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DEVELOPMENT OF DYNAMIC MODEL OF FORMING INVESTMENT VALUE OF RESOURCES IN INFORMATION SYSTEMS OF INTEGRATED SERVICE NETWORKS

Об'єктом дослідження є інвестиційна вартість цінової політики, максимізації інвестиційного прибутку у розвиту інформаційної системи. Одним із найбільш проблемних місць є визначення вартості корегування вхідного інвестиційного ресурсу з врахуванням динамічного коригуючого елементу, складової змінного часу та базисного інвестиційного ресурсу. При характеристиці незмінності коливання бізнес циклів ключовою проблемою є обмеження надання та споживання вихідної вартості інвестиційних ресурсів та складності диференціального коригування факторів виробництва. А також застосування методу лінійного багатопотокового моделювання інвестиційного процесу вартості інформаційного ресурсу, що дозволяє диференціально регулювати зміну ціни інформаційного ресурсу, як вихідної вартості споживання, так і корегування інвестиційної вартості активів.

В ході дослідження використовувався підхід лінійного моделювання величини надходження та надання інформаційних ресурсів в моделі динамічного інвестиційного процесу, що дозволяє усунути коливання вартості інвестиційного процесу у вартості та окупності.

Отримано трьохступінчату процедурну модель розрахунку вартості інформаційного ресурсу в динамічному інвестиційному процесі з можливостю перегляду ціни та регулювання об'єму вартості надання та споживання.

Розроблено економічний зміст цінової політики для ситуації, в котрих мережева можливість щільно обмежена ціною споживання, об'ємом та вартістю. А також, якщо мережевий оператор оцінює послуги не розглядаючи можливого обмеження та у випадку гарантування послуги інформаційної системи, коли інформаційна система не може відповідати вимогам виконання. Щодо цього випадку отримана стратегія показує, що у інформаційної системи підприємства повинна міститись можливість динамічного регулювання об'єму споживання, надання інформаційних ресурсів та динамічне регулювання інвестиційної складової вартості активів.

Вибірковість даного підходу в комплексній динаміці інвестиційної вартості інформаційної системи містить неповну оцінку даного виду продукту. Тому має існувати схема постійного перегляду її вартості, що містить динамічну складову інвестиційної вартості інформаційної системи.

Ключові слова: *інформаційна система, динамічне регулювання, динамічне інвестування, управління ціновою політикою.*

1. Introduction

In the context of the variability of economic processes, the speed of development and the scale of complexity acquire the planning of business processes by the nature of their fluid, containing many components of information and investment resources, influencing the formation of both assets and investment sources. In turn, the dependence of the investment process on the development of information systems of their integration makes it possible to identify the dynamic component of the formation of value, the adjustment of the value of assets, ensuring a cyclic calculation and consumption with the regulating price factor itself, as some dynamic linear magnitude.

Actual in the study there is the need to develop such system for formation of the investment value of the resources of the information system for provision of service that ensures the regulation of the cost of the business process and investment payback.

2. The object of research and its technological audit

The object of research is the investment pricing policy for formation of the cost of resources of information systems of integrated service networks for various types of services.

At present, with the rapid development of information and telecommunication systems, it is important to develop effective schemes for the formation of the cost of resources for various types of services.

The economic component of the formation of the cost of information resources contains an integral investment component of the information system. At present, in most cases, there is a practice of transferring all types of costs for the formation of both a given service and the entire list of services to the cost of the service itself in the manner of normal distribution, depending on the weight of the elements and the total cost.

The selectivity of this approach in the complex dynamics of the investment value of the information system contains an incomplete estimate of this type of product. Therefore, there should be a scheme for a constant review of its value, to contain a dynamic component of the investment value of an information system with the following properties:

– taking into account the weight, importance of the service;
– accounting frequency of the service request;
– accounting for the impact of this service on the quality of services already provided;
– «reserve of value» for this service – that is, the level of its paying, the implementation of prepayment. This means that it is necessary to pay for network resources already, and the funds for their use will be received in the next period.

That is, they should note that consumers will be ready to pay the full cost, and service providers provide them only when the maximum number of services (in the case under study, data cells) will be entered in the buffer (purchased) and transferred if the services are guaranteed to be paid (prepaid) (Fig. 1).

