HOW TO DYNAMICALY MODEL A DEVOLOPMENT OF E-GOVERNMENT SYSTEM

CUM SĂ MODELĂM DINAMICA DEZVOLTĂRII SISTEMULUI DE E-GUVERNARE

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SUMMARY

Electronic government or the term of e-government aims to improve and increase the accessibility of information, transactions, and government services by using the information and communications technologies (ICT) including the computers, the Internet, automation equipment and mobile devices. The main aim is to provide and satisfy the population needs with the focus on improvement of the e-government area.

The authors introduce the potential approach for defining the system as a dynamic system of development the area of e-government. The procedure for solving the dynamic model, described in the article, that uses contemporary mathematic methods of so-called ,,Differential Equations Theory" with delayed argument, can be successfully used for both modelling further specific economic relations and for economic models in general and also in various conditions.

Keywords: *E-government, Dynamic Modelling, Delay Differential Equations.*

REZUMAT

Guvernarea electronică sau termenul de e-guvernare urmărește să îmbunătățească și să sporească accesibilitatea la informații, a tranzacțiilor și serviciilor guvernamentale prin utilizarea tehnologiilor informaționale și de comunicații (TIC), inclusiv computere, internet, echipamente de automatizare și dispozitive mobile. Scopul principal este de a oferi și satisface nevoile populației cu accent pe îmbunătățirea zonei de guvernare electronică.

Autorii introduc abordarea potențială pentru definirea sistemului ca o zonă dinamică de dezvoltare a sistemului de e-guvernare. Procedura de soluționare a modelului dinamic, descrisă în articol, care folosește metodele contemporane „Teoria ecuațiilor diferențiale" cu argument întârziat, poate fi folosită cu succes atât pentru modelarea relațiilor economice mai specifice, cât și pentru modelele economice în general și, de asemenea, sub diverse condiții.

Cuvinte-cheie: *guvernare electronică, modelare dinamică, ecuații diferențiale.*

1. Introduction. Information technology has taken the world by storm. Its emergence has given rise to a new level of digital knowledge systems. Its application has been catalytic to the rapid changes taking place in the way people work, live and think, and is facilitating the development of our society and civilization in a new era. However, along with the tremendous benefits of information technology comes the challenging problem of e-government and information security management.

Currently, it is a natural trend in theoretical scientific disciplines to study various situations using increasingly precise models which, among other things, enable us to analyse more accurately the simulated processes, to search for more exact meaning of the circumstances under which they run, and to derive practical conclusions, bases, optimum solutions, and such from the findings. Measurement of economic quantities then corresponds to the use of quantitative methods, i.e. methods based on mathematical disciplines.

The aim of this article is to present a model of e-government system development which analyses the system integrity of organization management, operation application, information resources and technology by the use of analytic and synthetic methods, dynamical modelling and solving the system of delay differential equations. The model allows for the influence of previous periods, thus leading to the system of differential equations with delay.

2. Literature review. The provision of services in governmental portals has influenced the strategies of electronic services offered by several governments all over the world. More than offering services, development related policies have tried to widen the scope of their actions, bringing together the necessary aspects for an accurate alignment between the implementation of public services and the needs of the population.

Consequently, Local Public Administrations are now faced with a challenge of administrative modernization which tries to draw citizens closer to their services and, concurrently, to dematerialize their processes (Rocha & Sá, 2013; Sá & Rocha, 2012).

Over the last years, the quality of services in the public sector has been the subject of significant concerns. Many organizations have started to self-assess and measure the quality of the services they provide.

The European Commission (2013), in a press release, declared that in the universe of EU Citizens, 46% use the Internet to look for a job, to use the public library, to submit tax declarations, to register births, to request a passport or to use other public administration services. In the same document, it is said that 80% of the citizens believe that the public services offered on the Internet allow them to save time, 76% appreciate their flexibility, and 62% claim to save money with them.

