appropriate radiation, it neutralizes bacteria in the air of the room.

Smart functions. Many manufacturers equip the device with various additional smart functions and advanced features, which makes the use of the device more convenient and comfortable.

It is clear that the above parameters do not cover all the components, parameters and characteristics that affect the consumer choice of a particular user (buyer). Among other, not less important, it is necessary to note such, as: the price of the device, ountry of origin or manufacturer (brand), physical parameters (overall dimensions, weight), aesthetic appearance (design, quality of performance), manufacturer's warranty, availability of maintenance (repair, consumables), oisiness of work, security issues of components (strength, protection from unauthorized inclusion of children, automatic shutdown, etc.) availability of various certifi-

cates of conformity, ositive feedback (from doctors, friends, on the Internet, social networks, forums, other media). In each case, the consumer himself chooses the most important parameters for him, and then in a certain way carries out a multi-criteria choice.

6 Determination of selection models among household appliances available on the Ukrainian market for ionizing air in living quarters

In general, according to the applied method of air ionization, ionizers are classified into the following groups: plasma (ionizers), ultraviolet, thermal, *rown*, radium, water, lectrofluvial. Sometimes lamps with an integrated ionizer and various *Chizhevsky* chandeliers are also separately highlighted .

From a consumer's point of view, ionizers can also be classified according to their intended use for different places of application: (for) industrial premises, residential premises, car parlors, refrigerators and other food storage places, disinfection (closed parts of furniture, containers, packages, etc.) and individual use (small action distance and power).

For each of these groups, of course, there is a certain specific set of criteria for consumer choice, as well as a relationship between the importance of certain selection criteria (characteristics inherent in specific models of devices).

In our further research, we will focus on the consumer's choice of ionizers for their own living quarters. It should be noted that the supply of such goods in Ukraine is quite large and is constantly growing, so it is advisable to focus on models more or less close in terms of technical and functional characteristics. Because it is the presence of several models close in common impressions and perceptions on the part of the buyer (consumer) that causes difficulties, hesitations, and doubts for the buyer in the final evaluation and selection of only one model.

So, in this case, the availability and application of computational models (based on reasonable mathematical models and algorithms) for implementing a multi-criteria choice of a specific ionizer model on a set of alternatives becomes useful and necessary. Note that the most common, usual places of sale of ionizers for residential premises are consumer electronics stores and medical equipment stores.

Our analysis of their proposals made it possible to select for further consideration and comparison a number of similarities for general characteristics of models of domestic ionizers for premises (offered on the domestic market), presented below.

We selected and considered a group of household ionizers for rooms with a purification function of the average price category. Data on specific models of ionizers, their cost and technical characteristics are given in Table 1 (as of 08.08.2018).

Table 1.

Some basic characteristics of ionizer models selected for further comparison

	Super-Plus turbo	Zenet XJ-2100	Sharp-Plasmacluster KC-930EU	AirComfort XJ-902	AIC GH-2173	Double Strike-101	Timberk TAP FL 50 SF	Ballu AP-105	Rexel ActiVita Air	Steba LR 5 Electrostatic
price, UAH	1950	2099	2800	1017	4197	2250	1620	1998	2492	3792
working area, м^2	35	25	21	15	20	50	15	10	8	30
weight, kg.	2	1,4	6,1	1	3	1,2	1,1	0,84	0,7	5,8
consumption power, W	10	8	13	5	12	15	5	8	2,5	30
functions, (1-5 points)	4	4	5	3	5	5	5	3	2	5
conveniences (1-5 points)	4	3	5	3	5	5	4	3	2	5
manufacturer (1-3 points)	Russia 2	Germany 3	Japan 3	China 1	China 1	Taiwan 2	Israel 2	China 1	China 1	Germany 3

A preliminary analysis of the table and data collected indicates that in the vast majority of cases, the ionization of air is necessarily accompanied by its specific purification (the collection of already ionized contaminants in the device).

This function is not only in simple, ultra-budget, very cheap models (usually of Chinese origin, little-known brands).

This is due to the fact that in the absence of trapped charged pollutants, they will all settle anywhere in the room, and therefore the devices must be carefully and constantly cleaned.

The data on the warranty periods turned out to be practically identical, therefore it is expedient to delete this criterion with further modeling.

In addition, the guarantee is generally defined by general legislation (on consumer rights and duties of manufacturers, suppliers, and sellers of complex household appliances), and therefore there are no special differences in the warranty conditions.

You can also notice that the implementation of warranty rights is often very difficult, so the buyer pays more attention to the reliability and reputation of the device, the manufacturer and the brand.

