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MODELING THE PROCESS OF FORMING A KPI SYSTEM FOR EVALUATING A PRODUCT STRATEGY BASED ON A FUZZY COGNITIVE MAP

The business process of strategic analysis of product areas of an IT company and IT product evaluation is considered. An approach to forming a KPI system for evaluating product strategy is proposed, based on constructing a fuzzy cognitive map. Cognitive modelling was conducted to assess the impact of KPIs on aspects of product strategy evaluation: financial performance, customer satisfaction level, and sales/marketing effectiveness. As a result, a system of main KPIs of the product was formed, and KPI weighting factors were obtained for calculating the aggregate financial indicator, the average customer satisfaction indicator, and the average sales and marketing efficiency indicator. An analysis of various possible scenarios of the impact of changes in KPI values on aspects of product strategy implementation has been conducted. The product manager assesses the future consequences of implementing the product strategy based on the results of modelling KPI changes.

IT PRODUCT, PRODUCT STRATEGY, KPI, BUSINESS PROCESS, COGNITIVE MAP, MODELING, FUZZY LOGIC, NEURAL NETWORK, AGGREGATE INDICATOR, SCENARIO

В. Ю. Москаленко, М. А. Гринченко. Моделювання процесу формування системи KPI для оцінки продуктової стратегії на основі нечіткої когнітивної карти. Розглянуто бізнес-процес стратегічного аналізу продуктових напрямків IT-компанії та оцінки продукту. Запропоновано підхід до формування системи KPIs для оцінки продуктової стратегії на основі побудови нечіткої когнітивної карти. Проведено когнітивне моделювання для оцінювання впливу KPIs на аспекти оцінювання продуктової стратегії: фінансовий результат, рівень задоволеності клієнтів та ефективність продажів/маркетингу. У результаті сформовано систему основних KPIs продукту, отримані вагові коефіцієнти KPIs для розрахунку агрегованого фінансового показника, усередненого показника задоволеності клієнтів та усередненого показника ефективності продажів і маркетингової ефективності. Проведено аналіз різних можливих сценаріїв впливу змін значень KPIs на аспекти реалізації продуктової стратегі. Продакт-менеджер оцінює майбутні наслідки реалізації продуктової стратегії на основі результатів моделювання змін KPIs.

ІТ-ПРОДУКТ, ПРОДУКТОВА СТРАТЕГІЯ, КЛЮЧОВИЙ ПОКАЗНИК ЕФЕКТИВНОСТІ, БІЗНЕС-ПРОЦЕС, КОГНІТИВНА КАРТА, МОДЕЛЮВАННЯ, НЕЧІТКА ЛОГІКА, НЕЙРОННА МЕРЕЖА, АГРЕГОВАНИЙ ПОКАЗНИК, СЦЕНАРІЙ

Introduction

The IT industry is highly competitive. Competition exists at various levels, from the global IT market for core technologies to specific market niches for IT products and services. Increasing the competitiveness of a software product throughout its life cycle is a strategic problem for an IT company to maintain its competitive status [1]. This problem is addressed within the framework of implementing the corporate strategy. Corporate strategy is formulated at the senior management level. It defines the main framework of the company's business strategy. For its implementation, decomposition is carried out to identify strategies for strategic business units. As a business unit for a product IT company, a software product, an IT service, and a product direction are considered. An appropriate business strategy is developed for each business unit. All product business strategies are components of corporate strategy [2].

Therefore, the current strategic tasks for an IT company are the selection of promising (competitive) areas and the effective management of IT products/services. Product management is carried out by a manager throughout the life cycle of an IT product, from idea generation and development to product launch, growth, maturity, and eventual withdrawal from the market. Hence, product improvement to meet customer needs and achieve strategic business goals is constantly carried out.

The product manager conducts product examination, the results of which are necessary for making strategic decisions throughout the product life cycle [3]. Tracking product metrics enables the product manager to make data-driven decisions at every stage. Linking each product decision to business outcomes, as well as justifying the investment in product launch and market support (determining ROI), are essential aspects of product management.

However, there is a problem in determining essential indicators, the analysis of which will really make it possible to develop measures to increase product competitiveness.

Metrics and key performance indicators (KPIs) for product examination are selected. These are quantifiable metrics that allow an IT company to determine and track the success of a product or business activity. Metrics typically assess the performance of specific business aspects of a product by providing detailed operational data. At the same time, KPIs help evaluate the performance of a software product in relation to the company's strategic business goals. KPIs help to create a roadmap for each product and plan the business strategy of an IT company. Such metrics enable stakeholders to assess how users interact with the product, identify areas for improvement, compare performance, and make informed decisions about subsequent actions throughout the product lifecycle [4]. However, tracking too many metrics can create "noise" in product performance analytics. For example, a large amount of contradictory data or poorly interpreted data may be obtained. At the same time, tracking too few metrics can leave so-called "blind spots". That is, specific aspects of product implementation, such as changes in product user preferences, the emergence of new needs, or changes in the value of individual product functions, will not be considered in the analysis of such indicators.

The current challenge is to create a relevant list of KPIs, the examination of which will provide an information basis for informed management decisions on improving the product to maintain its competitiveness and achieve the company's strategic objectives.

