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MODELING OPTIMAL PRICE POLICY OF PHARMACEUTICAL COMPANIES FOR SALES MAXIMIZATION BASED ON DATA SCIENCE TECHNOLOGIES

The article contains the results of the application of Data Science technologies to modeling the results of marketing activities of pharmaceutical companies depending on the key elements of the marketing mix. The influence of pricing policy on the competitiveness of the enterprise and its position in the market is studied in detail. Based on the study, recommendations are offered for optimizing the price policy to maximize sales of pharmaceutical companies.

Keywords: price policy, marketing, Data Science machine learning, regression analysis.

Introduction. The competitive environment in which businesses operate requires them to provide efficient operations with sufficient profitability. Modern marketing focuses much attention on establishing a fair and reasonable price and tracking the relationship between the price level and sales volume. Pricing is an important component of the modern marketing system of any enterprise, where the main emphasis is on finding the optimal market price that will satisfy both the producer and the buyer [1].

The pharmaceutical industry is one of the fastest-growing in Ukraine. So, following the results of 9 months in 2019, the volume of retail sales of all categories of goods in the "pharmacy basket" amounted to ₴74.3 bn. ($2.8 bn.) Compared to the same period in 2018, sales increased by 15.9 percent in hryvnia and 18.3 percent in dollar terms. In physical terms, sales decreased by 3.1 percent and amounted to 1.25 billion packages.

In terms of sales of Ukrainian and foreign goods, the Ukrainian pharmaceutical market is characterized by the predominance of imported products in monetary terms. Domestic products prevail mainly in physical terms [2].

Indicators of the dynamics of the market of medicines in monetary terms show that the results of 9 months in 2019, the market developed mainly due to rising prices, as evidenced by the high inflation component, and due to the redistribution of consumption towards more expensive drugs (substitution index) (Fig. 1).

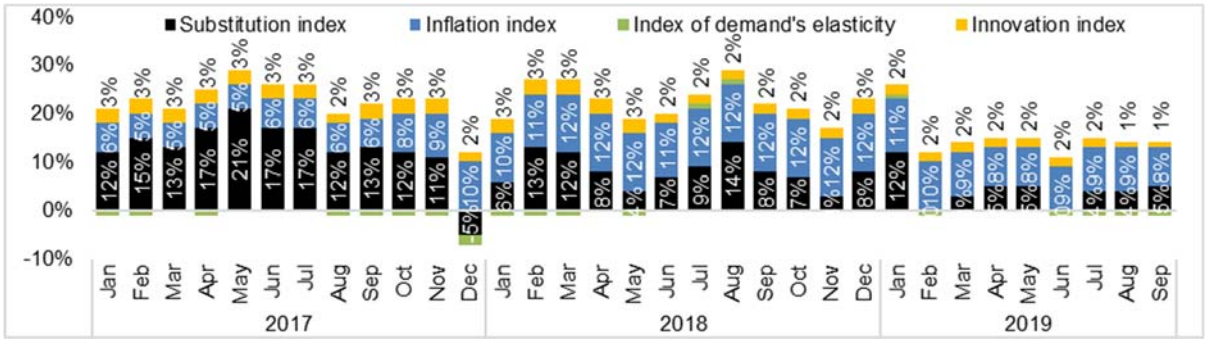

Figure 1. Indicators of changes in the volume of sales of drugs in monetary terms for the period from January 2017 to September 2019 compared to the same period of the previous year

Source: built up by the authors based on data from [2].

At the same time, according to the State Statistics Service of Ukraine [3], inflation in the pharmaceutical market and healthcare, in general, is still lower than in the country, as well as in comparison with many other categories of goods and services (fig. 2).

Figure 2. Growth rates of consumer prices for goods of different categories for H1 2019 vs H1 2018

Source: built up by the authors based on data from [3].

As a result of inflation, the weighted average cost of one package increased by 19.6 percent in nine months of 2019 compared to the same period in 2018 and amounted to ₴58.7 [2]. In such conditions, the increase in prices is partially offset by the growth of consumer income, because the development of the retail market depends almost entirely on the consumer and his welfare. In recent years, there has been an increase in both wages and incomes. The NBU continues to record a rise in wages, but its growth rate is slowing. Following the results of the second quarter of 2019, the State Statistics Service of Ukraine records an increase in real incomes of the population by 7 percent and by 17 percent in nominal [3].