The availability of additional features is also not always decisive. After all, sometimes for a large number of additional options and modes the manufacturer tries to hide the insufficient quality of the basic functionality of the device.

Also (on the other hand) it is difficult to use such a device, especially for the elderly, the sick and the pensioners. There is not always a need to use additional features, and they affect the price increase and decrease the reliability of the device as a whole.

The same applies to characteristics such as weight and electricity consumption. Here, consumer preferences are very individual and depend on the application of the device, the duration of its use, the room space availability, the need for

mobility and so on.

Nevertheless, consideration of the given characteristics in the model developed can greatly facilitate the consumer choice for a specific buyer.

7 Computer multi-criteria model for comparing household ionizers

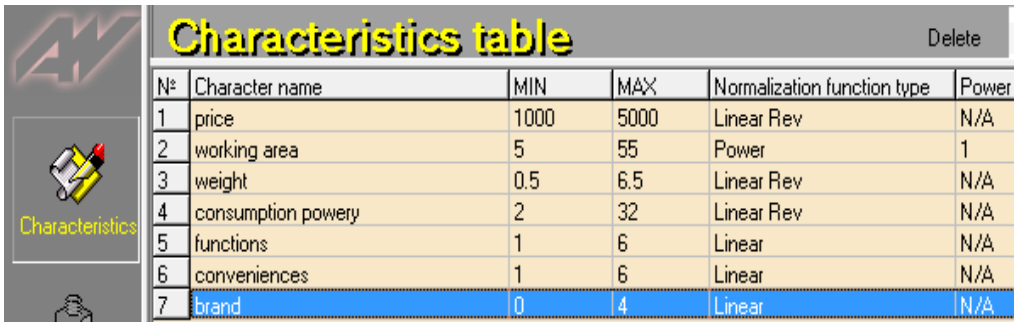
To model the multicriteria choice of ionizers, we will use the *Admiral* program.

This program has a simple and intuitive interface, a fairly complete and informative reference system, a standard minimum set of functions for working with information, the necessary capabilities for graphically visualizing the results of calculations and saving them (and the course of calculations) in *Excel* format.

It does not require special knowledge and skills from the user when working on a computer. Therefore, it is a quite convenient tool for solving tasks of this type by ordinary users, sales consultants and ordinary potential buyers.

Introduction of input data into the program consists of three main steps: filling in the characteristics table, filling in the table of objects and managing the ordinary information.

The first stage introduces a table of characteristics, which for the comparison problem of ionizers is shown in Figure 2.



№	Character name	MIN	MAX	Normalization function type	Power
1	price	1000	5000	Linear Rev	N/A
2	working area	5	55	Power	1
3	weight	0.5	6.5	Linear Rev	N/A
4	consumption powery	2	32	Linear Rev	N/A
5	functions	1	6	Linear	N/A
6	conveniences	1	6	Linear	N/A
7	brand	0	4	Linear	N/A

Figure 2. The completed characteristics table

The value of the table columns is as follows: - characteristic number; *Characteristic name* - name of the characteristic; *MIN* - the minimum value of the characteristic; *MAX* - the maximum value of the characteristic; *Normalisation function type* - type of normalizing function for a given characteristic; *Power* - the degree of importance of changing the property value.

The special dialog box (Figure 3) defines all the necessary values for a particular characteristic.

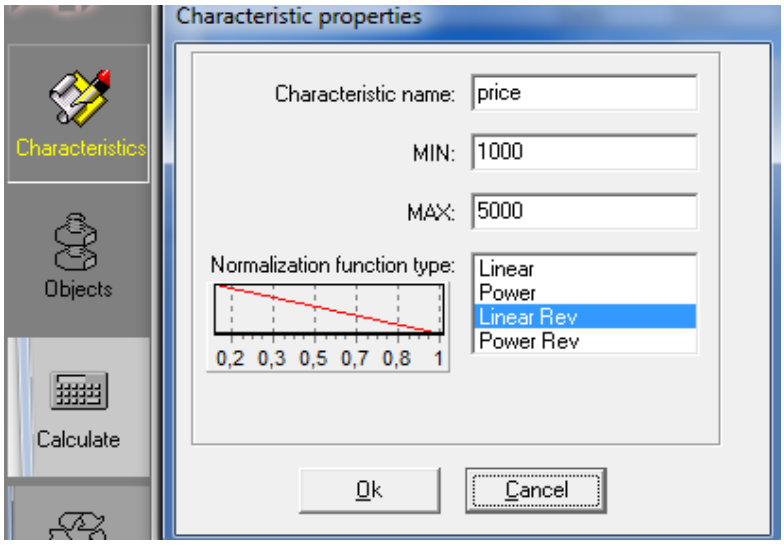


Figure 3. Establishment of characteristic parameters (for example, the price)