1. The problem of forming a KPI system for IT product management

IT product management practitioners and theorists are paying increasing attention to the issues of the process of analyzing the market success of IT products and services. The International Institute of Business Analysis (IIBA) has proposed an extension to the IT community to A Guide to the Business Analysis Body of Knowledge (BABOK Guide) - Guide to Product Ownership Analysis [5]. It is intended for professionals who act as product owners, product managers, and other professionals who are involved in the process of developing an IT product (service) and managing it. Product ownership analysis (POA) is applied at each of the three planning levels (strategy, initiative, and delivery) to continuously align the value of the product created with customer expectations and the IT company's goals [6]. It is necessary to conduct a market analysis, including an assessment of the product's competitiveness and the effectiveness of its implementation strategy, among other factors, for the first level of implementation: developing a product strategy. All this requires the formation of a KPI system for IT product management. In addition, the following advantages of tracking product indicators can be highlighted [7]:

– decision-making based on relevant data instead of the "intuition" of a specialist;

– Identifying inefficiencies in product development;

– measuring user satisfaction and overall customer experience;

– optimization of resource allocation between product development/improvement projects based on real data on the effectiveness of product strategies;

– checking the functionality of the product in terms of the requirements of users and existing competitors before entering the market;

– identifying product quality issues early before customers detect them;

– clear demonstration of the product's value to stakeholders (including users) and IT company management;

– reducing the risk of misunderstanding potential customer needs by measuring their engagement and retention levels.

Modern studies consider the issue of classifying indicators that characterize the effectiveness of product sales, its competitiveness, and other related factors. Since IT product KPIs are used to assess its success and align decisions to improve it with overall business goals, these indicators are usually divided into the following categories: business performance, customer engagement, and product development [7]. For example, tracking product management metrics helps the product development project team understand user behaviour, collect customer feedback, compare them to competitors, and continuously improve product performance. Increasing customer loyalty leads to higher revenue and increased market share.

However, there are challenges in measuring product management KPIs [8]:

– data inconsistency, i.e. the same indicator can be calculated in different ways, for example, a monthly active user can be considered someone who uses the product once a month, or only a user who performs specific actions (recommends others to use this product, etc.) or becomes a paying customer; this can lead to data distortion;

– excessive focus on numbers without understanding the real situation, for example, a drop in user engagement requires in-depth investigation; it could be a simple seasonality of product use or a decline in customer loyalty;

– data fragmentation, meaning that important information is spread across different tools and teams, making it difficult to get a complete picture of product performance; for example, a marketing department may track user engagement in one system, while a product manager may track it in other systems; data collection periods must also be considered.

Therefore, studies on measuring product management KPIs reveal that special attention is required for the formation of a KPI system, based on which product strategies can be evaluated and developed.

There are several recommendations for selecting KPIs for conducting an IT product examination and categorising them based on the product's field of use and type. Let's consider a few of these recommendations.

Atlassian, as a software company for teamwork and project management, recommends such a division of KPIs [9]:

– business performance indicators that focus on financial results;

– customer and user acquisition performance metrics that focus on satisfaction and loyalty;

– indicators that evaluate the effectiveness of product development.

LogMeIn [10], a company that develops solutions for remote access, collaboration, and support, provides the following classification of popular metrics:

– support services (average time to solve the problem, first call resolution rate, customer satisfaction);

– Network performance (network uptime, data latency, percentage of available network);

– system uptime and reliability (server uptime, number of incidents, average time between failures);

– safety and compliance (number of security incidents; patch management compliance, compliance assessment);

– backup and restore;

– the cost of the technologies used;

– employee productivity;

– project implementation.

These indicators are targeted at the IT company that produces products for device management. Therefore, indicators reflecting the effectiveness of services provided to customers through the corresponding product are added to the overall KPIs [10].

Specialised product analytics platforms, all-in-one project management tools, and specialized business intelligence software can be utilized to track product management metrics effectively. For example, tools such as ProductCentral [7], Sharpist with Miro, Mixpanel, and Google Analytics [11]. These tools help consolidate data, visualize performance dynamics, and provide actionable insights into user behaviour, product performance, and business outcomes. However, they enable product managers to calculate KPIs for specific product categories. For example, Google Analytics provides website and app performance tracking, allowing users to measure traffic, conversions, and customer engagement. Most of these tools offer a wide range of visualization of KPI calculation results.

However, for practical work, a product manager needs a tool that would have the functions of forming and tracking a system of indicators for a specific period, the tasks of generating data to evaluate the product strategy depending on the type of product and the company's goals, and the functions of indicator analytics for making decisions on improving the product strategy. As a result, this tool should support the strategic analysis of the product strategy and inform the decision-making process to improve it. To develop such a software tool, it is necessary to enhance the process of strategic analysis for product strategy.

2. Problem statement

A business process model for evaluating and analyzing product strategies of an IT company and forming recommendations for their improvement, taking into account the priority areas of development of an IT company (Fig. 1), was proposed in previous studies by the authors of this article [1, 12, 13].