Improving the economic situation in the country contributes to the development of the pharmaceutical market: in 2019, there are double-digit growth rates of sales of "pharmacy basket" goods in hryvnia and dollar terms, although they slowed down compared to the same period last year. According to the latest forecasts of experts, the development of the pharmaceutical market will continue, despite the impact of the COVID-19 crisis.

With the rapid development of the pharmaceutical industry and the solution of the problems related to the economic crisis, to improve the system of business competitiveness management, the mechanism of market pricing management is becoming increasingly important to increase competitiveness and maximize profits.

Pricing strategy in the system of international marketing occupies one of the key places [4]. Pricing is an integral part of marketing strategies, and there is significant potential for optimization for businesses that are deeply analyzing the market to find effective solutions and enhance their competitive advantage.

Making an informed decision on the choice of pricing strategy, its development using a systematic approach allow the company to succeed in the market. Based on this, there is an urgent need to improve the strategy of marketing activities and mechanisms for managing its components, and Data Science technology is the tool that opens up endless opportunities in this direction.

The **object of research** is the marketing activities of enterprises. The **subject of the study** is modeling and optimization of marketing results depending on the chosen price policy.

Literature review. The theoretical foundations of the study of pricing systems at the enterprise level and a wide range of issues related to the modeling of socio-economic processes are reflected in the works of such domestic and foreign scientists as I. Blagun, M. Kizim, T. Klebanova, V. Korinev, V. Ponomarenko, O. Pushkar, V. Khristianovsky, I. Ansoff, O. Gradov, F. Kotler, M. Porter, A. Thompson, V. Tarasevich, E. Utkin and many others.

Many Ukrainian scientists have paid attention to the theoretical and practical issues of marketing pricing policy. In our opinion, the greatest research on the mentioned problem was found in the works of L. Balabanova [5] and Y. Litvinenko [6]. R. Ivanova [7], I. Lipsitz [8], N. Noritsyna [9], focused on the relationship between marketing pricing in the enterprise and competitiveness. The importance of this issue for any enterprise was emphasized by O. Malysh [10] and V. Pankov.

The researches of the use of machine learning technologies and Data Science for modeling the marketing activity of enterprises were undertaken by such domestic and foreign scientists as Y. Bazhenov, R. Batra, J. Burnet, J. Büschken [11], M. Guz, T. Lukyanets, Y. Lysenko, A. A. Panasenko [12], F. Pankratov, A. Pargelova [13], E. Romat, J. R. Rositer, C. Sandage, V. Freiburger, D. A. Shakhov [12], S. Shapiro and others.

A significant amount of research has been conducted on this topic. Marketing mix modeling is the most commonly used method that involves building a regression model on historical data to display business metrics (sales) as a function of marketing and advertising variables, such as media activity, number of impressions, price index, and other variables such as seasonality, weather, market competition.

Mathematical modeling and data analysis open up many opportunities in the implementation of marketing activities of any enterprise. Thus, Chan and Perry (2017) [14] emphasize the importance for businesses to use different approaches to marketing modeling because advertisers need to understand the effectiveness of their media and marketing spend in driving sales to optimize the allocations of marketing budgets.

The contribution of regression analysis to media decision-making is quite significant, but there are alternative methods. Dawes et al. (2018) [15] describe evidence-based methods that have been shown to be useful for forecasting. Jin et al. (2017) [16], Zhang and Vaver (2017) [17] suggest using Bayesian hierarchical modeling.

According to research [14], the potential of MMM is often limited by the lack of detailed and qualitative data. As a solution, they propose to develop better data and models, as well as to test models using simulations as the main areas of improvement for MMM.