The values of the fields in this dialog are as follows:

Characteristic name - the field in which the characteristic name is specified;

MIN - field in which the minimum value of the characteristic is set;

MAX - field, where the maximum value of the characteristic is set;

Power - a field in which the degree of importance of changing the characteristic value is set (for the normalizing functions *Power* and *Power Rev*);

Normalisation function type - a field in which the type of normalizing function for a given characteristic is specified.

The choice of the latter is made of four possible options:

Linear - if the relative importance of the object from the point of view of the person making the decision is linearly dependent on the value of this characteristic;

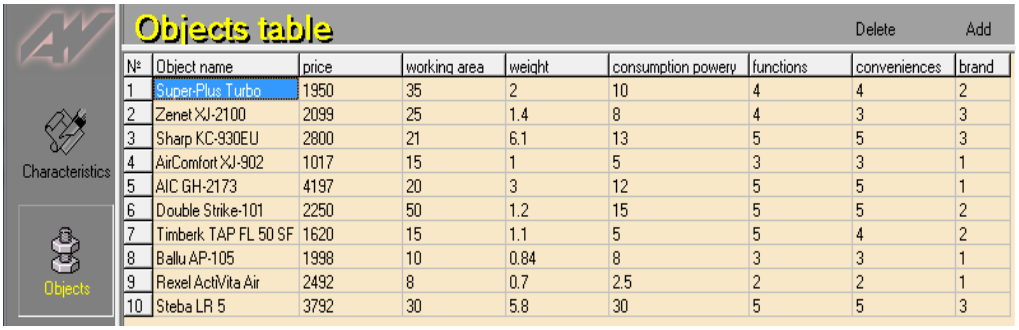
Power - if the dependence of the relative importance of the object from the point of view of the decision-maker on the value of this characteristic is a static function with a positive index specified in the Power field;

Linear Rev - if the relative importance of the object from the point of view of the decision-maker and the value of this characteristic are inversely related;

Power Rev - if the relative importance of the object from the point of view of the person making the decision and the value of these characteristics is related to the reverse static dependence on the indicator whose modulus is specified in the *Power* field.

The second step is to load into the model the characteristics of the ionizers chosen for comparison.

In Figure 4 each corresponds to a set of specific numerical values (for each characteristic).

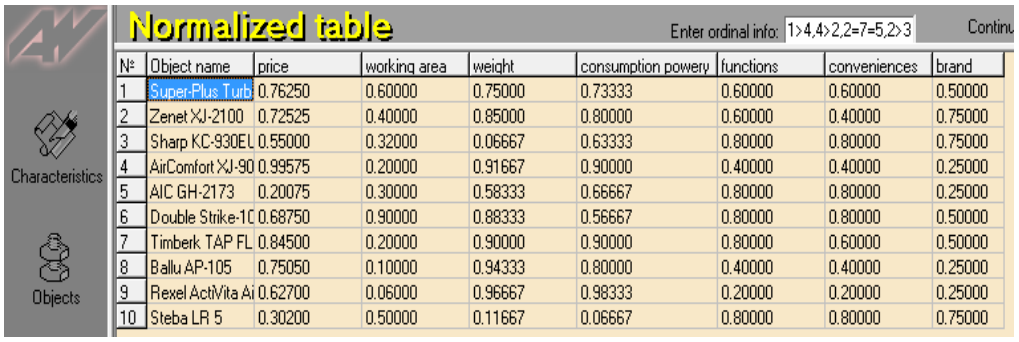


№	Object name	price	working area	weight	consumption powery	functions	conveniences	brand
1	Super-Plus Turbo	1950	35	2	10	4	4	2
2	Zenet XJ-2100	2099	25	1.4	8	4	3	3
3	Sharp KC-930EU	2800	21	6.1	13	5	5	3
4	AirComfort XJ-902	1017	15	1	5	3	3	1
5	AIC GH-2173	4197	20	3	12	5	5	1
6	Double Strike-101	2250	50	1.2	15	5	5	2
7	Timberk TAP FL 50 SF	1620	15	1.1	5	5	4	2
8	Ballu AP-105	1998	10	0.84	8	3	3	1
9	Rexel ActiVita Air	2492	8	0.7	2.5	2	2	1
10	Steba LR 5	3792	30	5.8	30	5	5	3

Figure 4. Values for ionizer parameters

In this case, it is necessary to observe the constraints specified in the table of characteristics with respect to the minimum and maximum values.