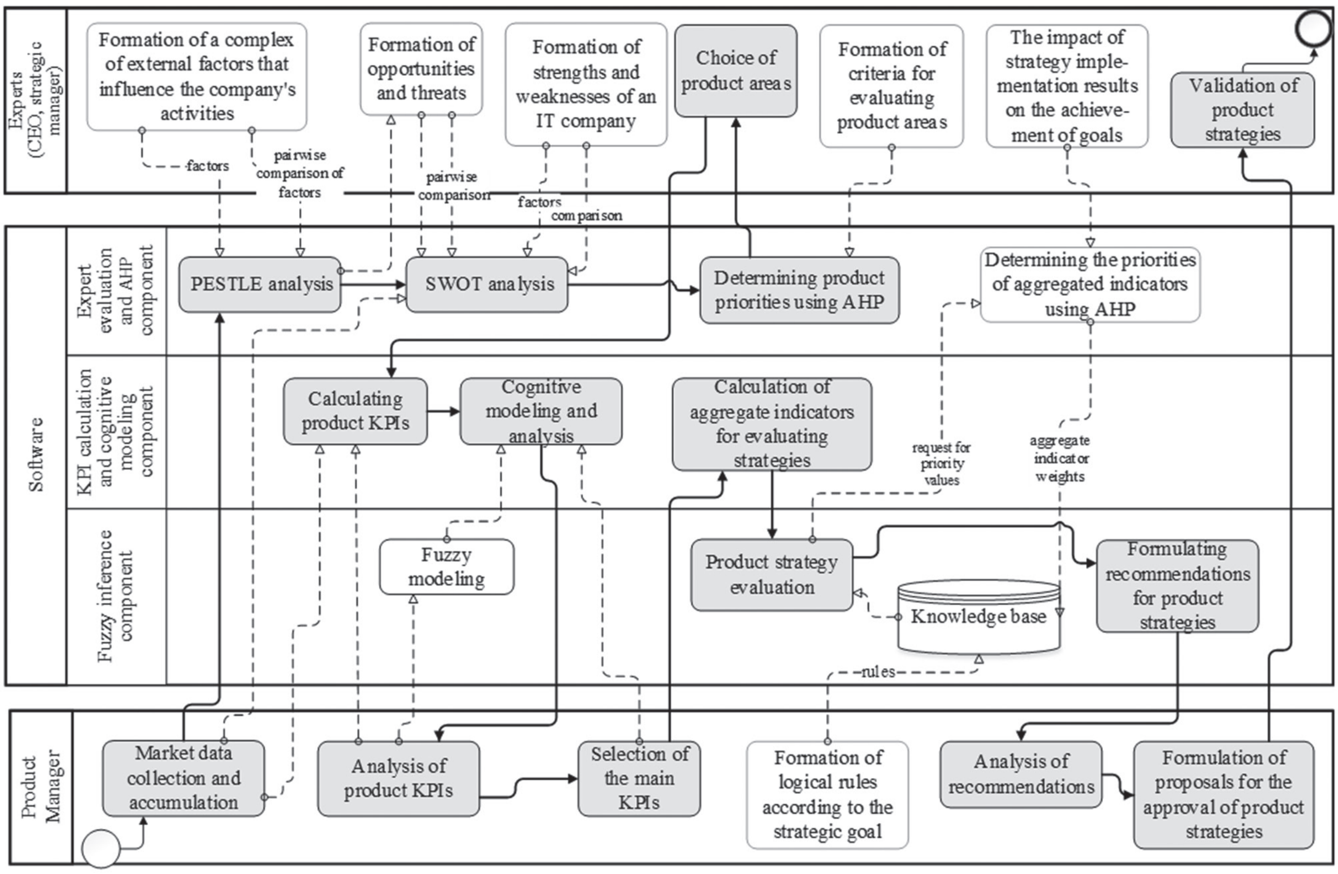


Fig. 1. Business Process Model for Strategic Analysis of IT Company Product Lines and Product Strategies

At the initial stages of this business process, a set of factors influencing the success of an IT company is identified, and the main criteria, which are then used to select promising product areas of an IT company, are determined through PESTLE analysis and SWOT analysis.

The next stage of the business process is the assessment of the company's product areas (product lines). Evaluation of product areas is carried out based on the defined criteria using the structured decision-making technique, the Analytic Hierarchy Process (AHP) [14]. Product areas assessment is carried out in relation to the strategic goal of the IT company. For example, increasing the competitiveness of an IT company can be considered a strategic goal. The level of market success for product areas and their associated risks is determined using the AHP technique, which involves pairwise comparison of hierarchy elements [15]. The results of the AHP implementation are submitted to the company's management. The management of the IT company, along with experts, selects promising product areas (or product lines).

Next, product managers conduct a strategic analysis of products within the selected product lines. The manager forms an appropriate KPI system for the product. The numerical values of these KPIs characterize the level of success of the product in the IT market by various aspects (finance, customers, marketing, competitors, etc.) [1].

In other words, this KPI system is designed to evaluate the product strategy and determine whether to continue its implementation in the planning period or to refine it based on the assessments received.

Therefore, the purpose of this study is to enhance the process of conducting a strategic analysis of product strategies by establishing a KPI system to evaluate the market success of an IT product. The product manager develops proposals for the product strategy based on the analysis of these indicators. The product strategy should include a plan to improve the KPI in line with the company's strategic goals.

3. Proposed approach to forming a KPI system for evaluating an IT product

This study examines a company that uses two business models:

1) IT products are sold on a subscription basis, providing customers with ongoing access to products (including updated versions) for regular payments;

2) selling licenses on various terms. It is necessary to define a KPI system for each product, since a different set of indicators describes the implementation of each business model.

Three groups of IT product strategy indicators were proposed to be considered according to the analysis of existing KPI classifications and the peculiarities of the Ukrainian IT market:

– indicators of the financial success of the product;
– customer satisfaction indicators;
– sales and marketing performance indicators.