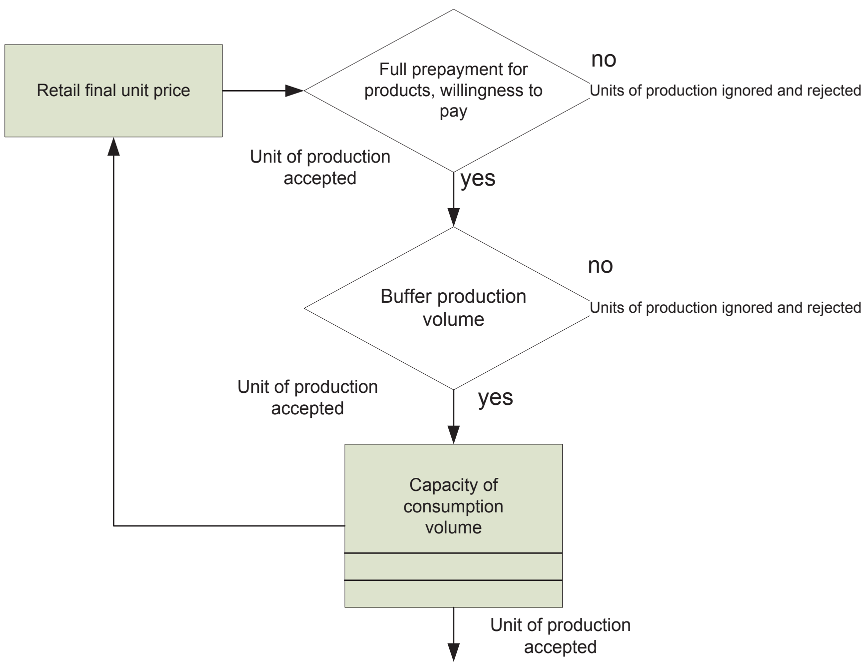

Fig. 1. Dynamic model of formation of investment cost of resources of the information system for obtaining the greatest number of services

The data is located in the buffer space (the amount of stock). If it is not enough, some of the cells will be omitted (ignored).

3. The aim and objectives of research

The aim of research is obtaining a model for formation of the cost of an information system of integrated service networks with the possibility of reverse adjustment of the price of services to the volume of consumption and the structure of assets.

To achieve this aim, it is necessary to perform a number of tasks:

1. To make the system of formation of the cost of services such that the volume of consumption corresponds to the volume of their guaranteed provision.

2. To ensure the existence of continuity with the dynamic component of the investment process, the length of the business cycle.

4. Research of existing solutions of the problem

Among the studies devoted to solving the problem of the characteristics of information systems of integrated service networks identified in the resources of the world scientific periodicals, work [1] devoted to the formation of investment value can be singled out and also works [2, 3], which deal with the formation of investment value in conditions of dynamic regulation of investments. The pricing policy of the information system is shown in [4].

An alternative solution to the problem of price policy management, set forth in [5, 6], does not provide for reverse regulation of the cost of integrated services. Taking into account the opinion of the authors that the cost of integrated service network services depends on the volume of investments [5, 6], feedback is shown in [7, 8].

The possibility of dynamic regulation with differential dependence of the initial value to the volume of provision of services and the investment value of resources is also considered [9, 10].

Thus, the results of the analysis lead to the conclusion that it is possible to calculate the value of the investment value of assets aimed at ensuring the development of an information system of integrated service networks with an internal adjustment of the cost of services.

5. Methods of research

Let's describe the characteristics of the model and the dependence. In this model, users upload data to the previous payment. Let's assume that all cells are loaded into the buffer (B_s).

Willingness to pay for each cell sent to the network, which was given the advantage.

Each time in a time (t), the network sets the cut-off price $p_b(t)$, which is a function of both variables, both the present size and the possibility of prepayment of the future receiving of data cells. All cells will be accepted if and only if the willingness to pay for a cell is greater than $p_b(t)$ and for $p_b(t)$ will also be paid for downloads for each cell. Accepted (recognized) cells will be addressed to the buffer and should correspond to the length and size of the buffer. When the cells are already addressed to the buffer, they will be subsequently transferred to the end user, depending on the specific order of the algorithm: first receiving, payment priority [1].