Unresolved parts of the overall problem. Despite the scientific achievements of these scientists, many issues in the search for ways to optimize pricing policy remain unresolved. The problems of pricing in the marketing system are well studied, but the optimization-marketing and forecasting mechanism for setting prices for products requires more thorough research. After all, an effective marketing pricing policy, as well as improving the pricing mechanism is a determining factor in the sale of products of any enterprise [1]. Adaptation of pricing policy in highly competitive industries is one of the areas of daily work of every pharmaceutical company in Ukraine and the world. Therefore, the search for data-based solutions to this issue is extremely important.

Methodology. The study includes results of economic and mathematical modeling (including the one based on machine learning technologies and regression analysis) of the dependence of sales (market share in volume and value) of certain drugs on the following factors: penetration of pharmacy networks (pharmacy coverage and drug availability for consumers), pricing policy (the ratio of the price of the drug compared to competitors), advertising activity of the brand and its competitors in all channels of communication (television, Internet, radio and outdoor advertising), recommendations of doctors and pharmacists and others.

Data on all indicators for the period from 2015 to 2019 were collected in a weekly breakdown for all drugs in the relevant category [18, 19, 20]. Due to confidentiality, all data in the article will be changed.

For the constructed multiple regressions, which were estimated by the method of least squares, hypotheses about the adequacy of the models, the significance of the coefficients, the presence of heteroskedasticity, and autocorrelation were tested.

Also, for the formation of recommendations for optimal pricing policy, an approach based on machine learning technologies was developed to determine the optimal range of price index (price compared to the average price of competitors) to maximize market share in packaging or market share in value depending on the company's goals.

Formulation of tasks and goals of the article. The purpose of the article is to study the impact of pricing policy on sales of pharmaceutical companies based on machine

learning technologies, as well as the formation of recommendations for optimizing the price of a particular product. The tasks of this work are to get acquainted with the development trends of the pharmaceutical market, the peculiarities of marketing activities in this area, and to outline ways to improve the efficiency of the marketing activities of companies in the pharmaceutical industry.

Main results of research. The high level of competition in the pharmaceutical market, the increase in the price of advertising activity, and the desire to constantly increase sales among manufacturers create the need to find effective marketing solutions. To achieve such goals, it is necessary to actively use the data available on the market, using machine learning technologies and data mining. Data Science is an extremely effective tool for improving the effectiveness of marketing activities of pharmaceutical companies, its optimization, and greater validity.

The case studies of several brands of pharmaceutical companies will show how with the help of economic-mathematical modeling and other Data Science technologies can analyze what factors and to what extent affect the business results of the enterprise (sales or market share in the category). Understanding the factors of influence makes it possible to calculate the elasticity of sales to each factor and as a result to calculate the optimal range for each of them taking into account their marginal utility (for example, calculating price elasticity and finding the optimal value of the price index – the ratio of brand price and average market price). In addition, understanding the effectiveness of each communication channel allows you to develop an effective media strategy for the brand.

Process and results. The project was deployed following the most widely-used analytics model CRISP-DM [21, 22]. CRISP-DM describes the process through 6 main stages: "Business Understanding, Data Understanding, Data Preparation, Modeling, Evaluation and Deployment" (Fig. 3).

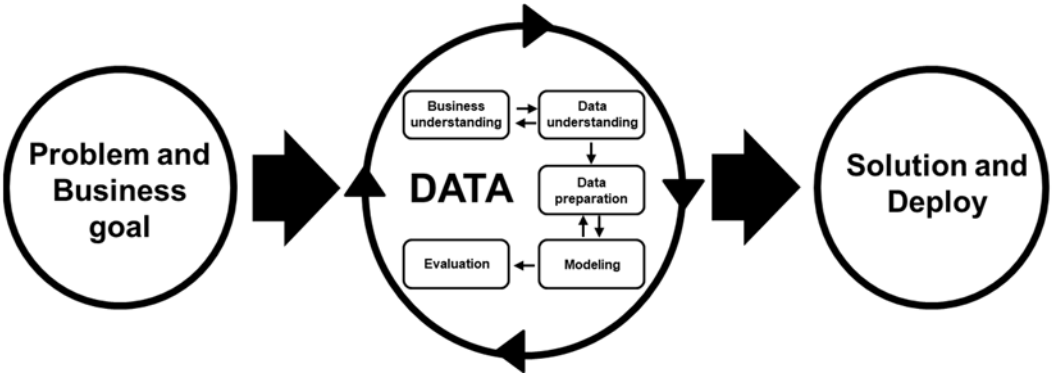

Figure 3. CRISP-DM

Source: built by the authors based on information from [23].