Then, an intermediate operation of normalization of the values entered is performed. As a result, we get the normalized table shown in Figure 5.



№	Object name	price	working area	weight	consumption powery	functions	conveniences	brand
1	Super-Plus Turb	0.76250	0.60000	0.75000	0.73333	0.60000	0.60000	0.50000
2	Zenet XJ-2100	0.72525	0.40000	0.85000	0.80000	0.60000	0.40000	0.75000
3	Sharp KC-930EU	0.55000	0.32000	0.06667	0.63333	0.80000	0.80000	0.75000
4	AirComfort XJ-90	0.99575	0.20000	0.91667	0.90000	0.40000	0.40000	0.25000
5	AIC GH-2173	0.20075	0.30000	0.58333	0.66667	0.80000	0.80000	0.25000
6	Double Strike-10	0.68750	0.90000	0.88333	0.56667	0.80000	0.80000	0.50000
7	Timberk TAP FL	0.84500	0.20000	0.90000	0.90000	0.80000	0.60000	0.50000
8	Ballu AP-105	0.75050	0.10000	0.94333	0.80000	0.40000	0.40000	0.25000
9	Rexel ActiVita Ai	0.62700	0.06000	0.96667	0.98333	0.20000	0.20000	0.25000
10	Steba LR 5	0.30200	0.50000	0.11667	0.06667	0.80000	0.80000	0.75000

Figure 5. Normalized table of values of ionizer parameters

This figure contains relative values normalized in accordance with the normalizing function selected and the minimum and maximum variation limits of the characteristic values.

A normalized table is equivalent to a table of objects with an accuracy to the normalization rule.

The last, third step in preparing input data for calculations is the introduction of ordinal information.

It reflects the user's perception of the relative importance of each characteristic when choosing the best object from the available ones. The ordinal information allows you to choose between alternatives of the *Pareto* set.

You can specify information, not about all the characteristics that the user entered. If you do not enter any ordinal information at all, the significance of all characteristics will be considered the same.

In the incomplete definition of ordinal information, the system itself makes assumptions about missing coefficients by some internal consistent algorithm.

The above information is given in the form of strict inequalities (equalities) of

the form 3>5=6.

This means that characteristic 3 is more important than characteristic 5, which coincides in importance with characteristic 6. It is possible to introduce not one but several benefit systems.

For example, the permissible variants are: 1>2,3<4; 1=2=3<4,5=1,4>6; 1=1. Any consistent system is allowed. On the contrary, contradictory systems cannot be set. Examples of contradictory systems are: 1=2<1; 1=2,2<1; 1=2,2=3,3>1; 1=2=3>1.

One should bear in mind that in the ordinal information of form 1>2>3, characteristics 1 and 3 are in relation to a strong advantage.

Therefore, information of the form 1>3 (simple advantage) will contradict the previous one.

In the event that contradictions are detected in the given ordinal information, the system warns the user and indicates the place in the sequence where the contradictions were detected.

For our task, ordinal information is the next 1=4>2,2=7=5,2>3,3=6, which corresponds to the ratio of the significance of each parameter relative to the others, indicated in Table 2.

Table 2.

The importance of separate characteristics in the selection of ionizers

Importance with respect to others	Separate characteristic of ionizer
very important	price, consumption powery
important	working area, brand (manufacturer country), functions (additional functionality)
less important	weight, conveniences (ease of use, usability)

It is clear that comparative assessments are subjective (individual for each individual customer), therefore they are carried out in the model calculations for both a different significance and for the same importance of the characteristics.

In the workprocess the system performs randomization of the weight characteristics based on the ordinal information given by the user.

In this case, a certain number of iterations are performed to determine the mathematical expectation and variance of the result.

To increase the accuracy of the result, the number of iterations can be increased.

The setting of this parameter is done through a dialog box where the user can set the number of iterations that the system performs in a randomized calculation.

The settings window with the default settings looks as shown in Figure 6.