Assuming that at the present time (t), the cell receiving process is a Poisson distribution of two variables with the expected value $\lambda_b(0, t)$ and the acceptance is also a Poisson distribution of the expected value $\lambda_b[p_b(t), t]$.

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Let's define $S_b(t)$ as an instantaneous indicator of the transfer of cells for a certain time, then:

$$S_b(t) \le C_T - s[q_1(t), q_2(t), ..., q_N(t)], \tag{1}$$

where $s[q_1(t), q_2(t), ..., q_N(t)]$ – the indicator of the instantaneous transmission size of all guaranteed cells, which is a function of the number of executed cells.

Formula (1) illustrates the instantaneous transmission of the entire number of cells, which is not capable of exceeding the bandwidth.

When accepting the proposed data, then:

1) the accepted cells will constitute a Poisson process;

2) the value of instantaneous transmission will depend both on the capacity of service providers and on each casual recipient;

3) the size of the volume of the receiving side of the information system is limited. There is a possibility that even accepted service network services with items in data cells (cells for which it is possible to pay more for before, and not as a price for failure) can be lost due to the temporary fullness of the volume of the transmitting side of the service network.

Let's specify $\upsilon(t, \Delta t)$ how the number of cells actually admitted to the buffer during the interval $[t, t+\Delta t]$, when the instantaneous value can be determined as:

$$\omega_b(t) = \lim_{\delta t \to 0} \frac{\upsilon_b(t, \Delta t)}{\Delta t}, \tag{2}$$

where $\omega_b(t)$ – random variable and take the expected value:

$$\varpi_b(t) \le \lambda_i[p_b(t), t)], \tag{3}$$

where $q_b(t)$ is defined as the number of cells in the buffer for a time interval t:

$$\frac{d_q b(t)}{dt} = \varpi_b(t) - s_b(t), \tag{4}$$

$$s_b(t) = q_b(t) \le B_s. \tag{5}$$

On this structure, let's build the assumptions of the *Model of the optimal price policy.*

Let's suppose that network operators want to maximize gross profit during a period formed by multiple identical business cycles (for example, the other day).

The length of the cycle is T for its optimal use, it is possible to have a schedule for the cost of each type of guaranteed service $p_i(t)$ and the maximum number of services that can be performed when they are purchased at their own expense $p_b(t)$ and the amount of bandwidth to maximize the following objectives.

1. Variables in the definition of «guaranteed services»:
– N – different number of services;
– $p_i(t)$ – the cost of the service unit i, as a function of the start time of the call t;
– $\lambda_i(p_i, t)$ – the time of service receiving i for a time t at a price p;
– r_i – the number of cell calls i;
– $q_i(t)$ – the number of cell calls i in time t;
– $\bar{q}_i(t)$ – the expected value $q_i(t)$;
– $s[q_1(t), q_2(t), ..., q_N(t)]$ – the total indicator of all guaranteed services in time t;
– $\bar{s}[\bar{q}_1(t), \bar{q}_2(t), \ldots, \bar{q}_N(t)]$ – the average of all the guaranteed services for the time t;
– $\tilde{\beta}_i(t)$ – the probability of the desired blocking of the service i for the time t.

2. Variables describing the maximum number of services that can be provided on condition that they are purchased at their own expense:
– $p_b(t)$ – the price for one admitted cell in the buffer in time t;
– $q_b(t)$ – the required length of the maximum number of services in time t;
– $s_b(t)$ – the transfer rate of cells in time t;
– $s_b(t)$ – the indicator of the admitted cells, that is, the receiving frequency of cells for which they are ready to pay more than $p_b(t)$; $\omega_b(t)$ – an indicator of available cells in time t; $\varpi_b(t)$ – expected value $\omega_b[p_b(t), t]$.

