УДК 336.1.0018

Dzhalladova I., Dsc, prof. Department
of Mathematics FISIT KNEU, Ukraine
Ruzickova M., RNDr, Csc, professor Department
of Mathematics, University of Zilina, Slovak Republic
Melnikova M., economist, post graduate KNEU, Ukraine
Bastinec J., RNDr, Csc, docent Department of Mathematics,
BUT, Brno, Czech Republic

CREATION OF MATHEMATHICAL MODELS FOR ANALISIES DINAMIC OF PRISE ON MEDICINES

станом ціноутворення на лікарські засоби (ЛЗ) в Україні. Згідно постанови КМУ № 340 з 01.06.2012 по 31.12.2012 буде здійснюватись реалізація Пілотного проекту по впровадженню державного регулювання цін на ЛЗ для лікування осіб з гіпертонічною хворобою шляхом встановлення граничного рівня оптово-відпускних цін на відповідні препарати з використанням механізму визначення порівняльних (референтних) цін і відпрацювання механізму часткового відшкодування їх вартості за рахунок коштів державного і місцевого бюджетів (системи реімбурсації).

На даний момент негативним моментом є той факт, що в Україні спостерігається перенасиченість аптечними закладами. Так, на 1 аптеку припадає 1,3 тис. жителів, а в м. Києві і того більше — 2,27 тис. осіб. У порівнянні в країнах ЄС даний показник становить в середньому 3,3 тис. осіб на 1 аптеку. Як наслідок — висока конкуренція, неможливість тримати широкий асортимент ліків через надмірність витрат і загрозу збитків, що пов'язана з неможливістю здійснення вчасної реалізації та надмірності торгової націнки на препарат або дефіцит на деякі ліки. Крім того, існує зацікавленість серед працівників у реалізації більш дорогих ЛЗ з метою збільшення прибутків аптек.

Ряд наведених фактів говорить на користь впровадження та вдосконалення пілотного проекту, який загалом покликаний зробити ситуацію на ринку ЛЗ більш прогнозованою, контрольованою та сприятливою для отримання стабільного прибутку та сталого розвитку вітчизняного виробництва ЛЗ.

Розробка цього проекту потребує сучасного математичного апарату, який пропонується далі. Апарат із застосуванням теорії випадкових процесів дозволить будувати моделі, які сприятимуть знаходженню оптимальних шляхів вирішення зазначеної проблеми.

КЛЮЧОВІ СЛОВА. Пілотний проект, референтні ціни, реімбурсація, прогнозування стабільного прибутку, розвиток вітчизняного виробництва ЛЗ, напівмарковський процес, необхідні умови оптимізації.

АННОТАЦИЯ. В работе сначала обсуждается проблема, связанная с состоянием ценообразования на лекарственные средства (ЛС) в Украине. Согласно постановлению КМУ № 340 с 01.06.2012 по 31.12.2012 будет осуществляться реализация Пилотного проекта по внедрению государственного регулирования цен на ЛС для лечения лиц с гипертонической болезнью. Предлагается установление предельного уровня оптово-отпускных цен на соответствующие препараты с использованием механизма определения сравнительных (референтных) цен и отработ-

ки механизма частичного возмещения их стоимости за счет средств государственного и местного бюджетов (системы реимбурсации).
На данный момент негативным моментом является тот факт, что в Украине наблюдается перенасыщенность аптечными учреждениями. Так, на 1 аптеку приходится 1,3 тыс. жителей, а в Киеве и того больше — 2,27 тыс. человек. По сравнению в странах ЕС данный показатель составляет в среднем 3,3 тыс. человек на 1 аптеку. Как следствие — высокая конкуренция, невозможность держать широкий ассортимент лекарств через избыточность затрат и угрозы ущерба, связанная с невозможностью осуществления своевременной реализации и излишества торговой наценки на препарат или дефицит на некоторые лекарства. Кроме того, существует заинтересованность среди работников в реализации более дорогих ЛС с целью увеличения прибыли аптек.
Ряд приведенных фактов говорит в пользу внедрения и совершенствования пилотного проекта, который в целом призван сделать ситуацию на рынке ЛС более прогнозируемой, контролируемой и благоприятной для получения стабильной прибыли и устойчивого развития отечественного производства ЛС.
Разработка этого проекта требует современного математического аппарата, который предлагается далее. Аппарат с применением теории случайных процессов позволит строить модели, способствующие нахождению оптимальных путей решения указанной проблемы.