According to the Strategic Analysis Business Process (Fig. 1), the values of the relevant KPIs are the basis for calculating the Aggregate Financial Indicator (AFI), the Average Customer Satisfaction Index (ACSI), and the Average Sales/Marketing Performance Indicator (ASPI). These aggregated metrics are used to evaluate a product strategy using a fuzzy logic tool, specifically the fuzzy inference subsystem (FIS) trees [16, 17].

Therefore, the product manager should select the primary KPIs that best align with the product lifecycle stage and business objectives. When analyzing a product in its early stages of the life cycle, user engagement rates may be a key priority. Then, when analyzing a product at mature stages, focus on revenue growth and user retention [4].

As a result of the study, a list of the main KPIs was formed. Their conditional division into three groups has been carried out.

1. Indicators of the product's financial success (FI).

FI1. Revenue Indicator [4]. Average revenue per user (ARPU) applies to various digital products, including e-commerce websites, online games, and travel apps. ARPU is the amount of revenue that a company receives from one user for a certain period (for example, a month, quarter, or year):

APRU ($) = Total revenue / Total number of users.

Suppose you are analyzing a strategy for subscription-based products. In that case, it is recommended to use annual recurring revenue (ARR) and monthly recurring revenue (MRR) instead of ARPU, depending on the analysis period:

MRR ($) = APRU x Number of accounts in a month = sum of current monthly subscriptions + revenue from new subscriptions + upgrades - downgrades - revenue from lost customers.

FI2. Customer Lifetime Value (CLTV) assesses the financial benefits of attracting and retaining each customer, indicating the total revenue that the business generates from a single customer over the entire duration of their relationship. You need to multiply the average lifespan of the customer (how long the user usually uses the product) by ARPU to calculate the CLTV:

CLTV($) = Average customer lifetime x ARPU.

The CLTV is also used to assess a customer's loyalty to a product or IT company.

FI3. Customer Acquisition Cost (CAC) is the cost of persuading a potential consumer to buy a product or service:

CAC ($)= Total sales and marketing spending / Number of new customers.

CLTV and CAC indicators enable you to determine whether customers generate less revenue for the company than they spend on them. Analyzing these metrics influences decisions to revise the pricing strategy and marketing of the product to attract more users. It is also worth determining the CAC for different sales channels to compare their effectiveness.

Therefore, the CLTV and CAC metrics can also be considered in the analysis of the effectiveness of marketing activities and the sales team.

Other financial indicators can be added to the first group; these include gross/net margin, as well as return on investment in product development and market promotion.

2. Customer satisfaction indicators (SI). These indicators characterize the level of customer loyalty of an IT company. Information about how users interact with the product, their overall level of satisfaction with it, and other relevant metrics is obtained through the analysis of these metrics.

SI1. Customer retention rate (CRR) is the percentage of customers who continue to use the product over a period. CRR shows the user success of a product because the product has value to loyal customers:

Retention rate (%) = ((Customers at the end of the calculated period - New customers) / Customers at the start of the computed period) x 100.

SI2. Customer churn rate (CCR) determines the percentage of customers that a company loses over a specified period. It is essential for subscription companies:

Customer churn rate (%) = (Customers lost / Total customers) x 100.

You can use the Revenue Churn Rate:

Revenue churn rate (%) = (Revenue from lost customers / Total revenue) x 100.

SI3. The Net Promoter Score (NPS) measures customer loyalty and satisfaction based on customer survey results, and how likely they are to recommend a product to others:

NPS = Percentage of promoters - Percentage of detractors.

You need to get product ratings from customers to calculate the NPS. For example, the assessment should be conducted on a scale of 0 to 10. Disloyal customers will receive 0 to 6 points, neutral customers – 7 or 8 points, and loyal customers (promoters) – 9 or 10 points.

SI4. Overall Satisfaction Score (OSAT) shows the overall level of customer satisfaction with the product:

OSAT (%) = (Number of satisfied responses / Total number of responses) x 100.

Different scales can be used to measure it, for example, a scale from 0 to 10, where dissatisfaction ranges from 0 to 4, and satisfaction ranges from 5 to 10.

If the product has already been on the market for some time and you need to evaluate improvements to it, such as adding additional features, then the requests will only apply to this part of the product.

SI5. Earned growth rate (EGR) indicates the increase in revenue resulting from regular customers and their referrals over a specified period (month, quarter, or year). It characterizes the impact of customer loyalty and customer support on the growth of the company's income from the sale of an IT product:

EGR (%) = NRR + ENC,

where *NRR* – Net Revenue Retention,

NRR (%) = ((MRR at the beginning + Expansions + Upsells - Churn - Contractions) / MRR at the beginning) x 100;

MRR ($) – Monthly Recurring Revenue;

ENC – Earned New Customers is income from customers purchased through recommendations and word of mouth:

ENC (%) = (New customer revenue earned through referrals / Total new customer revenue) x 100.

The EGR measure assesses whether customer referrals have been converted into revenue, thereby quantifying the impact of customer loyalty on financial performance. This indicator can be attributed to the first group, since it evaluates the financial result.

The following metrics can be added for a more thorough analysis of the product's customer/user satisfaction:

Time to Value (TTV) shows how quickly a new user realizes the value of a product or new feature;

The Error Correction Factor is calculated as follows: the number of corrected errors during the specified period divided by all identified errors; it shows the effectiveness of the development team in maintaining the product quality.