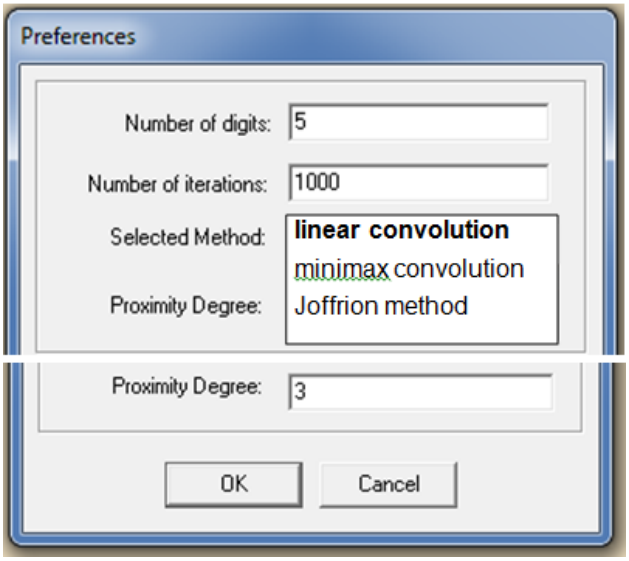


Figure 6. Setting calculation options

You can set the calculation method in the *Selected Method* field (*linear convolution, minimax convolution*, or *Joffrion* method).

Also, in the *Proximity Degree* field, you can set the minimum proximity of the two minimax conversion results, which require refinement by linear convolution.

The *linear convolution* algorithm is based on the construction of an evaluation function in the form of a linear combination of the available characteristic values for each object.

In this case, the coefficients of the linear combination (convolution) are a randomized (random) set of weights, constructed in accordance with the user-defined ordinal information.

The disadvantage of the method is the fact that it is true only for a convex *Pareto* set.

The *minimax convolution* algorithm is based on the construction of an estimating function as the minimum product of the product of the normalized characteristic of the object and its corresponding weighting factor, which is a randomization of (random) the set of coefficients constructed according to user-defined ordinal information.

The disadvantage of the method is that it can allocate, as the best, alternatives that are not generally included in the *Pareto* set.

The *Joffrion* algorithm is constructed on the basis of a combination of linear and minimax convolution methods.

First, the minimax convolution method is realized, which separates all the kernels of *Pareto* sets and inefficient alternatives.

Then a choice is made based on the linear convolution that removes weak points and finally completes the selection of the *Pareto* set.

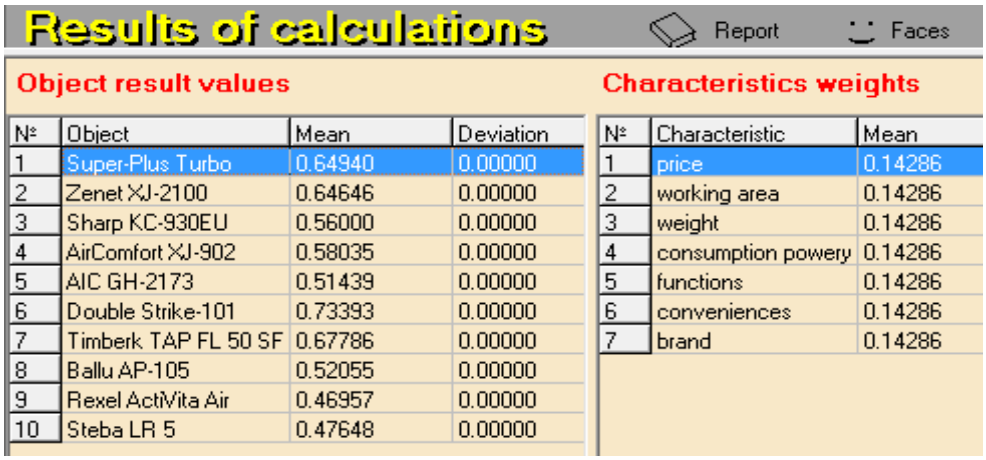
After the input data is entered, the table is normalized and the ordinal informa-

tion is specified (if necessary), the resulting values of mathematical expectations and variances are calculated for the weighting coefficients of the characteristics and for the estimated values of the objects.

8 Results of calculations on the computer model

This calculation allows comparing alternatives (objects) and the characteristics themselves (their effect on the final results).