INTRODUCTION. By today's day approximately 12 million people in Ukraine suffer from the arterial hyperpiesis, in fact it means every third adult person. As a result — the constant growth of serious diseases, such as strokes, heart attacks and etc. To avoid such situation, all who suffer from the arterial hyperpiesis as a preventive course are to take a special medicine in their various combinations.
In connection with the urgency of this problem the Ukrainian government gave start on the 1st of June 2012 to a Pilot project [13]. It means the implementation of the governmental control over the price policy on the medicines for prevention of the arterial hyperpiesis. The main aim of the Pilot project is to fix and control the margin level of the volume and disbursing prices on medicines by means of mechanism of compensation of their cost from the state and local budgets (the so-called «system of reimbursement»). The Pilot project covers 7 international non-patented names of medicines in tablets and caplets. To make the Pilot project effective a legislative background has been worked out by the authorized governmental institutions in strong cooperation with the leading non-governmental organizations and scientific departments of the pharmaceutical and medical institutes. The modern world trends in improving the system of manufacturing and storage of medicines were taken into account while working on the rules of cooperation of counteragents and its general legislative framework. Much more, thanks to the process of constant monitoring a number of positive and necessary changes took place while implementing the Pilot project. The total sum of money given by the government amounts to 40 mln. grvn.
By todays day we can say that Pilot project gave an ability to decrease the number of those who suffer from arterial hyperpiesis; helps to implement more adequate schemes of cure and prevention of disease by taking the necessary consultation with the doctor; improve the price competition in the Ukrainian pharmaceutical market; stimulates the Ukrainian pharmaceutical manufacturers to produce more competitive and effective products and to develop new prospect market niches both on foreign and local (domestic) markets.
It is also necessary to say that the system of reimbursement is widely spread in the leading European countries and is widely used by their governments to control the situation on the markets of different strategic goods to improve the

quality of life of population. So, it also a serious attempt to bring the standards of living in our country to those which exists in more developed world economics taking into account the abilities and specific needs of Ukrainian society.
In this paper consider the linear controllable systems which defined differential equations with semi-Markov coefficients and random transformation of solutions which occurred simultaneous with jump semi-Markov process. Using equations for Lyapunov function we find minimal values for an functional. Finding necessary condition of optimal solutions, which reaches synthesis optimal control this class system.

1. ANALITICAL DETERMINATIONS of Semi MARKOV PROCESS and FUNCTIONS

Let in every moment of time the system can be in one of n possible states $\theta_1, \theta_2, ..., \theta_n$, with known initial state of the system ($\xi = 0$ in the initial time t) and the probability of transition $\pi_{ks} = P\{\xi(t_j) = \theta_k | \xi(t_{j-1}) = \theta_s\}$ $(k, s = 1,2,...,n)$ where t_j $(j = 0, 1, 2,...)$ — jumps moments of a random process $\xi(t)$, $t_0 = 0$.

Let's assume that the process $\xi_j = \xi(t_j)$ is a homogeneous Markov chain and $\xi(t_j) = \lim_{t \to t_j + 0} \xi(t)$, i.e. the function $\xi(t)$ is continuous on the right at the points gap.

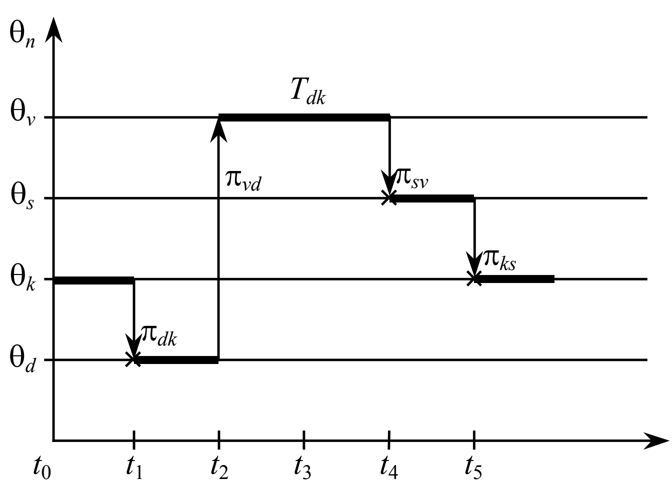

Figure 1.1. The behavior of semi-Markov process

Let every non-zero element π_{sv} of the conditional probabilities of transition matrix correspond an integral value T_{sv} of the distribution function value $F_{sv}(t) = P\ (T_{sv} < t)$. T_{sv} depends on condition θ_v and θ_s. We will consider it an integral and continuous with probability density $f_{sv}(t)(t < 0)$.