3. Other variables:
– T – length of the business cycle;
– $C_T T$ – total throughput;
– KC_T – depreciation, write-off of the value of investments during one business cycle;
– B_s – buffer size.

$$\int_0^T \left\{ \sum_{i=1}^N (1 - \tilde{\beta}_i) \frac{\lambda_i[p_i(t), t]}{ri} p_i(t) + \varpi_b(t) p_b \right\} \mathrm{d}t - K(C_T), \tag{6}$$

at requirements:

$$\frac{d\bar{q}_i}{dt} = (1 - \tilde{\beta} i)\lambda_i(p_i, t) - r_i \bar{q}_i, \bar{q}_i \ge 0,\ i = 1, N, \tag{7}$$

$$A[\bar{q}_i(t), ..., \bar{q}_N;\ \bar{\beta}_1(t), ..., \bar{\beta}_N(t)] \le C_T, \tag{8}$$

$$\frac{dq_b(t)}{dt} = \omega_b(t) - s_b(t), \tag{9}$$

where

$$q_b(t) = B_s,\ \ \omega_b(t) \le s_b(t), \tag{10}$$

$$0 \le \theta b(t) \le B_s, \tag{11}$$

$$s_b(t) \le C_T - s[q_1(t), q_2(t), ..., q_N(t)], \tag{12}$$

where

$$q_b(t) = 0,\ \ \omega_b(t) \ge s_b(t), \tag{13}$$

$$q_i(0) = q_{i0},\ \ i = 1, N. \tag{14}$$

In formula (6), $(1 - \beta_i)\lambda_i(p_i, t)$ – expected value of the service call i, which will be allowed during the period $[t, t+\mathrm{d}t]$, multiplying these digits by the unit cost $p_i(t)$ and the expected call time $1/r_i$ yields the expected revenue from all service calls, which are allowed in this interval.

During the time t, the network also creates a price for each cell of the largest number of services that are put into the buffer, and $\omega_b(t)\mathrm{d}t$ – the expected number of cells nested in the buffer during the time t.

The total profitability is calculated by summing up the expected income of all services provided during $[0, T]$ minus the write-off of the cost.

6. Research results

The three-stage procedural model is constructed by research results for optimization of practical application (Fig. 2).

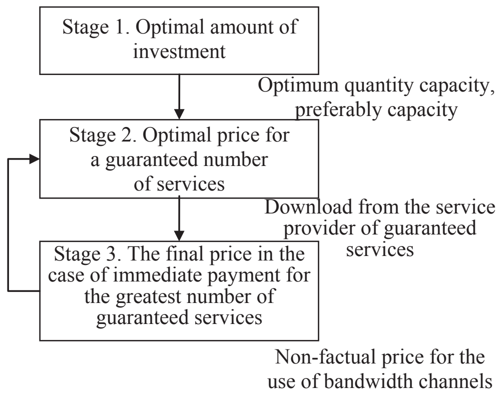

Fig. 2. By research results for optimization of practical application

Decision. Degree 1. The optimal amount of investment in this block is decided:

– C_T – the total amount of transmission frequencies;
– $\tilde{\beta} i(t),\ i=1,N$ – desirable opportunity to block for each guaranteed service at any time;
– $[0,T]$ in the time interval M of each length W_m $(m=1,M)$, the average frequency of receiving during the entire time of this interval;
– λ_{im} – the average frequency of receiving is defined as the price p_{im}:

$$\lambda_{im}=\frac{\int_{[m-1,\,m]}\lambda_i(\tau)d\tau}{w_m}. \quad (15)$$

Let's assume that the cells are received during the interval $[m-2,\ m-1]$, at which, let's have an impact on traffic loading during the interval $[m-1,\ m]$. β_{im} – the possibility of blocking during the interval $[m-1,\ m]$, which is a function of network loading during the interval.