3. Presales & Marketing Team Performance Metrics (PI).

PI1. Win Rate (WR) shows the percentage of leads that the sales team was able to convert into paying customers:

WR (%) = (Number of closed deals / Total opportunities) × 100 %.

PI2. Average Deal Value (ADV) is a key metric for sales teams. ADV shows the average estimate of revenue from each deal:

Average deal Value ($)= Total value generated / Total number of closed-won deals.

Although the average revenue per contract is high, the agreement signing process incurs high costs, which can negatively impact the contract margin. ADV also affects the financial outcome of implementing the product strategy.

PI3. Churn Rate (CR) is a metric that determines the percentage of customers that a company loses over a period:

CR = Number of lost Customers / (Total Number of Customers at the beginning of the period) x 100.

PI4. The Inbound Qualified Lead Velocity (IQLV) measures the monthly increase in the number of new leads who show genuine interest in a product or service compared to the previous month. It is used to understand the possibilities of sales directions, i.e. tracking the flow of leads. An IT company can predict which leads will bring the company the most revenue and are most likely to become paying customers, based on:

IQLV(%) = ((Current Month's Lead Count - Last Month's Lead Count) / Last Month's Lead Count) x 100.

Knowing about potential customers provides greater certainty about future sales. The higher the speed and volume of this sales funnel, the easier it is for the management team to make decisions about planning the direction and volume of sales for IT products/services.

PI5. Contract Profitability (CP). Keeping track CP helps the sales team manage and improve the efficiency of their operations.

The analysis of the developed KPI system is conducted in accordance with the study's objectives. It is concluded that assigning a specific KPI to one group or another can cause controversy. Therefore, it is proposed to analyze the impact of each indicator on the financial result, on the level of customer orientation of the product (customer satisfaction) and on the effectiveness of sales/marketing. It is necessary to determine the KPIs that will be used to calculate the aggregate indicators of AFI, ACSI and ASPI, as well as their weighting factors. It is proposed to use fuzzy cognitive modelling.

4. Constructing a fuzzy cognitive map

A fuzzy cognitive map (FCM) was constructed as part of the study. A map was created to determine the level of influence of each indicator on the aspects of evaluating the product strategy: financial results, customer satisfaction, and sales/marketing efficiency.

FCM is a tool for presenting knowledge about a system characterized by uncertainty, causality and complex processes. FCM is a peculiar combination of fuzzy logic, cognitive mapping, and neural networks. Let's consider two approaches to describing FCM.

1. A fuzzy cognitive map is a fuzzy oriented graph of the first kind and is described as follows [18]:

$$\tilde{G} = (A, \tilde{U}), \quad (1)$$

where $A=\{a_i\}$, $i \in I=\{1,2,...M\}$ – a distinct set of graph vertices (in this problem, the graph vertices are the KPIs); $\tilde{U} = \{<\mu_U(a_i, a_j) / (a_i, a_j)>\}$ – fuzzy set of edges of a graph, $(a_i, a_j) \in X^2$; $\mu_U(a_i, a_j)$ – the degree of belonging of an oriented edge (a_i, a_j) to the fuzzy set of oriented edges $\tilde{U}$; edge (a_i, a_j) exists if changing the parameter a_i has a direct effect on changing the value of the parameter a_j.

The process of propagation of a perturbation along the graph $\tilde{G}$ with known initial values at all vertices $\{a_i^0\}$ and the initial perturbation vector $\{P_j(0)\}$ is determined by the formula:

$$a_V(t+1) = a_V(t) + \sum_{j=1}^{k-1} f_{ij} P_j(t) + Q_i(t), \quad (2)$$

where $a_i(t)$ and $a_i(t+1)$ are the values of the indicator at the vertex a_i respectively, at the *t-th* moment (simulation cycle) and the t+1-th moment; $P_j(t)$ – change in vertex j at the t-th moment; f_{ij} – function to convert links between KPIs; $Q_i(t)$ – vector of disturbances (changes in parameters).

Introducing perturbations simulates a scenario that answers the question of scientific prediction: "What will happen to the system at time t+1 if ...?".

2. In the modern scientific literature, FCM is implemented as a recurrent neural network with interpretive features [19]. Recurrent NN is a set of neurons and causal relationships between them. The activation value of such neurons takes the value in the interval [0, 1]. The stronger the activation value of a neuron, the greater its impact on the network. The strength of the causal connection between two neurons A_i and A_j is quantified by the numerical weight $w_{ij} \in [-1, 1]$.

In this paper, we consider neurons A_i and A_j, which are KPIs.

There are three types of causal relationships between neurons in FCM:

if $w_{ij} > 0$, then there is a positive relationship, an increase (or decrease) in A_i generates an increase (decrease) in A_j with intensity $|w_{ij}|$;

if $w_{ij} < 0$, then there is a negative relationship between the indicators, so an increase (decrease) in A_i leads to a decrease (increase) in A_j with intensity $|w_{ij}|$;

if $w_{ij} = 0$, then there is no causal relationship between the parameters.