Let's suppose that point that reflects the behavior of the plane is in the state θ_v during the time T_{sv} before it turns into state θ_s (Fig.1.1). After achieving instant status θ_s in accordance with the matrix of transition probabilities $\|\pi_{sv}\|$ is elected the next state of θ_k and after state θ_k is selected, the waiting time in θ_s is vested with equal distribution T_{ks} with the function $F_{ks}(t)$ or probability density $f_{ks}(t)$. When the indefinite extension of this process regardless the next state and latency are elected every time.

Thus, if we mark the state of systen like $\xi(t)$ in the moment of tome, the resultant process is called semi-Markov. If you do not pay attention to the nature of the waiting time, the process $\xi(t_j)$ is a homogeneous Markov chain. If we take into account the time spent in different states for a random interval of time, the process $\xi(t)$ wouldn't be Markov, because of non-exponentially distribution of all waiting times. This justifies a name 'semi-Markov process'. It is considered that at the initial moment of time $t_0 = 0$ the system jumps into a state of shock θ_k, and the next state with the probability π_{dk} is the state θ_d. Then the absolute distribution function of full waiting time in the state θ_k is

$$F_k(t) = P\{\omega : T_k < t\} = \sum_{\alpha=1}^{n} \pi_{\alpha k} F_{\alpha k(t)} \ (k, \alpha = 1, 2, ..., n),$$

and the unconditional probability density of a waiting time in the state θ_k:

$$q_k(t) = \sum_{\alpha=1}^{n} \pi_{\alpha k} f_{\alpha k}(t) \ (k, \alpha = 1, 2, ..., n).$$

Let's take

$$\psi_k(t) = 1 - F_k(t) = \int_t^\infty q_k(t)dt = P\{T_k \ge t\} \ (k, \alpha = 1, 2, ..., n).$$

Let's suppose that $\Phi_{\alpha k}(t)$ — conditional probability at which the system is in θ_α state at the moment of time t in the condition it got into a state θ_α. The probability $\Phi_{\alpha k}$ is called the interval — transition probability. From the initial state θ_α to the state θ_α the system can get into a moment of time t time by two ways:

if the system $\theta_k = \theta_\alpha$ cannot leave the state θ_k for a time t; the system is in an arbitrary state θ_α through some interim state θ_v, in a moment τ. Basing on the above equation we have [16]:

$$\Phi_{\alpha k}(t) = \delta_{\alpha k}\psi_k(t) + \sum_{v=1}^{n} \pi_{vk} \int_0^{+\infty} f_{vk}(\tau)\Phi_{\alpha v}(t-\tau)d\tau \ \ (1 \le k, \alpha \le n), \quad (0.1)$$

where

$$\delta_{\alpha k} = \begin{cases} 1, \alpha \ne k \\ 0, \alpha \ne k \end{cases}.$$

The system of linear integral equations (0.1) expresses the interval-transition probabilities through the main characteristics of semi-Markov process. Let's denote $q_{\alpha k}(t) = \pi_{\alpha k} f_{\alpha k}(t)$.Then the system of equations is

$$q_{\alpha k}(t) = \delta_{\alpha k}\psi_k(t) + \sum_{v=1}^{n} \pi_{vk} \int_0^{t} q_{vk}(\tau)\Phi_{\alpha v}(t-\tau)d\tau \ \ (1 \le k, \alpha \le n)$$

it can be written in matrix form

$$\Phi(t) = \psi(t) + \int_0^t \Phi(t-\tau)Q(\tau)d\tau,$$

where

$$Q(\tau) = \|q_{\alpha k}(\tau)\|_1^n, \ \ \Psi(t) = \|\delta_{\alpha k}\psi_k(t)\|_1^n, \ \Phi(t) = \|\Phi_{\alpha k}(t)\|_1^n.$$