Network controls for the p_{im}, p_{bm}, C_T operator to maximize total profit:

$$\max_{P_{im},P_{bm},C_T}\sum_{m=1}^{M}w_m\left[\sum_{m=1}^{N}\frac{(1-\beta_{im})\lambda_{im}(p_{im})p_m}{r_i}+ \atop + p_{bm}\lambda_{bm}(p_{bm})\right]-K(C_T), \quad (16)$$

provided that:

$$\bar{q}_m=\frac{(1-\beta_{im})\lambda_{im}(p_{im})}{r_i}, \quad (17)$$

$$\beta_m^p=A(\bar{q}_{im},i=1,N,C_T), \quad (18)$$

where

$$\beta_m^{\omega}=(\beta_{1m},\ldots,\beta_{Nm}),$$

$$\bar{s}[(1-\beta_{im})\bar{q}_{im},i=1,N]+\lambda_{bm}\le T,\ m=1,M. \quad (19)$$

By giving the value of the sum of frequencies C_T and the probability of optimal blocking $(\tilde{\beta}_i(t),\ i=1,N)$, calculated in the first stage, it is possible to simplify the model of the optimal price given in formulas (6)–(14):

$$\max_{p_i(t),\,p_b(t)}\int_0^T\left\{\sum_{i=1}^{N}[1-\tilde{\beta}_i(t)]\lambda_i(p_i,t)-r_iq_i(t)]\right\},\ i=1,N, \quad (20)$$

when

$$\frac{d\bar{q}_i}{dt}=[1-\tilde{\beta}_i(t)]\lambda_i(p_i,t)-r_iq_i(t)],\ i=1,N, \quad (21)$$

$$A[\bar{q}_1(t),\ldots,\bar{q}_N;\tilde{\beta}_1(t),\ldots,\tilde{\beta}_N(t)]\le C_T, \quad (22)$$

$$\lambda_b(p_b,t)+\bar{s}[\bar{q}_1(t),\ldots,\bar{q}_N(t)]\le C_T, \quad (23)$$

$$q_i(0)=q_{i0},\ i=1,\ N. \quad (24)$$

Let's assume that the optimal solution exists for this price model. The optimal solution in (20)–(24) must obey the following, which gives an optimal pricing policy.

The optimal pricing policy is the solution. Let's assume that $p_i^*(t)$, $p_b^*(t)$ – the optimal solution in the price model is defined in (20)–(24), then:

$$1)\ \ p_i^*(t)=\frac{\varepsilon_i(p_i^*,t)}{1+\varepsilon_i(p_i^*,t)}\cdot h_i(t)\ \text{ and}$$
$$p_b^*(t)=\frac{\varepsilon_b(p_b^*,t)}{1+\varepsilon_b(p_b^*,t)}\cdot l_2(t), \quad (25)$$

if $l_2(t)>0,\ \ h_i(t)>0,\ \ i=1,\ N;$

$$2)\ \ p_i^*(t)=\frac{\varepsilon_i(p_i^*,t)}{1+\varepsilon_i(p_i^*,t)}\cdot h_i(t)\ \text{ and }\ p_b^*(t)=p_b^0(t), \quad (26)$$

if $l_2(t)=0,\ \ h_i(t)>0,\ \ i=1,\ N;$

$$3)\ \ p_i^*(t)=p_i^0(t)\ \text{ and }\ p_b^*(t)=p_b^0(t), \quad (27)$$

if $l_i(t)=0,\ i=1,N,$

where $p_i^*(t)$ – maximization of $p_i^*(t)\lambda_{ii}^0(p_i,t)$; $p_i^0(t)$ – maximization of $p_b(t)\lambda_b(p_b,t)$;

$$\varepsilon_i(p_i^*,t)=\frac{\partial\lambda_i}{\partial p_i}\cdot\frac{p_i^*}{\lambda_i},\ \ \varepsilon i(p_i^*,t)=\frac{\partial\lambda_b}{\partial p_b}\cdot\frac{p_b^*}{\lambda_b}; \quad (28)$$

$$h_i(t)=\int_t^T\left[\frac{\partial A}{\partial\bar{q}}l_1\left(\tau+\frac{\partial\bar{s}}{\partial\bar{q}_i}r_ie^{-r_i(r-t)}\right)d\tau\right],\ i=1,N; \quad (29)$$

$h_1(t)$ – the Lagrangian multiplied by the restriction (28);
$l_1(t)$ – the Lagrangian multiplied by the restriction (29).

The economic content of the price policy, shown in (25), develops for the situation in which the network opportunity is tightly limited by the price of consumption, volume and cost. If the network operator evaluates the services without considering a possible limitation, in the case of guaranteeing the information system service, when the network can't meet the performance requirements, some services will be blocked by value.