Faced with the growing technological evolution and daily access to public services by populations, governments all over the world are constantly challenged to transform and reinvent themselves, in order to provide efficient, effective and economical services. Citizens, users who evaluate the provision of these services, are increasingly well informed on the one hand, and demanding on the other hand. Lee and Kim (2014) contend that the ability to measure the quality of a service is a prerequisite to obtain a high-quality level. In their study, Khawaja and Bokhar (2010), reveal that organizations struggle to evaluate the quality of the services they provide to clients, that is, they find it difficult to evaluate if, in the context of a service, there are any faults or if the delivery takes place within the stipulated time.

Local Public Services are thus facing the challenge of administrative modernization, trying to bring the residents closer to their services and, simultaneously, dematerializing their processes (Rocha and Sá, 2014; Sá and Rocha, 2012).

Based on these assumptions, concepts, models, frameworks and methodologies need to be developed to evaluate, in the specific context of local authorities, the quality of Electronic Government services, in order to improve the level of satisfaction attached to these services.

Methods and Data Sources. The study of various modelsfocus on simulating conditions, and search for outcomes, optimal solutions and so on are among the most important current trends. For example, McNelis (2003) in his paper applies neural network methodology to inflation forecasting in the Euro-area and the USA. Ioana et al. (2015) present a new concept for Fuzzy Logic in economic processes. They then compared the effects of reform policies on access to institutional credits in the Nigerian agricultural sector before and after the reforms (1978 - 1985; and 1986 -2009). In his paper, Zhang (2012) investigated the sensitivity of estimated technical efficiency scores from different methods including stochastic distance function frontier. In related work, Boucekkine et al.(1999) also studied the two-stage optimal control problem involving two deterministic AK models, and Harada (2010) examined the switch from the Solow to AK economies using a similar technique. Many studies have been conducted in order to validate the hysteresis hypothesis, e.g. Pérez-Alonzo (2010).

Particular specific sets of tasks concerning differential equations with dynamic arguments were being solved by L. Euler and M. Kondors, but their systematic study only began in the 20th century.

In their monograph, Kobrinskij and Kuzmin (1981) pointed out the necessity of using historic variables in dynamic economic models that have impact on system development and lead to major changes in the character of the entire process. Simonov (2003, 2009) has modified existing micro and macro economical models, such as the Walras-Evans-Samuelson (WEC) model with regard to delay between offer and demand, Allen's model on the single-commodity market, with regard to delay of deliveries and dependence of demand and offer on the price and speed of price changes Alen, Vidal-Wolf's model of single-product sale Dykchta and Samsonjuk(2003) etc.

Included in the category of dynamic economic models we can recognize such economic and mathematical models, the structure of which includes behaviour of the analysed system over time. McNelis (2003) presents a dynamic model of e-government system development, composed of fourth first-order differential equations. The author has come up with a model which describes the temporal variation of three static variables:

Suppose **M** is the Government Efficiency level state value of a government system.

A is the state variable of corresponding Economic Performance level.

R is the state variable of corresponding Digital Public Services level.

T is the state variable of present technological Infrastructure development level.

The model is then represented by fourth-dimensional ordinary differential equations:

$$M'(t)= - k_1M(t) - k_2A(t)+k_3T(t)$$
$$A'(t)=k_4M(t)+k_5R(t)+k_6T(t)$$
$$R'(t)=k_7M(t)+k_8T(t)$$
$$T'(t) = k_9T(t-\Delta) \qquad (1)$$

where $\mathbf{k_i, i=1..9}$ are non-negative constants.

3. Analysis of the solution. Let us now analyse the problem mentioned above using the modern theory of so-called functional differential equations, a very special part of which is also the theory of linear difference equations with delayed argument. In order to numerically solve the problem in question for the system of differential equations with delayed argument, a method was used, which has been, in current studies, derived for solving marginal problems for systems of so-called functional differential equations.

General theory, which makes it possible to solve not only the above mentioned problems, but also others, can be found in a monograph Kiguradze and Půža(2003), and its application on the above mentioned types of differential equations with delay, including the description of the way the desired solution was designed can be found in for example Novotna (2015) and their cited bibliography.

Calculations were made using the system Maple, which is used as mathematical software because of the possibility to deal with calculations symbolically. It is very similar to the programs Mathematica and Maxima, which offer much fewer functions. An indisputable advantage of Maple is that it cannot only make analytic calculations with formulae, but it can equally provide a numerical calculation or graphic representation of results. Therefore, it is a system with a very attractive and user-friendly environment which offers a range of options regarding the application of quantitative methods in practice, application problems, and scientific calculations for many disciplines, etc.