The matrix $\Phi(t)$, $(t \geq 0)$ is called the transition matrix of semi-Markov process. The functions $q_{\alpha t}(t)$ $(\alpha, k, = 1, 2, ..., n)$ are called transition intensities from state θ_k to state θ_α and satisfy the conditions:

$$q_{\alpha t}(t) \geq 0\,; \quad \int_0^\infty q_k(t)dt = 1\,; \quad q_k(t) \equiv \sum_{\alpha=1}^{n} q_{\alpha k}(t),$$

$$\int_0^\infty q_{\alpha k}(t) = \pi_{\alpha k} \quad (1 \leq d,\ k \leq n). \tag{0.2}$$

Remark. The Markov process is a particular case of semi-Markov if

$$\psi_s(t) = e^{t\alpha_{ss}} \quad (s = 1,\ ...,\ n),$$

$$q(t) = \alpha e^{t\alpha_{ss}} \quad (k,\ s = 1,\ ...,\ n;\ \ s \neq k),\ \ q(t) \equiv 0.$$

2. MATHEMATICAL STATEMENT OF THE PROBLEM

On probability bases $(\Omega, \Im, \mathbf{P}, \mathbf{F} \equiv \{F_t, t \geq 0\})$ consider the linear control system

$$\frac{dX(t)}{dt} = A(t, \xi(t))X(t) + B(t, \xi(t))U(t), \tag{1}$$

with initial conditions $X(0) = \varphi(\omega) : \Omega \to R^n$ and semi-Markov coefficients which defined intensities $q_{\alpha t}(t)$ $(\alpha,\ k = 1,\ 2,\ ...,\ n)$ of transition from state θ_k in state θ_α Supposed, that vectors $U(t)$ belong set of control U. The function $q_{\alpha t}(t)$ $(\alpha,\ k = 1,\ 2,\ ...,\ n)$ satisfy condition (0.1):

$$q_{\alpha k}(t) \geq 0; \ \int_0^\infty q_k(t)dt = 1; \ q_k(t) \equiv \sum_{\alpha=1}^{n} q_{\alpha k}(t).$$

On space $C^1(G) \times U$ introduce functional

$$J = \int_0^\infty \left\langle X^*(t)Q(t,\xi(t))X(t) + U^*(t)L(t,\xi(t))U(t)\right\rangle dt\,, \qquad (2)$$

where $Q(t,\xi(t))$ and $L(t,\xi(t))$ symmetric positive defined matrix with semi-Markov elements, which we called ***an quality criterion.***.

Definition 1. Vector

$$U(t) = S(t,\xi(t))X(t), \qquad (3)$$

where $S(t,\xi(t))$ — matrix with semi-Markov elements that minimizes an quality criterion *J(X,U)* subject to (1) called of ***optimal control***.

Introduced denoted

$$G(t,\xi(t)) \equiv A(t,\xi(t)) + B(t,\xi(t))S(t,\xi(t)),$$

$$H(t,\varsigma(t)) \equiv Q(t,\varsigma(t)) + S^*(t,\varsigma(t))L(t,\varsigma(t))S(t,\varsigma(t)),$$

Obtained the system of linear differential equations

$$\frac{dX(t)}{dt} = G(t,\xi(t))X(t), \qquad (4)$$

Considering that finding values the functional

$$J = \int_0^\infty \left\langle X^*(t)H(t,\xi(t))X(t)\right\rangle dt\,. \qquad (5)$$

Supposed also that every jump of random process $\xi(t)$ in time t_j solutions of the system equations (4) have random transformation

$$X(t_j + 0) = C_{sk}X(t_j - 0) \ \ (s,k = 1,...,n),$$

as conditions $\xi(t_j + 0) = \theta_s$, $\xi(t_j - 0) = \theta_k$.

Definition 2. Concept of semi-Markov functions $a(t,\xi(t))$ defined next. Select this n difference determinant function $a_k(t)$ $(k = 1,...,n)$ at $t \ge 0$. If $\xi(t_j - 0) = \theta_k$, $\xi(t_j + 0) = \theta_s$ $(s,k = 1,...,n)$, then at $t_j \le t < t_{j+1}$ functions $a(t,\xi(t))$ have kind $a(t,\xi(t) = \theta_s) = a_s(t - t_j)$.

Appling semi-Markov functions enablement using concept of stochastic operators. Really semi-Markov functions $a(t,\xi(t))$ is operator from semi-Markov process $\xi(t)$, because only definition of values t and $\xi(t)$ not defined of value semi-Markov functions $a(t,\xi(t))$. You must also specify the function $a_s(t)$ at $t \geq 0$ and the value of the jump t_j, proceeding the moment of time t.