The process involves the possibility of a flexible transition between phases in any order, going back when the need arises. Data Mining has cyclic nature, as the process of finding solutions continues after the project has been deployed. The key learnings and expertise from the previous cycle can generate new, probing business questions, which have a positive influence on future data mining processes [23].

At the first stage of working with a business task, it is necessary to dive in detail into the specifics of the brand and the category for which the analysis is conducted to understand all the factors that affect the final performance of the business. In this case, we are working with a brand that is the leader in the category, but is gradually losing its position under the onslaught of those brands that have active media support on television, as well as actively promoted to doctors and pharmacists.

In addition, the specificity of this category is the existence on the market of two forms of the drug – drops or syrup (liquid form) and capsules or tablets (solid form), so in the future when using machine learning to model market share will be considered separately model for liquid and solid forms of the drug (Fig. 4).

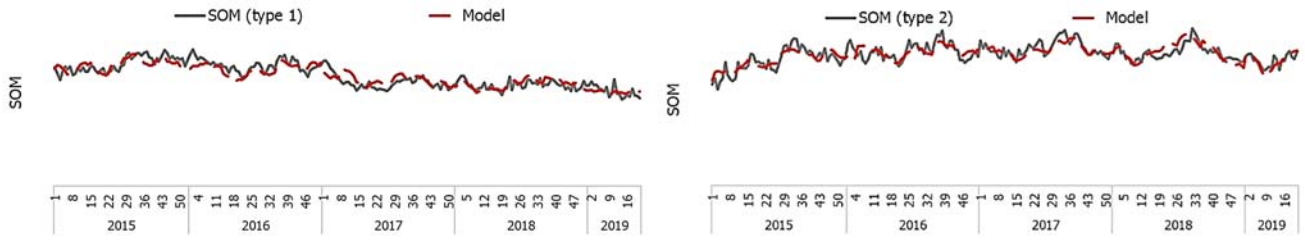

Figure 4. Models for liquid and solid forms of the drug

Source: author's calculations based on data of the pharmaceutical company from Proxima Research, as well as the Industrial Television Committee and Nielsen Ukraine (data modified due to confidentiality) [18, 19, 20, 24].

The economic and mathematical model allows:

- Identify the factors that affect sales, as well as the extent of this impact;
- Assess the elasticity of sales for each factor;
- Predict the target metric depending on the plans of each factor;
- Give recommendations on the optimal/necessary values of each factor to achieve the goals;

- Compare the influence of factors for the company's brand and competing brands in the case of model building for other brands also.

Among the main factors influencing the dynamics of sales and market share of the drug, the following should be noted:

- Base level (set of rational and marketing factors);
- Penetration – the level of coverage of pharmacies (percentage of pharmacies in which the drug is available);
- Pricing policy – price index in relation to competitors (the ratio of the price of the drug and the average market price in this category);
- Doctors' recommendations;
- Pharmacists' recommendations;
- Media activity of competitors in terms of communication channels, creativity, etc.;
- Brand's media activity in terms of communication channels, creativity, etc.

It is the assessment of each of these factors using machine learning methodology that creates the basis for finding effective marketing (including media) solutions and forming an effective strategy for the company's development for the future.

The constructed models have high-quality indicators (coefficients of determination R^2 are 78 percent and 70 percent, respectively, and the average error is less than four percent, the model is adequate, all factors are significant, the model is characterized by lack of autocorrelation and heteroskedasticity), which confirms their practical application for optimization of marketing activities.

The optimal model for each form of the drug is the multiple regression model and looks like this:

$$SOM = Constant + a1 * Penetration_1 + a2 * Penetration_2 + a3 * Price\ index + a4 * Doctors + a5 * Pharmacists + a6 * Adstock(TV1) + a7 * Adstock(TV2) + \dots + an * Adstock(TVn) + b1 * Adstock(TV\_Competitor\_1) + b2 * Adstock(TV\_Competitor\_2) + \dots + bm * Adstock(TV\_Competitor\_m)$$

where *SOM* – share of the market in Volume; *Adstock* is the instant, prolonged and lagged effect of advertising on consumer purchase behavior, which indicates the influence of TV activity during a time. $Adstock(TV)_t = TV_t + a * Adstock(TV)_{t-1}$.