Numerical procedures for solving ordinary differential equations used in Maple are transferred, via the theory mentioned above, to solutions of differential equations with delayed arguments.

4. Situation for the Czech Republic - illustrative example. To demonstrate the initial problem solution, we have selected the environment of the Czech Republic in the sense of setting the initial solution conditions at values known for the Czech Republic. The data were acquired from the IMD World Competitiveness Centre (hereinafter "IMD") (2015) comparing the competitiveness of different countries in the new issue of "Yearbook 2015" and from the Digital Economy and Society Index (DESI) (2015), which is a composite index developed by the European Commission.

(DG CNECT) to evaluate progress of EU countries towards digital economy and society. IMD compares the individual pillars of overall competitiveness, including economic performance, state governance efficiency, efficiency of enterprises and infrastructure. DESI collects a set of relevant indicators divided into 5 dimensions: Connectivity, Human Capital, Use of Internet, Integration of Digital Technology and Digital Public Services.

In 2015 the Czech Republic took the 29th position according to IMD. The current advance of the Czech Republic to a better position was promoted by economic growth, positive development of government finance and improved motivation and organization in business. These factors collectively contributed to an improvement in the relative status of the Czech Republic in economic performance (26th position), governance efficiency (31st) and business efficiency (31st).

When compared to other countries, according to IMD the Czech economy is attractive due to its skilled work force, cost competitiveness, level of education and reliable infrastructure.

Based on the DESI 2015 index evaluation, the Czech Republic achieved an overall score of 0,46 (1 being the maximum level), which put it in the 17th position out of 28 EU member states. Czech citizens demonstrate a good level of digital skills, which enable them to use the Internet for a wide range of activities. At the same time, Czech small and medium enterprises are at the top of online sales in the EU, their turnover reaching top positions.

However, the Czech Republic shows substandard results in ensuring advanced digital public services. This area remains the principal challenge for the Czech Republic. This is illustrated by the mere 14% of users who use the Internet to fill in and send forms to public administrative bodies, which places the Czech Republic at the 26th position in the EU for this metric.

5. Model Solution. To demonstrate the options of solving the initial problem we assume "historical development" of the T variable before time t=0, which may be simulated by function y=0,6sin(t)+27. The development of the respective variables will be monitored for 86 months.

The initial conditions were set as follows:

M(0)=31,A(0)=38,R(0)=0,46,T(0)=27.

After insertion of selected parameters into the system the result is:

$$M'(t)=-0{,}001M(t)-0{,}001A(t)+0{,}015T(t)$$
$$A'(t)=0{,}0001M(t)+0{,}0003R(t)+0{,}0001T(t)$$
$$R'(t)=0{,}00001M(t)+0{,}00002T(t)$$
$$T'(t)=0{,}01T(t-\Delta)$$