If the greatest number of services, the number of allowed cells exceed the number of transferred, then the queue will grow infinitely.

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In this scenario, the obtained strategy shows that the information system of the network operator of an enterprise should contain the possibility of connecting the cost for each service ($h_i(t)$ for the guaranteed number of services, and $l_2(t)$ for the largest number of services). And also the prices of network services, as some material product. The cost of marginal costs of production should be replaced by costs in the likelihood of their occurrence.

7. SWOT analysis of research results

Strengths. The positive strengths of research include:
– increase in the load of the information service network of the enterprise;
– increase in the productivity of information processing;
– reduce in the level of system losses through more efficient use;
– reduction and adjustment of the internal price of services;
– adequate amount of investment assets of the service network is ensured with the possibility of its dynamic regulation.

Weaknesses. The weaknesses of the research results include the complication of the interaction between the optimality of loading and the efficiency of consumption of information service network services, which leads to a constant increase in investment in the components of the system.

Opportunities. The prospect of further research can be the solution of the problem of multi-threaded investment projects in development of an information system with the coordination of the cost of services at the time and the future cost of services.

Threats. Threats to the negative nature of the research object are factors of the future value of the attracted investment resources, which significantly unbalance the length of the business cycles of business processes, reducing the expected amount of payback complicating the calculation of the cost of information network services.

8. Conclusions

1. The system of cost formation is developed, in which the volume will be assigned to connect the cost for each service $h_i(t)$, for the guaranteed number of services, and $l_2(t)$ for the largest number of services.

2. As a result of the conducted research, the model of cost formation of the information system of the integrated service network is obtained, which allows dynamically to take into account the cost of each service at a time and also to regulate the volume of consumption, depending on the final price of a unit of consumption, followed by a cycle of adjusting the size of investment assets. The dynamic consistency of the model with respect to the business cycle is made, taking into account the system's capacity and the investment payback of the process.

References

1. Brailsford T., Gaunt C., O'Brien M. A. The investment value of the value premium // Pacific-Basin Finance Journal. 2012. Vol. 20, No. 3. P. 416–437. doi:10.1016/j.pacfin.2011.12.008
2. Briglauer W., Cambini C., Grajek M. Speeding up the internet: Regulation and investment in the European fiber optic infrastructure // International Journal of Industrial Organization. 2018. doi:10.1016/j.ijindorg.2018.01.006
3. Huang Y., Soder L. Assessing the impact of incentive regulation on distribution network investment considering distributed generation integration // International Journal of Electrical Power & Energy Systems. 2017. Vol. 89. P. 126–135. doi:10.1016/j.ijepes.2017.01.018
4. Information System Investment Questionnaires 1995–1997 // Economic Analysis of Information System Investment in Banking Industry. Springer-Verlag, 2005. P. 193–206. doi:10.1007/4-431-27381-6_11
5. The relationships between information management, process management and operational performance: Internal and external contexts / Prajogo D. et al. // International Journal of Production Economics. 2018. Vol. 199. P. 95–103. doi:10.1016/j.ijpe.2018.02.019
6. Karmarkar U. S. Financial Service Networks: Access, Cost Structure and Competition // Creating Value in Financial Services. Springer US, 2000. P. 267–287. doi:10.1007/978-1-4615-4605-4_14
7. A cost-effective software testing strategy employing online feedback information / Zhou Z. Q. et al. // Information Sciences. 2018. Vol. 422. P. 318–335. doi:10.1016/j.ins.2017.08.088
8. Paggi H., Soriano J., Lara J. A. A multi-agent system for minimizing information indeterminacy within information fusion scenarios in peer-to-peer networks with limited resources // Information Sciences. 2018. Vol. 451–452. P. 271–294. doi:10.1016/j.ins.2018.04.019
9. Meyn S. et al. The value of volatile resources in electricity markets // 49th IEEE Conference on Decision and Control (CDC). IEEE, 2010. doi:10.1109/cdc.2010.5717327
10. Alinaghian L., Razmdoost K. How do network resources affect firms' network-oriented dynamic capabilities? // Industrial Marketing Management. Elsevier BV, 2017. doi:10.1016/j.indmarman.2017.12.006

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