The basic level of sales/market share is the level of sales that the company will have in the short term with a minimum level of presence in pharmacies, a minimum price level compared to competitors, minimal work with doctors and pharmacists, no media activity in the brand for which conducted analytics, and competing brands, and includes some other qualitative characteristics.

Depending on how long the drug has been on the market, the share of the baseline impact on sales and market share will range from the minimum level to most of the sales of the drug. So, if the drug is on the market in the last few years and we conduct analytics from the moment of its withdrawal, the baseline will be absent and vice versa – if the drug is on the market in the last 5–10 years or more, the share of the baseline will be significant.

On the example of our brand, the base level provides a significant share of sales – 57 percent, but this factor is stable in the short term (is a constant in the model), so it is the right work with other factors creates opportunities for the brand for future growth (Fig. 5).

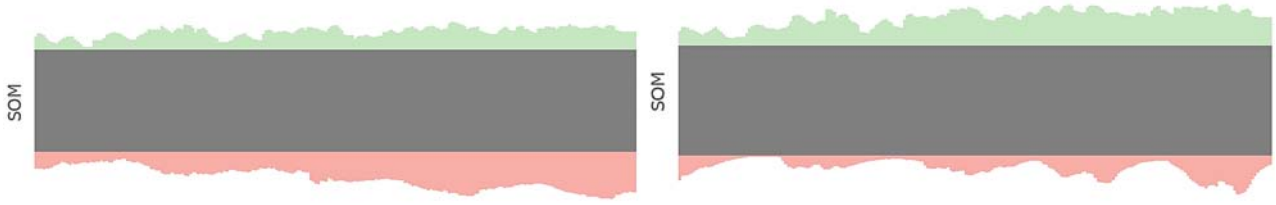

Figure 5. Model decomposition by a different group of factors (base line, positive factors, negative factors)

Source: author's calculations based on data of the pharmaceutical company from Proxima Research, as well as the Industrial Television Committee and Nielsen Ukraine (data modified due to confidentiality) [18, 19, 20, 24].

To understand the impact of each factor on sales, it is necessary to analyze in detail the dynamics of each of them, assess their impact through the construction of models, as well as compare all indicators with indicators for competing brands in the category.

Factor 2 – penetration. Of course, the right level of penetration is an integral part of effective brand development, because the presence on the shelf is a key sales factor not only for pharmaceutical companies but also for all FMCG brands. Our brand is one of the leaders in the pharmaceutical market and in 2019 reached a high level of penetration for the main SKU – at 90 percent actively increasing it in previous years. Changes in penetration during the analyzed period provided a significant additional increase in brand sales.

Factor 3 and 4 – recommendations of doctors and pharmacists. Working with doctors and pharmacists is one of the key channels of communication with the consumer, as we often make the final purchase decision after a doctor's recommendation or pharmacist's advice. Therefore, the proper level of work with doctors and pharmacists is a necessary condition for the effective functioning of the company and the brand in the market. Of course, working with doctors and pharmacists, even at a low level, provides an increase in the company's sales, and its strengthening increases the company's efficiency and sales. Thus, changes in work with doctors and pharmacists during the analyzed period provided additional sales growth, generating X packages for the period 2015–2019.

Factor 5 is pricing policy. During 2015–2019, the company raised its pricing policy faster than its competitors, which led to an increase in the price index (the ratio of the price of the drug compared to average market prices). The average price of the drug is 5–25 percent higher than the

price of competitors, depending on the segment, which negatively affects the dynamics of sales in packaging.

Ukrainians are the nation that tends to save, so rising prices faster than competitors leads to switching to other brands and losing market share in packaging. Thus, changes in the price index during the analyzed period led to a loss of brand sales (Fig. 6).