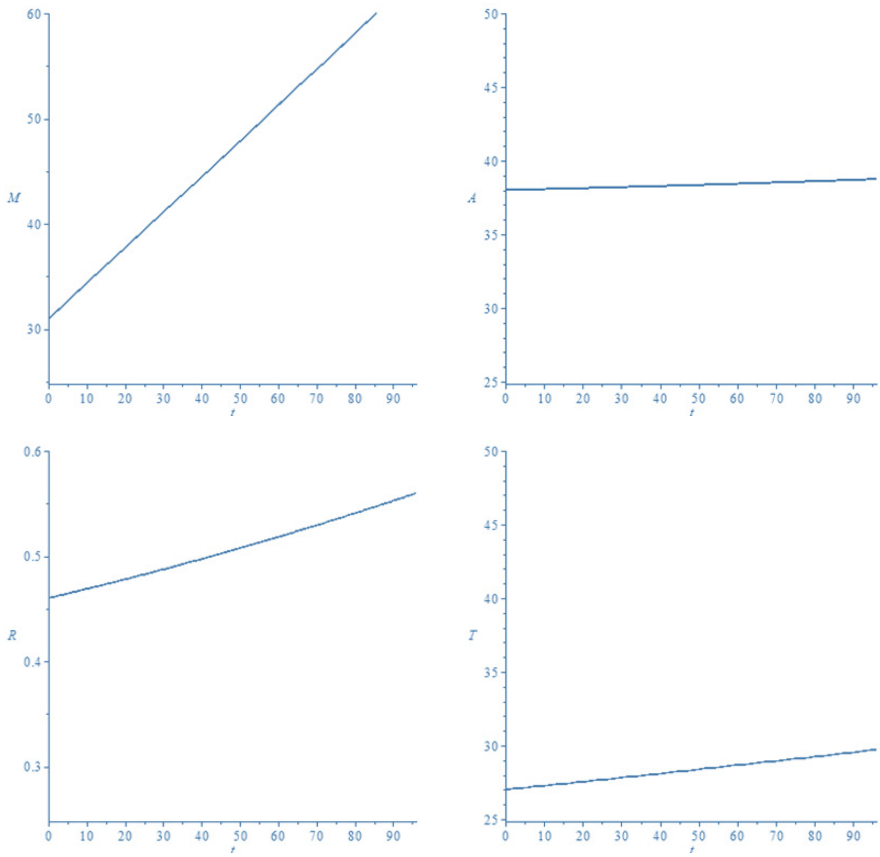

Figure 1. The delay is three months. (Source: Own processing).

The first set of graphs illustrates a system solution in the event the delay in the fourth equation is three months.

The second set of graphs demonstrates a solution in the event the parameter k1 is altered to 0.009 and the remaining parameters are maintained. The value of this parameter will have a significant impact on the development of government efficiency and slow down its increase. (Fig. 2)

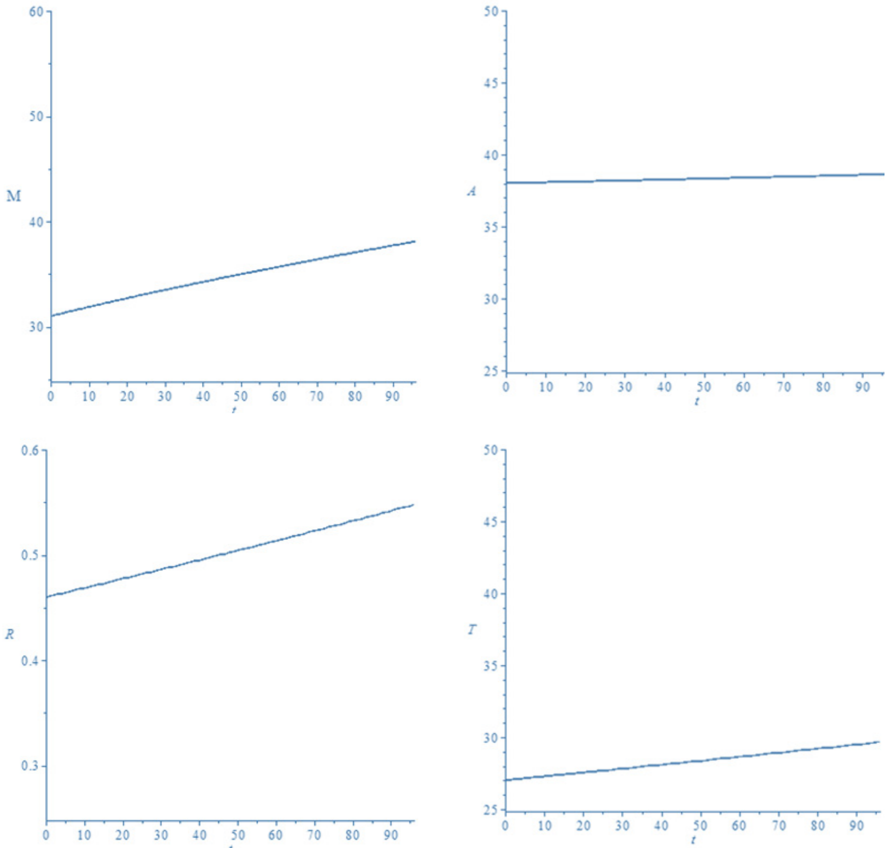

Figure 2. The parameter k_1 is altered to 0.009. (Source: Own processing).