3. MAIN RESULTS

Theorem. *Let coefficients of the controllable system (1) is semi-Markov function and defined next equality*

$$\frac{dX_k(t)}{dt} = G_k(t)X_k(t),\ G_k(t) \equiv A_k(t) + B_k(t)S_k(t) \quad (k = 1,\dots,n). \tag{6}$$

Then set of optimal control is nonempty subset of space U, which coincide with set of solutions systems equations

$$U_s(t) = -L_s^{-1}(t)B_s^*(t)R_s(t)X_s(t) \quad (s = 1,\dots,n), \tag{7}$$

Where matrix $R_s(t)$ defined from the system equations Ryccatty type

$$\begin{aligned} \frac{dR_s(t)}{dt} &= -Q_s(t) - A_s^*(t)R_s(t) - R_s(t)A_s(t) + \\ &+ R_s(t)B_s(t)L_s^{-1}(t)B_s^*(t)R_s(t) - \frac{\psi_s'(t)}{\psi_s(t)}R_s(t) - \\ &- \sum_{k=1}^{n} \frac{q_{ks}(t)}{\psi_s(t)} C_{ks}^* R_k(0) C_{ks} \quad (s = 1,\dots,n). \end{aligned} \tag{8}$$

Proof. Remember that at $t_j \leq t < t_{j+1}$, $\xi(t) = \theta_s$ coefficiets the system equations (1), (4) and functionals (2), (5) next:

$$A(t,\xi(t)) = A_s(t - t_j),\ B(t,\xi(t)) = B_s(t - t_j),$$
$$Q(t,\xi(t)) = Q_s(t - t_j),\ L(t,\xi(t)) = L_s(t - t_j),\ S(t,\xi(t)) = S_s(t - t_j).$$

Analogously, we have

$$G(t,\xi(t)) = G_s(t-t_j) \equiv A_s(t-t_j) + B_s(t-t_j)S_s(t-t_j),$$
$$H(t,\xi(t)) = H_s(t-t_j) \equiv Q_s(t-t_j) + S_s^*(t-t_j)L_s(t-t_j)S_s(t-t_j).$$

For calculation functional (5) using formula

$$\mathrm{V} = \sum_{k=1}^{n} C_k \circ D_k(0) = \sum_{k=1}^{n} \int_{E_m} v_k(x) f_k(0,x)\,dx\,, \tag{9}$$

where $v_k(x) \equiv x^* C_k x \ (k=1,...,n)$ — particular Lyapunov's functions

$$v_k(x) \equiv x^* C_k x = \int_0^\infty \left\langle X^*(t) H(t,\xi(t)) X(t) \middle| X(0) = x, \xi(0) = \theta_k \right\rangle dt \quad (k=1,...,n). \tag{10}$$

For particular Lyapunov's function (10) finding expression

$$v_k(x) \equiv x^* C_k x =$$
$$\int_0^\infty \left(X_k^*(t) \left(\psi_k(t) Q_k(t) + \sum_{s=1}^{n} q_{sk}(t) C_{sk}^* C_s C_{sk} \right) U_k^*(t) \psi_k(t) L_k(t) \ U_k(t) \right) dt \quad (k=1,...,n). \tag{11}$$

Then systems equations (6) have kind

$$\frac{dX_k(t)}{dt} = A_k(t) X_k(t) + B_k(t) U_k(t), \ U_k(t) \equiv S_k(t) X_k(t) \ (k=1,...,n). \tag{12}$$

Let for systems control (1) exist optimal control of kind (3), that no depending from initial value $X(0)$. From formula (9) follow, that optimal control according minimal values of particular Lyapunov's function $v_k(x)$ $(k=1,...,n)$ (8). It also follow from the fact the functions $v_k(x)$ $(k=1,...,n)$ are particular values functional (9). Finding the minimal values $v_k(x)$ $(k=1,...,n)$ by choosing optimal control $U_k(x)$ is well studied problem, and the main results in [5]. Significantly, that in expression in formula (11) all matrix C_s $(s=1,...,n)$ are constant, and hence, in solving optimization problem can be considered as matrices of parameters.

Therefore, finding of optimal control (3) for systems (1) reduce to solutions n problem of finding optimal control for deterministic system (12) for the systems of linear differential equations like (22).