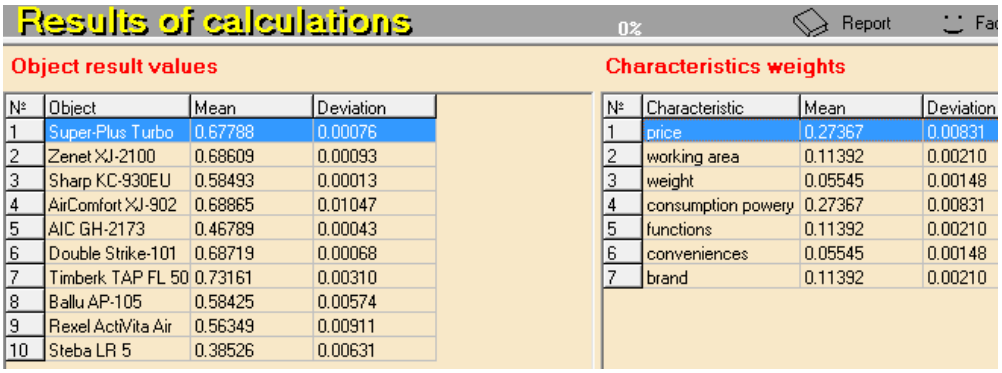
The results are shown in Figures 7 and 8 (for the same and different relative importance of parameters).



№	Object	Mean	Deviation
1	Super-Plus Turbo	0.64940	0.00000
2	Zenet XJ-2100	0.64646	0.00000
3	Sharp KC-930EU	0.56000	0.00000
4	AirComfort XJ-902	0.58035	0.00000
5	AIC GH-2173	0.51439	0.00000
6	Double Strike-101	0.73393	0.00000
7	Timberk TAP FL 50 SF	0.67786	0.00000
8	Ballu AP-105	0.52055	0.00000
9	Rexel ActiVita Air	0.46957	0.00000
10	Steba LR 5	0.47648	0.00000

№	Characteristic	Mean
1	price	0.14286
2	working area	0.14286
3	weight	0.14286
4	consumption powery	0.14286
5	functions	0.14286
6	conveniences	0.14286
7	brand	0.14286

Figure 7. Result for the same importance of parameters



№	Object	Mean	Deviation
1	Super-Plus Turbo	0.67788	0.00076
2	Zenet XJ-2100	0.68609	0.00093
3	Sharp KC-930EU	0.58493	0.00013
4	AirComfort XJ-902	0.68865	0.01047
5	AIC GH-2173	0.46789	0.00043
6	Double Strike-101	0.68719	0.00068
7	Timberk TAP FL 50	0.73161	0.00310
8	Ballu AP-105	0.58425	0.00574
9	Rexel ActiVita Air	0.56349	0.00911
10	Steba LR 5	0.38526	0.00631

№	Characteristic	Mean	Deviation
1	price	0.27367	0.00831
2	working area	0.11392	0.00210
3	weight	0.05545	0.00148
4	consumption powery	0.27367	0.00831
5	functions	0.11392	0.00210
6	conveniences	0.05545	0.00148
7	brand	0.11392	0.00210

Figure 8. Result for the different importance of parameters

If the calculations take too much time (for example, many objects and characteristics are specified), it is possible to stop the calculation process or to affect the computation speed by decreasing the number of iterations and decreasing the number of decimal digits used for calculations and when displaying the result.

After completing the calculations, we have weights of characteristics and objects containing the mathematical expectations and variances of the values calculated.

The data obtained can be interpreted in this way - an object whose value of the mathematical expectation of the estimated function is maximum is the best alternative with given characteristics and their relative importance.

Moreover, the second table (containing mathematical expectations and variances of characteristics) shows which characteristics with large mathematical expectations had the greatest impact on the decision-making process.

With a significant number of objects, the graphical interpretation of the results is more obvious.

You can select an object diagram (Figure 9) or a weight diagram (Figure 10) for characteristics.