Figure 6. The impact of price on market share in the dynamics of 2015-2019 (model decomposition)

Source: author's calculations based on data of the pharmaceutical company from Proxima Research, as well as the Industrial Television Committee and Nielsen Ukraine (data modified due to confidentiality) [18, 19, 20, 24].

However, if we talk about the price, a certain level of price increase may lead to a drop in sales in packaging, but generate an additional level of profit when the price increase compensates for the fall in sales in packaging and vice versa – a significant increase in drug prices can lead to a significant drop in sales in packaging and the company's revenue will be significantly reduced. Accordingly, there is potential for optimization depending on the price elasticity of sales and market share in value and volume.

Depending on the client's goals – to increase market share in money (increase profits) or increase market share in packaging (increase drug penetration among consumers), pricing policy recommendations will be radically different.

Based on the constructed econometric models for liquid and solid forms of the drug, we can derive the curves of market share in value and market share in volume depending on the price index, as the coefficients of models at the price index indicate how market share will change with increasing price index by 1 unit (the nature of the connection is linear in the case of constructing a linear regression or nonlinear in another case).

The market share in money and the market share in the volume are linked by a price index. Since the rate of change of market share in packaging does not coincide with the rate of change of the price index, there is a nonlinear relationship between the price index and market share in money, which leads to an optimization zone depending on business objectives.

On the example of this drug, the optimal value of the price index to maximize market share in money was – 1.0–1.4 (Fig. 7), which means that the drug should have parity prices to the market or be more expensive up to +40 percent to average market prices to obtain the maximum profit level. Depending on the goals of the business, such a methodology becomes a flexible tool for the pricing department, as it is possible to form a price recommendation to meet the goals of both market share in value and market share in volume.

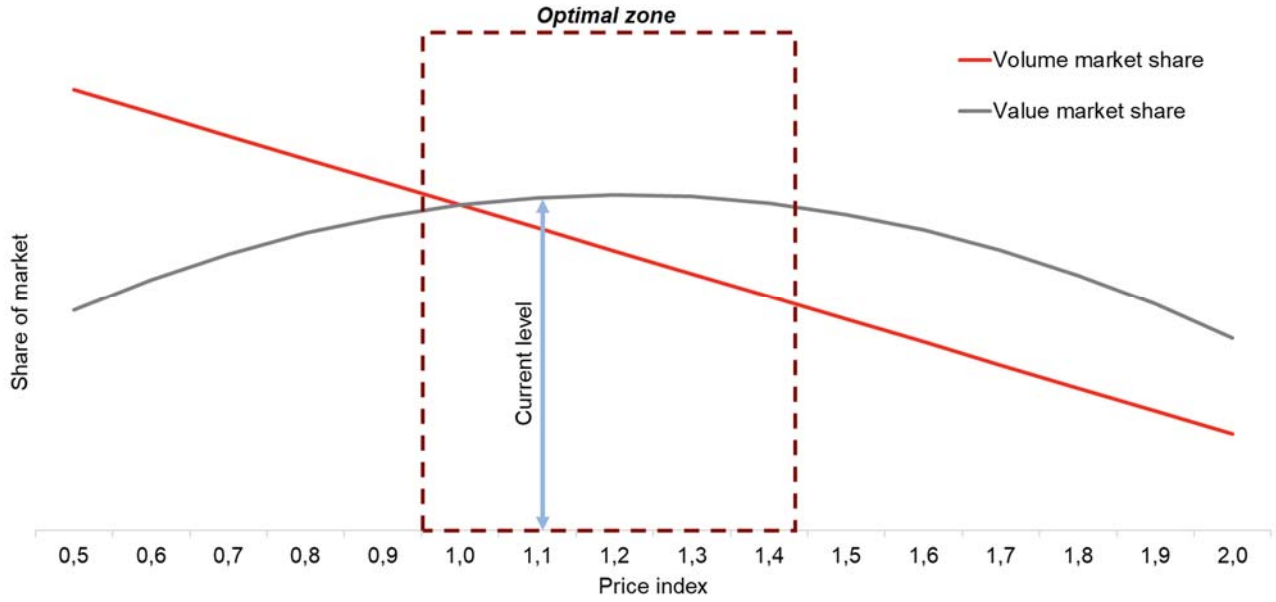

Figure 7. The optimal level of price index in terms of growth of value market share

Source: author's calculations based on data of the pharmaceutical company from Proxima Research, as well as the Industrial Television Committee and Nielsen Ukraine (data modified due to confidentiality) [18, 19, 20, 24].