There is a Cosco activation rule for each neuron at t+1 iteration of NN training [20]:

$$A_i^{t+1} = f\left(\sum_{\substack{j=1 \\ i \neq j}}^{M} w_{ij} \cdot A_i^t\right), \quad (3)$$

where A_i^{t+1} – state of the i-th neuron at the t+1-th training iteration; A_i^0 is the initial state of the i-th neuron; $f(\cdot)$ is a monotonically non-decreasing activation function, in this work, a sigmoid function is used:

$$S(x) = \frac{1}{1+e^{-\lambda x}}, \quad (4)$$

and hyperbolic tangent

$$tanh(x) = \frac{e^{\lambda x} - e^{-\lambda x}}{e^{\lambda x} + e^{-\lambda x}}, \quad (5)$$

where the λ parameter is used to control the slope of the activation function, taking a value greater than 0, and its value is closely related to the convergence behaviour of the FCM [21]; x is the current value of the neuron.

The primary difference between their use in FCM lies in the range of node activation values, which results in different interpretations of indicator states.

The sigmoid function produces a value between 0 and 1; a value of 0 means no or minimal activation, while a value of 1 indicates the maximum possible activation.

Scenarios using the sigmoid form are well-suited for situations where all concepts exist on a unipolar scale (e.g., presence/absence, low/high) and negative values do not make sense.

The hyperbolic tangent function produces values from -1 to 1. A value of 0 represents the neutral state, 1 represents the maximum activation, and (-1) means the maximum negative presence or suppression of the activation level.

Scenarios using the hyperbolic tangent function are ideal for systems where components may exhibit contrasting or bipolar states (e.g., positive vs. negative change, agreement vs. dissent), making it the preferred method for handling negative influences and fluctuations in system dynamics, as it displays negative inputs as strongly negative.

So, for each scenario, the appropriate activation function will be selected. The activation rule repeats iteratively until the stop condition is met. The new activation vector is computed on each iteration, and after a fixed number of iterations, the FCM will be in one of the following states:

1) equilibrium point;
2) limited cycle;
3) chaotic behaviour [20].

5. Experimental studies

A fuzzy cognitive model was constructed using the Mental Modeler application (Fig. 2) to analyze the KPI relationships. Mental Modeler enables you to intuitively create cognitive maps based on fuzzy logic, utilizing a user-friendly interface [22].

The cognitive map (Fig. 2) is constructed as follows: the vertices represent KPIs, which are divided into three groups: indicators of the product's financial success, indicators of customer satisfaction (including customer loyalty), and sales and marketing performance indicators, as discussed above. We also added vertices that represent the generalized financial result of the product strategy implementation (FI), the level of customer satisfaction (SI) and the level of sales/marketing efficiency (PI).

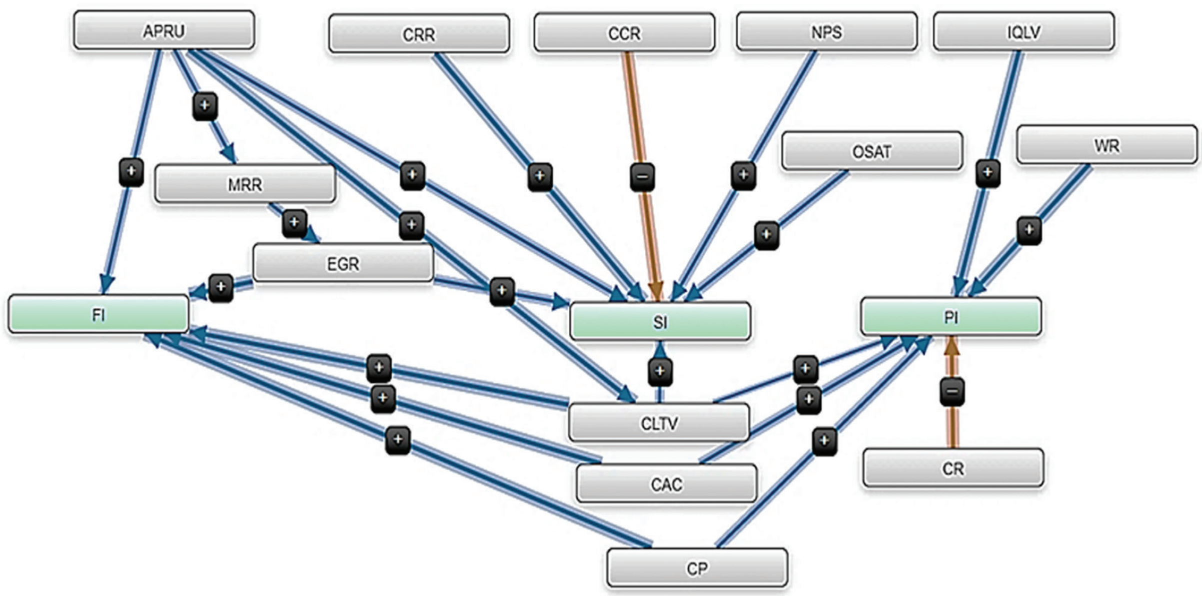


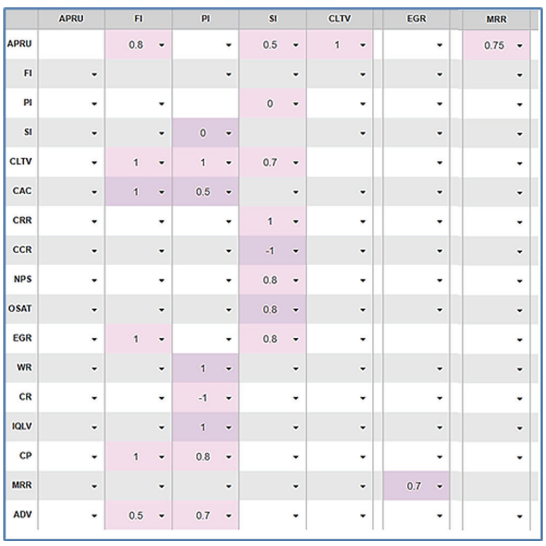
Fig. 2. Cognitive map

The presence of an edge between the indicators means the influence of one indicator on another, and the scales determine the degree of influence.