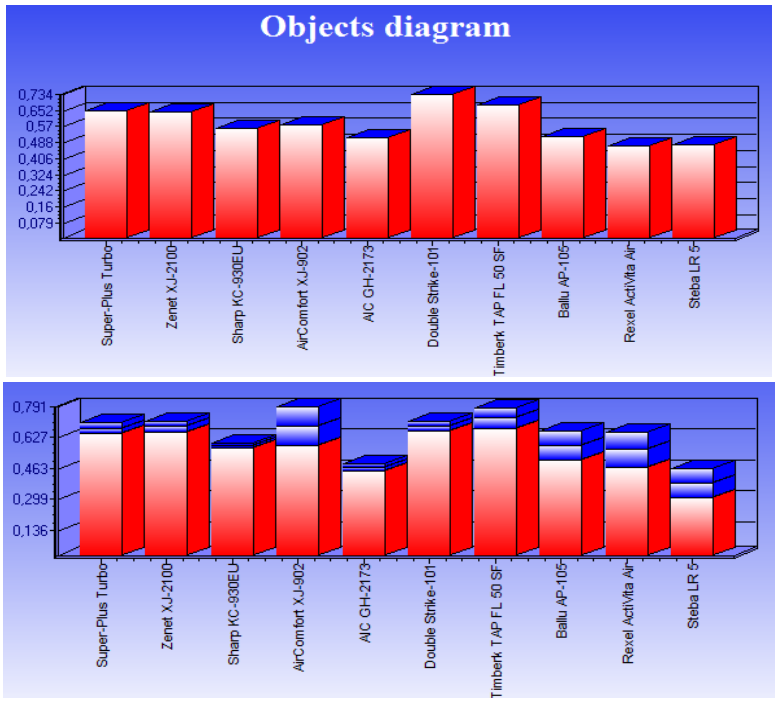


Figure 9. The results of calculations
(above - the same, below - the different relative importance of parameters)

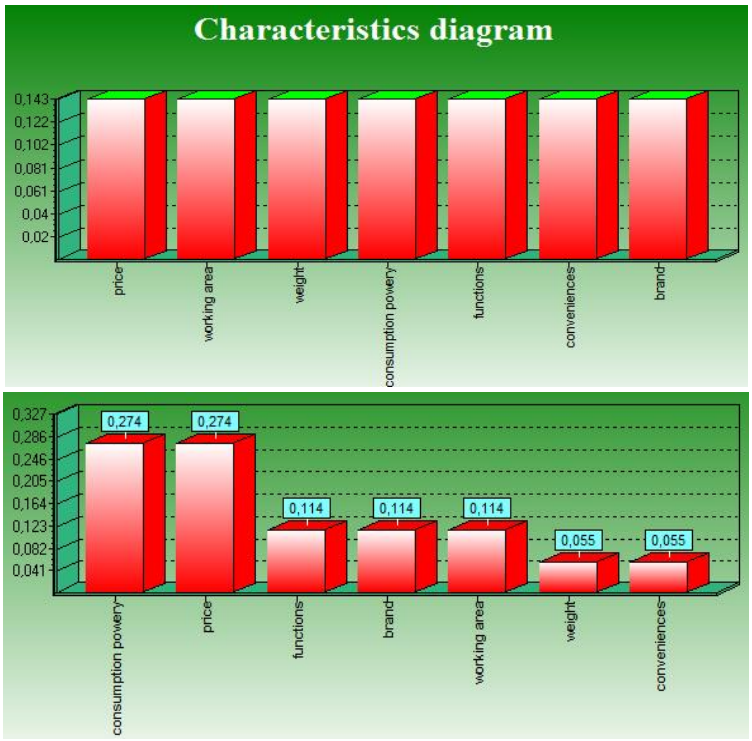


Figure 10. The ratio of selection characteristics
(above - the same, below - different)

Each shows the mathematical expectation minus half the standard deviation (on top - the standard deviation of the corresponding value) for a visual comparison of the results.

In this case, objects that have a smaller variance (meaning deviation - the square root of the variance) and greater mathematical expectation are preferred.

Characteristics with a large mathematical expectation are dominant.

As we see, with the same significance of the parameters, *Double Strike-101* is the best choice. But for different (defined by the importance ratio), *AirComfort XJ-902* comes first (with minimal advantage).

The results can also be represented in the form of the so-called *Chernov faces* (Figure 11). This graphic interpretation is easily perceived by the ability of a person to distinguish between small differences in facial expressions.