The third set of graphs demonstrates a solution in the event the parameter k9 is altered to 0.01 and the remaining parameters are maintained. The value of this parameter will have a significant impact not only on further technology development but also on the development of government efficiency and will considerably accelerate its increase. (Fig. 3)

To conclude, the examined system demonstrates unambiguous complex dynamic performance. Based on an analysis of the above solutions of delay differential equation systems it can be stated that an alteration of system parameters has a significant effect on the overall system stabilization. As far as we are able to estimate the parameter value, conclusions can be made concerning other system trends and stabilization options.

The newly used methodology of delay differential equation system numerical solution using the fixed point method provides for a successful solution to the above problem and thus for performing an analysis of the effect of the individual parameters alteration. Alterations of the coefficient of delay impact on system performance were the sole alterations demonstrated as an illustration.

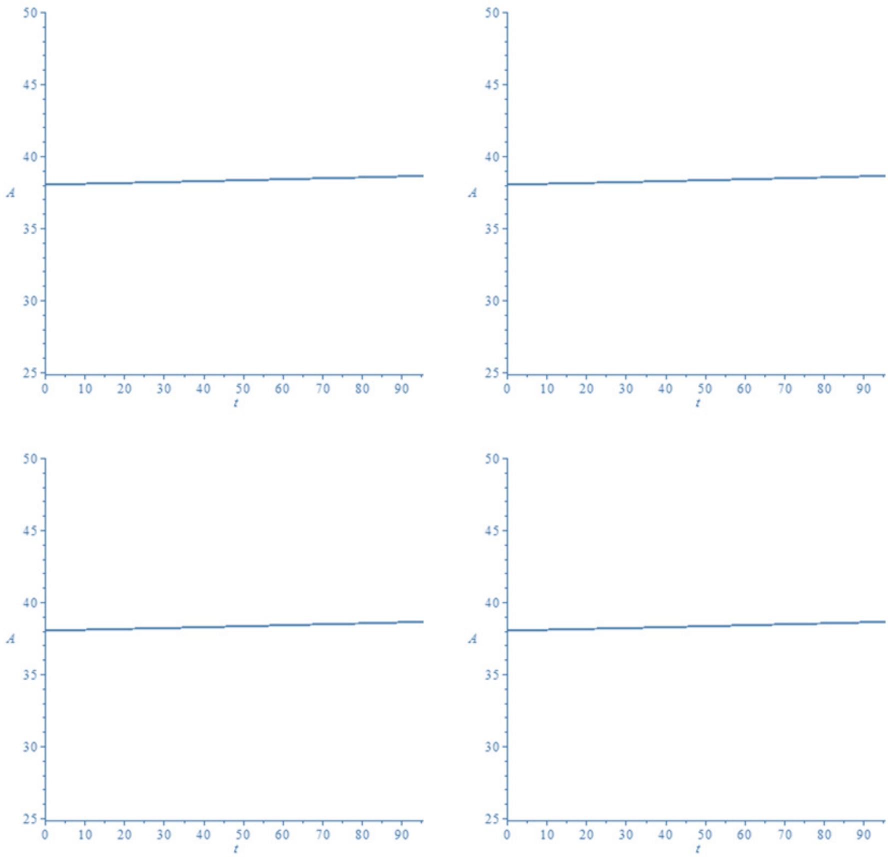

Figure 3. The parameter k_9 is altered to 0.01. (Source: Own processing).

6. Conclusion. When modelling complex economic issues, we often have to face the fact that trade-offs between variables are temporal. The dynamic character can be captured by including delay exogenous and endogenous variables in specifying the structure of a model.

Another way to include dynamic processes in models is to see time as a continuous variable and to describe dynamic models by means of differential equations.

The new model allows for the influence of previous periods, thus leading to the system of differential equations with delay. Its solution required use of modern methods of the theory of functional differential equations.

It is to be expected that the procedure for solving the dynamic model, described above, that uses contemporary mathematic methods of so-called "Differential Equations Theory" with delayed argument, can be successfully used for both modelling further concrete economic relations and for economic models in general.

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