After constructing the model, the relationships between KPIs were analyzed, and the values were revised $\{w_{ij}\}$, as well as changes in the degrees of their belonging. Expert assessments of specialists involved in product management within the company's IT and financial analytics teams were used to analyze the connections.

An adjacency matrix was constructed, with each element representing an edge weighting factor (w_{ij}), which relates the force of the influence of indicator Ai on Aj.

The strength of the influence of each KPI on FI, SI and PI was analyzed. Figure 3 shows a fragment of the adjacency matrix.



	APRU	FI	PI	SI	CLTV	EGR	MRR
APRU		0.8		0.5	1		0.75
FI							
PI				0			
SI			0				
CLTV		1	1	0.7			
CAC		1	0.5				
CRR				1			
CCR				-1			
NPS				0.8			
OSAT				0.8			
EGR		1		0.8			
WR			1				
CR			-1				
IQLV			1				
CP		1	0.8				
MRR						0.7	
ADV		0.5	0.7				

Fig. 3 Fragment of the adjacency matrix

This numerical representation of relationships enables experts to analyze the level of impact and interdependence of KPIs. For example, the set of indicators that affect financial results was changed as a result of an expert analysis of the previous version of the map. The EGR score, which was initially classified as a metric that only affects the level of SI customer loyalty (with a weight of 1), has been added. But the decision that the EGR indicator directly affects the financial results of FI was made by experts after a thorough analysis of the map. Therefore, the weights were redefined as follows: EGR affects the FI result as much as possible (*wij* = 1); it also affects the SI result, but less (*wij* = 0.8). Therefore, the degrees of influence of the indicators were redefined as a result of analyzing the cognitive map. Fig.2 shows the latest version of FCM.

The KPI weights for calculating the corresponding aggregate indicators (AFI, ACSI, ASPI) are determined through adjacency matrix analysis.

Let's consider an example of calculating weighting factors for calculating the aggregate indicator API. The indicators CLTV, CAC, ERG, and CP (each with a weight of 1) have a direct effect on FI. The APRU indicator affects FI with a weight of 0.8, and the ADV indicator affects FI with a weight of 0.5. Then, you can calculate the weighting factors as follows:

$$\alpha_{CP,FI} = \frac{w_{CP,FI}}{w_{CP,FI} + w_{CLTV,FI} + w_{CAC,FI} + w_{ERG,FI} + w_{APRU,FI} + w_{ADV,FI}},$$

where $w_{CP,FI}, w_{CLTV,FI}, w_{CAC,FI}, w_{ERG,FI}, w_{APRU,FI}, w_{ADV,FI}$ are the weights that are obtained from the adjacency matrix, in this case they are equal to 1, respectively; 1; 1; 1; 0,8; 0,5.

In this example, the weighting factors will be equal to the following values:

$$\alpha_{CP,FI} = \alpha_{CLTV,FI} = w_{CAC,FI} = w_{ERG,FI} = 0{,}19,$$

$$\alpha_{APRU,FI} = 0{,}15, \alpha_{ADV,FI} = 0{,}09.$$

Then the value of the aggregate financial indicator will be determined as follows:

$$AFI = w_{CP,FI} \cdot \hat{CP} + w_{CLTV,FI} \cdot \hat{CLTV} + w_{CAC,FI} \cdot \hat{CAC} +$$

$$+ w_{ERG,FI} \cdot \hat{ERG} + w_{APRU,FI} \cdot \hat{APRU} + w_{ADV,FI} \cdot \hat{ADV},$$

where $\hat{CP}$, $\hat{CLTV}$, $\hat{CAC}$, $\hat{ERG}$, $\hat{APRU}$, $\hat{ADV}$ are normalized values of CP, CLTV, CAC, ERG, APRU, ADV indicators, respectively.

The relative importance of indicators for assessing the implementation of a product strategy was analyzed using the tool Preferred State&Metrics (Fig. 4).

The Centrality column (Fig. 4) shows the conceptual weight/importance of the vertices of the FCM graph. The vertices of the FCM graph represent KPIs and generalized results of implementing the product strategy FI, SI, and PI. In this example, SI is more important (Centrality=5.71). This is because the outcome is determined by a larger number of key performance indicators (KPIs) that measure customer satisfaction than those that measure financial potential (FI) and profitability of sales/marketing (PI).

Preferred State & Metrics

Component	Indegree	Outdegree	Centrality	Preferred State	Type
SI	5.71	0	5.71	Increase	receiver
FI	4.8	0	4.8		receiver
PI	4.75	0	4.75		receiver
APRU	0	3.28	3.28	Increase	driver
CLTV	0.97	2.15	3.12	Increase	ordinary
EGR	0.7	1.8	2.5	Increase	ordinary
CP	0	1.8	1.8	Increase	driver
MRR	0.9	0.7	1.6		ordinary
CAC	0	1.5	1.5	Increase	driver
IQLV	0	1	1	Increase	driver
CR	0	1	1	Decrease	driver
WR	0	1	1	Increase	driver
CCR	0	1	1	Decrease	driver
CRR	0	1	1	Increase	driver
OSAT	0	0.8	0.8	Increase	driver
NPS	0	0.8	0.8	Increase	driver

Fig. 4 Tool Preferred State&Metrics

Simulations of various scenarios have been carried out, specifically examining how the values of FI, SI, and PI change in response to changes in performance indicators. As an example, let's consider two such scenarios.