4. OTHER METHOD of PROOF

Conduct independent proved of theorem 3. Finding optimal control $U(t)$ which reaches a minimum of quality criterion

$$x^*Cx = \int_0^T \left(X^*(t)QA\right)X(t) + U^*(t)L(t)U(t))dt \qquad (13)$$

i introduce Lagrange function

$$I = \int_0^T \left(X^*(t)Q(t)X(t) + U^*(t)L(t)U(t) + 2Y^*(t)\left(A(t)X(t) + B(t)U(t) - \frac{dX(t)}{dt} \right)\right)dt,$$

where $Y(t)$ — column-vector of Lagrange multiplies.

Equalizing to zero the firs variations of functional δI_x i δI_y obtained the system of linear differential equations

$$\frac{dX(t)}{dt} = A(t)X(t) - B(t)L^{-1}(t)B^*(t)Y(t),$$
$$\frac{dY(t)}{dt} = -Q(t)X(t) - A^*(t)Y(t). \qquad (14)$$

Then optimal control $U(t)$ finding on formula

$$U(t) = -L^{-1}(t)B^*(t)Y(t), \qquad Y(T) = 0.$$

For synthesis optimal control need finding integral manifolds of solutions systems (14) of kind

$$Y(t) = K(t)X(t), \qquad K(T) = 0.$$

According to the theory of integral manifolds [12] finding for matrix $K(t)$ differential matrix equation Riccaty type

$$\frac{dK(t)}{dt} = -Q(t) - A^*(t)K(t)A(t) + K(t)B(t)L^{-1}(t)B^*(t)K(t). \quad (14)$$

Which integrating from time $t=T$ to time $t=0$ with initial conditions $K(T)=0$.

Then for obtained Lagrange functions receive expressions for optimal control

$$U(t)=-L^{-1}(t)B^*(t)K(t)X(t).$$

Proved, that this

$$\int_t^T \left(X^*(\tau)Q(\tau)X(\tau)+U^*(\tau)L(\tau)U(\tau)\tau d\tau\right)=X^*(t)K(t)X(t). \quad (15)$$

Really, differentiating equality (15) by *t* obtained matrix equation

$$-X^*(t)Q(t)X(t)-U^*(t)L(t)U(t)=X^*(t)\frac{dK(t)}{dt}X(t)+$$
$$+X^*(t)K(t)(A(t)X(t)+B(t)U(t))+$$
$$+(X^*(t)A^*(t)+U^*(t)B^*(t))K(t)X(t).$$

Expected $U(t)$, obtained differential equation for $K(t)$, which coincide with (14).From positive defined matrix $Q(t), L(t)$ holds that matrix $K(t)=K^*(t)$ at $t<T$. Therefore from equation (15) we have, that $K(t)=0$, then from equation (13) follow, that $C=K(0)$. Using formula (14) to system equations (11) with minimal functionals (12), finding expression for optimal control

$$U_s(t)=-\psi_s^{-1}(t)L_s^{-1}(t)B_s^*(t)K_s(t)X_s(t) \qquad (s=1,\dots,n),$$

where symmetric matrix $K_s(t)$ satisfy at systems matrix differential equations

$$\frac{dK_s(t)}{dt}=-\psi_s(t)Q_s(t)-A_s^*(t)K_s(t)-$$
$$-\sum_{k=1}^n q_{ks}(t)C_{ks}^*C_kC_{ks}+K_s(t)B_s(t)\psi_s^{-1}(t)L_s^{-1}(t)B_s(t)K_s(t) \quad (s=1,\dots,n). \quad (16)$$

Systems equations (12), (16) defined necessary condition of optimal solutions of systems (2). This that matrix $S_k(t)$ $(k=1,\dots,n)$, which defined optimal control, finding from the systems equations (11) and have form

$$S_k(t) = -\psi_k^{-1}(t)L_k^{-1}(t)B_k^*(t)K_k(t) \quad (k = 1,...,n).$$

In the system equations (16) matrix C_s defined from equations

$$C_s = K_s(0) \qquad (s = 1,...,n).$$

Simplify the system equations (16), taking

$$R_s(t) = \psi_s^{-1}K_s(t),\ \psi_s(0) = 1,\ C_s = R_s(0) \quad (s = 1,...,n).$$

Then systems equations (16) has of kind (8), a optimal control defined formula (7).