Factor 6 and 7 – media activity of the brand and its competitors. One of the key factors in increasing sales is the active promotion of drugs through advertising because advertising is the main way of communication between producers and the end consumer.

The pharmaceutical market of Ukraine continues to develop actively. At the same time, it is highly competi-

tive, and in the struggle for the consumer, pharmaceutical companies are forced to actively promote their brands through advertising.

The key channel for the advertising activity of pharmaceutical manufacturers has long and stable been television. According to the All-Ukrainian Advertising Coalition (VRK) [20], in 2019 the volume of the TV advertising market (direct advertising and sponsorship) increased by 24 percent and amounted to ₴11.5bn, which corresponds to about 47 percent of the total volume of advertising media market of Ukraine in 2019 [20].

Pharmacists are one of the key advertisers on television. The share of investments of pharmaceutical companies in TV advertising consistently occupies about 30 percent of the total investment in this channel. If we talk in more detail about the investments of pharmaceutical companies, then the results of 9 months in 2019, they invested more than ₴2.1bn in advertising their brands on television, increasing their investment by 28 percent compared to the same period in 2018. Data on pharmaceutical companies' investments in TV advertising show a steady increase, but the volume of activity (EqTRPs – weighted target ratings) has been declining in recent years due to significant inflation [25].

The effectiveness of investment in advertising is determined by the indicators of EqTRPs, which ultimately affect the company's sales. Due to the rising cost of advertising tools due to high inflation among pharmaceutical companies significant preconditions are created for finding data-based solutions based on in-depth analysis of all available data on the market using Data Science technologies to optimize marketing (including media) solutions.

TV support ensures the growth of the brand's market share, but the TV activity of competitors has a significant negative impact. Realizing the significant negative impact of competitors' TV activity, it is important in the future to control SOV (share of voice) on TV and parity placement with competitors, because the more media activity a brand launches during the year, the higher sales it generates. The loss of voice on TV is the main reason for the loss of the brand's position in the market for our brand.

The effectiveness of advertising activity depends on a significant number of factors, both media (weekly pressure, periods, creatives, duration of videos, etc.) and non-media (including penetration and pricing policy). To test these hypotheses, similar economic and mathematical models were built for other brands in this category. After that, the results of all models were aggregated and the following conclusions were proved:

- The impact of penetration on the effectiveness of media activity: the lower the level of penetration of pharmacy networks, the lower the effectiveness of TV activity, because the interested audience, coming to the pharmacy can not buy the product due to its absence. The drug for which the analysis was performed has a high level of penetration, which has a positive effect on the effectiveness of TV support.
- The effect of price on efficiency from media activity is opposite, but also quite significant: the higher the price of the drug, the fewer interested consumers dare to buy because the price in this case is a barrier for the consumer (Fig. 8). The drug for which the analysis was performed is in the middle price group and has sufficient effectiveness from TV support. The optimal value of the price index to maximize sales of the drug: 1.0-1.4 (Fig. 7).