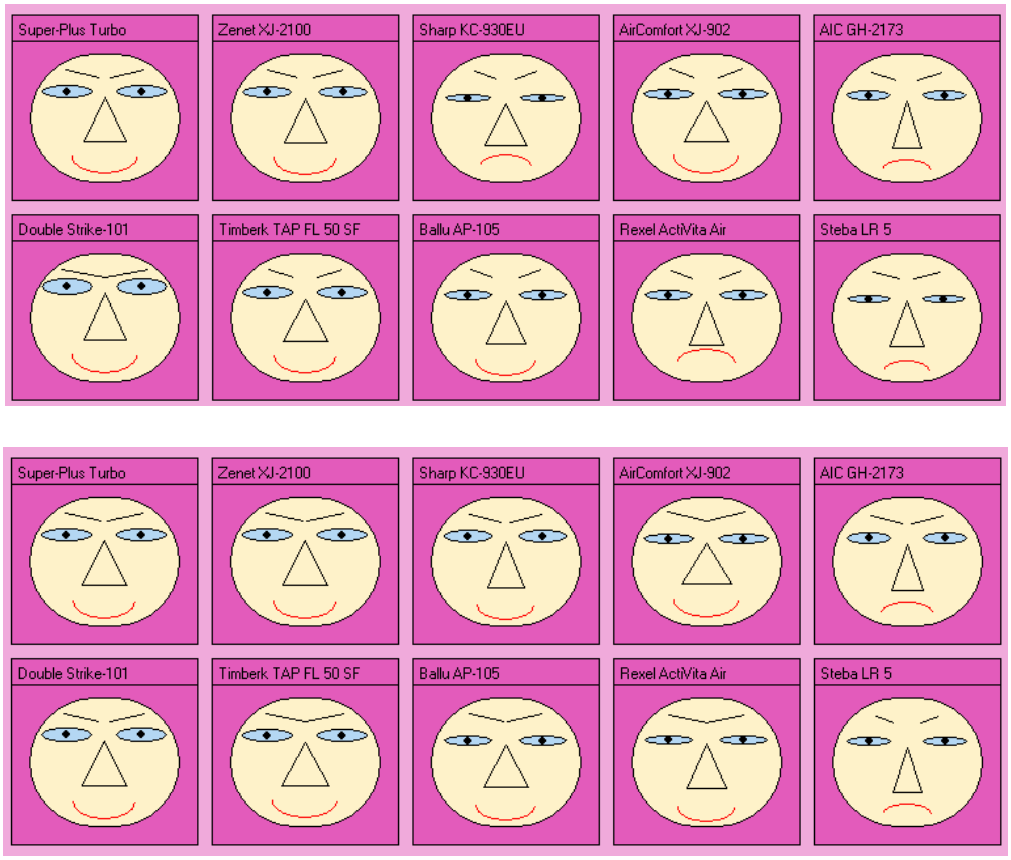


Figure 11. *Chernov faces*, the importance of the signs is the same (top), or different (bottom)

This technique has certain advantages when displaying a large number of results. Differences can easily be found on *Chernov faces* because they describe emotional reactions. The main convenience of using *Chernov faces* is that they give a simple qualitative understanding of the numerical data obtained. The user can independently select the scale of the image of these persons in an enlarged form for improving individual perception.

The results of the calculations performed for the choice of the best ionizer can be made in the form of a report of the format of the popular *Microsoft Excel* application from the *Microsoft Office* suite. This will automatically download *Microsoft Excel* and dynamic data transfer with subsequent formatting. After the completion of the formation, this report can be saved. This completes the construction and calculations for the model, and it becomes possible to analyze the results, further adjustments, and experiments with it.

9 Conclusions

Considering the results obtained from numerical calculations carried out with the help of the model developed, it is necessary to take into account several

important provisions related to the correct use of them.

As you can see, the model is very sensitive to input data, responsible for the relative (among themselves) importance of individual criteria (characteristics) of alternatives (in our case, ionizers). It is clear that this importance for each individual consumer (user, buyer) is individual. It is determined by his personal preferences, capabilities, goals, and conditions of use of the ionizer. Accordingly, the preliminary justification for establishing the importance of individual criteria is a necessary condition for obtaining correct results.

For comparison, it is desirable to choose alternatives (ionizers), similar in general and for individual characteristics. It is in the case of several similar (by certain features) alternatives, that the empirical choice becomes difficult for the consumer. In this case, modeling with the help of this approach allows the consumer to make more informed decisions. In another case (when a certain, separate characteristic essentially prevails over others in importance for consumers), they can easily make the necessary choice independently, without additional support.

It should be especially emphasized that the best alternative proposed by the application of the model is not the final, unconditional decision. The application of this model (as well as other models of multicriteria choice on a variety of alternatives) is only a tool to facilitate consumer further analysis of possible options (only advice that simplifies further decision-making). It concerns especially the case of obtaining close final estimates for several alternatives. Further, consumer comparison can be carried out independently, at the level of consciousness (or using other models and methods).

The model can also be useful if there are too many alternatives (options for comparison and selection). Because it allows for reasonable mathematical (computer) calculations to reduce their number to an acceptable number. After all, as is known (by psychological features), a person can simultaneously compare no more than 7-9 such alternatives.

An additional tool for updating (correcting) the model is the possibility of determining nonlinear (arbitrary) analytical functions of the importance of increasing (decreasing) the value for each individual parameter from the set that is considered. Also, some other settings are possible, on which the results of further calculations will depend (and which can be changed in the course of further computational experiments with the model already created).

The final verification of the model constructed provides, by selecting these settings, the most acceptable (coincident with the empirical solutions of consumers) results. After that, the model can already be working in user mode.

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