Remark 2. If systems control (1) is determinant, then $q_{ks}(t) \equiv 0$, $\psi_s'(t) \equiv 0 \quad (k, s = 1,...,n)$ and systems equations (8) coincide with system equations like Rikkaty (14).

CONCLUZION (HOPE). The models using of mathematical instruments — semi Markov process gives an ability to enrich the scientific background and the existing methods of analyze of effectiveness of this or that innovation aimed to improve the quality of life of our society in general as well as particular in some sphere. It helps to reinforce the existing approaches, to find new and more appropriate (OPTIMAL) ways of solving burning problems which our society constantly faces with. It gives the chance to make our decisions less complex though as a result more economically effective, to save the limited resources and at the same time to gain THE MAXIMUM SATISFACTION FROM LIFE.

Reference

1. *Artem'ev V.M.* Handbook on the theory of automatic control / V.M. Artem'ev, I.E. Kazakov. — M. : Nauka, 1987. — 721 pp.(on Russian)
2. *Qvakernaak H*. The linear optimal system of control. / X. Qwakernaak, P. Sivan. — M. : Mir, 1977. — 650 p. .(on Russian)
3. *Valeev K.G*. Optimization of linear system with random coefficients: Monography / К.Г. Валеев, О.Л. Карелова, В.И. Горелов. — М. : Из-во РУДН, 1996. — 258 с. .(on Russian)
4. *Valeev K.G.* Methods of moments equations/ K.G.Valeev, O.L.Strijak. — K., 1985. — 56 p. (on Russian)
5. *Valeev K.G.* Constructing of Lyapunov function / K.G. Valeev, G.S. Finin. — K. : Nauk. dumka, 1981. — 412 p.

6. *Barbashyn E.A.* Lyapunov functions / E.A. Barbashin — M. : Nauka, 1970. — 240 p.
7. *Bellman P*. Introducein teory of matrix / Р. Беллман. — M. : Nauka, 1969.- 368 с.
8. *Valeev K.G*. Optimization of random process / K.Г.Valeev K.G., I.A. Dzhalladovaa. —K. : KNEU, 2006. — 310 p.
9. *Hyhman I.I.* Controlable of random process / I.I.Gihman, A.V. Skorohod. — K. : Nauk. dumka, 1977. — 252 p.
10. *Dzhalladova I.A*. Optimization of stochastic system / I.A.Dzhalladova. — K. : KNEU, 2005. — 284 p.
11. *Jasinskyy V.K.* Problem of stability and stabilization of dynamic systems with finite aftereffect / V.K. Jasinskiy, E.V. Jasinskiy. — K. : TVIMS, 2005. — 578 p.
12. *Valeev K.G.* Infinity systems of differential equations / K.G.Valeev, O.A. Jautykov. — Alma-Ata : Nauka, 1974. — 415 p.
13. *Барміна Г.* Стан реалізації пілотного проекту: доповідають експерти // Щотижневик «АПТЕКА». — № 31 (852). — 6 с.

Стаття надійшла до редакції 11.12.2012 р.

УДК 330:378

О. Д. Шарапов, канд. техн. наук, проф.,
О. П. Степаненко, канд. екон. наук, доцент,
ДВНЗ «Київський національний економічний університет
імені Вадима Гетьмана»

НОВА ПАРАДИГМА ОСВІТИ В ІНТЕЛЕКТУАЛЬНІЙ ЕКОНОМІЦІ

АНОТАЦІЯ. У статті розглянуто сучасні тенденції економічного розвитку, досліджено проблеми формування інтелектуальної економіки, визначено ключові фактори становлення та розвитку інтелектуальної економіки, досліджено роль освіти та інформаційно-комунікаційних технологій у нових економічних відносинах, проаналізовано досвід провідних університетів світу, розглянуто підходи до вдосконалення системи освіти відповідно сучасним соціально-економічним вимогам.

КЛЮЧОВІ СЛОВА: інтелектуальна економіка, інформаційна економіка, освіта, наука, університет, людський капітал, інформаційно-комунікаційні технології.

АННОТАЦИЯ. В статье рассмотрены современные тенденции экономического развития, исследованы проблемы формирования интеллектуальной экономики, определены ключевые факторы становления и развития интеллектуальной экономики, исследована роль образования и информационно-коммуникационных технологий в новых экономических