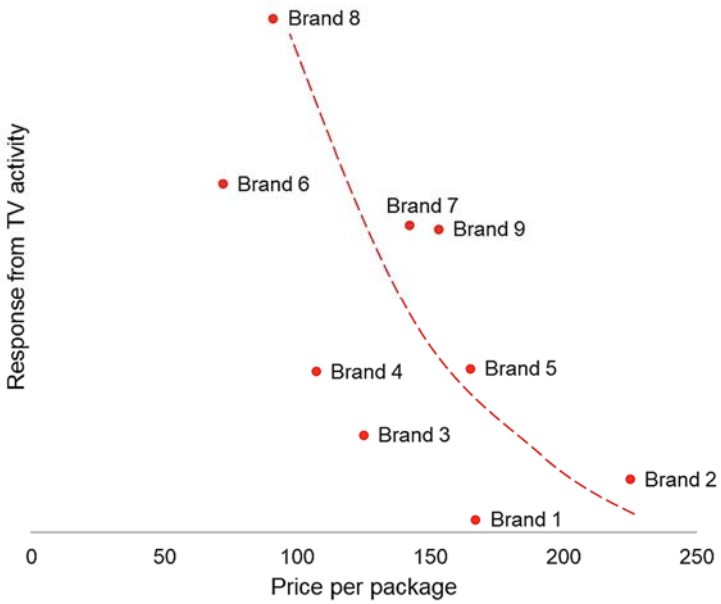

Figure 8. The impact of price on efficiency of media support

Source: author's calculations based on data of the pharmaceutical company from Proxima Research, as well as the Industrial Television Committee and Nielsen Ukraine (data modified due to confidentiality) [18, 19, 20, 24].

It is important to clarify that such recommendations cannot be taken simultaneously for all companies in the market, as the results are a combination of many factors and conditions that are formed at each time, which requires an individual approach in each case.

Conclusions and prospects for further development in this direction. Thus, the econometric model makes it possible to understand the contribution of each factor in the sale of the brand and to form recommendations for each of them. The econometric model in such conditions becomes a flexible tool for sales management because it allows you to find the optimal combination of parameters to meet business goals. Ongoing support for the model allows you to maximize the impact of each factor, which ultimately allows you to get the necessary business results for the minimum budget or higher business results for the existing budget.

Thus, the model and regular process of data analysis become a convenient tool for making operational marketing decisions:

- clarification regularly of the optimal price index taking into account the dynamics of competitors' prices and tracking its impact on sales;
- calculation of the forecast at different variants of activity in the communication channels with the consumer due to work with doctors and pharmacists;
- monitoring the effectiveness of the advertising campaign;
- calculation of the forecast for different combinations of factors (scenario forecasting);
- determination of optimal values of each factor taking into account the marginal efficiency;
- analysis of the impact of factors on brand sales, evaluation of winnings and losses.

The econometric model acquires the greatest value at the moment when it becomes a tool for business simulations and the possibility of implementing scenario forecasting. In such conditions there is an opportunity to work with various scenarios of development, for example:

- What will happen if we transfer the budget for TV activity to work with doctors and pharmacists?
- What will happen if we increase TV support by X% and reduce the price by Y%?
- What will happen if we raise prices by X% and increase work with doctors and pharmacists by Y%?

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МОДЕЛЮВАННЯ ОПТИМАЛЬНОЇ ЦІНОВОЇ ПОЛІТИКИ ФАРМАЦЕВТИЧНИХ КОМПАНІЙ З МЕТОЮ МАКСИМІЗАЦІЇ ПРОДАЖІВ НА БАЗІ DATA SCIENCE ТЕХНОЛОГІЙ

Подано наслідки застосування Data Science технологій для моделювання результатів маркетингової діяльності фармацевтичних компаній залежно від ключових елементів маркетингового міксу. Детально досліджено вплив цінової політики на конкурентоспроможність підприємства та його позиції на ринку. На основі проведеного дослідження сформовано рекомендації щодо оптимізації цінової політики для максимізації продажів компанії.

Ключові слова: цінова політика, маркетинг, Data Science, машинне навчання, регресійний аналіз.

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МОДЕЛИРОВАНИЕ ОПТИМАЛЬНОЙ ЦЕНОВОЙ ПОЛИТИКИ ФАРМАЦЕВТИЧЕСКИХ КАМПАНИЙ С ЦЕЛЬЮ МАКСИМИЗАЦИИ ПРОДАЖ НА БАЗЕ DATA SCIENCE ТЕХНОЛОГИЙ

Представлены последствия применения технологии Data Science для моделирования результатов маркетинговой деятельности фармацевтических компаний в зависимости от ключевых элементов маркетингового микса. Подробно исследовано влияние ценовой политики на конкурентоспособность предприятия и его позиции на рынке. На основе проведенного исследования сформулированы рекомендации по оптимизации ценовой политики для максимизации продаж компании.

Ключевые слова: ценовая политика, маркетинг, Data Science, машинное обучение, регрессионный анализ.