Scenario 1: Average revenue per user (ARPU) increased a lot. Fig. 5 shows that significant positive changes in values will not substantially affect the results of implementing the product strategy in three aspects of FI, SI, and PI. This is because the weights set by experts for this indicator are less than 1 for FI and SI.

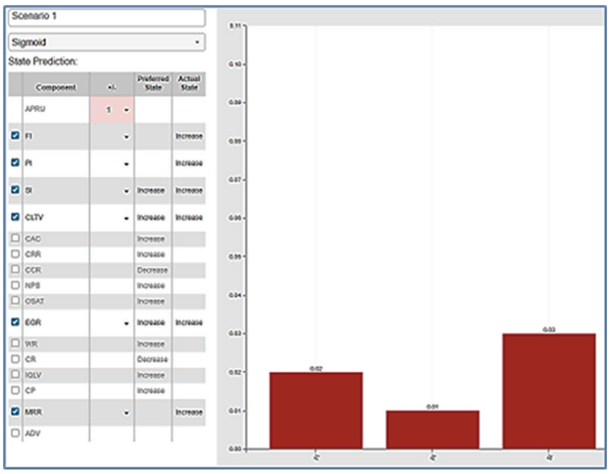


Fig. 5 Results of scenario 1

Scenario 2: Customer Acquisition Cost (CAC) decreased due to an increase in the cost of working with a potential consumer by 40%, Net Promoter Score (NPS) increased by 60% due to the rise in the value of the product for the customer, and the Customer Retention Rate (CRR) also increased by 20% (Fig. 6).

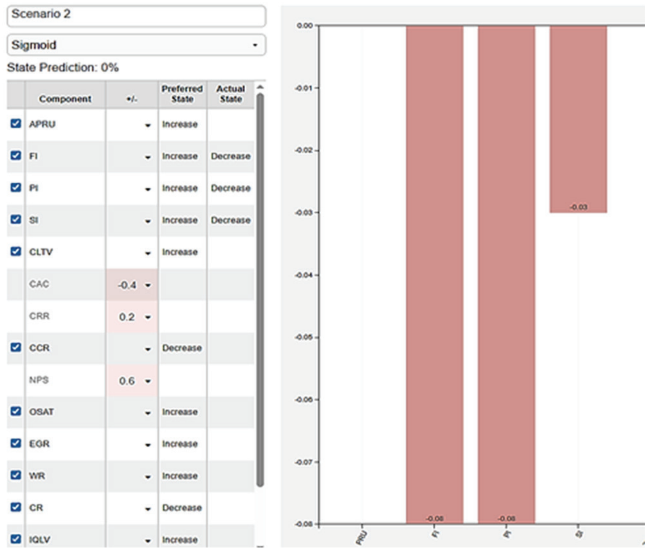


Fig. 6 Results of scenario 2

As a result, we have seen a deterioration in the implementation strategy's results in all aspects. Therefore, this is a reason to revise the product strategy and focus on the indicators that characterize financial results and sales efficiency. Most likely, the funds spent on marketing and stimulating the presale did not yield the expected financial outcome.

Thus, making changes to the cognitive map models presents a scenario that addresses the question of scientific prediction: "What will happen to the aspects of the product strategy at time t+1 if some indicators are changed?"

Using a cognitive map that reflects the cause-and-effect relationships of the influence of KPIs on the results of the product strategy implementation by aspects (FI, SI and PI), the product manager obtains weight coefficients for measuring aggregated indicators of strategy implementation.

Since the value of KPIs is a numerical measure of the market reaction to the implementation of the product strategy, modelling their changes allows the product manager to assess the future consequences of deterioration or improvement in the effectiveness of the product strategy.

Conclusion

The study considers the business process of strategic analysis of IT company directions and product strategies.

An approach to forming a system of KPIs for evaluating a product strategy is proposed, based on the construction and analysis of a fuzzy cognitive map.

As a result of the cognitive modelling, a system of KPIs was formed, and the weighting coefficients of KPIs were obtained to calculate:

– the aggregate financial indicator;
– the average indicator of customer satisfaction;
– the average indicator of sales efficiency and marketing effectiveness.

Aggregated indicators are used to evaluate the product strategy.

The analysis of various possible scenarios for the impact of changes in KPI values on aspects of product strategy implementation is conducted.

It is proposed to consider the following aspects: financial result, level of customer satisfaction and level of sales/marketing efficiency.

Thus, modelling changes in KPIs enables the product manager to assess the future consequences of implementing the product strategy.

As a result of the research, it was found that the formation of a system of KPIs depends on the type of business model used for implementing an IT product. In further research, it is planned to develop cognitive maps as neural networks for analyzing the KPIs system.

It is planned to investigate the training processes of neural networks using the algorithms of Hebb and Hopfield [23] to enhance the models for developing a system of KRIs for evaluating product strategy.

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