THE USAGE OF ASP TECHNOLOGY TO CREATE WEB APPLICATION FOR SOLVING SOME ECONOMETRICS PROBLEMS

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Abstract:

This paper describes some methods for creating user-oriented Web applications, based on ASP technology, and designed for software implementations of the solving of two well-known econometrics problems. Firstly, based on the original author's source code, written in VBA programming language, it described the procedure for creating the ASP page to solve the model of dynamic programming. Finally, it described the software's procedure, implemented in statistical programming language "R", designed to address the problem of antagonistic games, as the popular mathematical models of conflict situations that arise in the contemporary management decisions.

INTRODUCTION

Mathematical modeling is increasingly spreading to different areas, both natural and social sciences, especially economics. The reason for this is certainly a very turbulent financial movements, crises and conflicts that occur in the various forms, from the local economy to the global, macroeconomics level. Contemporary problems in the financial market are good motivation for an exact, mathematical way to solve very difficult and intricate economics problems. In this sense, quantitative analysis methods can be very effectively used to describe the complex economic relationships. Based on these, the managements of the companies have reliable mathematical models and methods which can be used to finding the most optimal solution of some complex economic problem, and make the best business decisions. That is the motivation for researchers to increasing attention and commitment to research different mathematical - econometric models and their application in various fields for the sake of a successful business.

Naturally, the use of mathematical models in describing the complex economic reality involves the application of modern information technology and software, without which it is unthinkable contemporary economics. This is supported by the fact that most econometric problems usually can be solve algorithmic, i.e. in a manner suitable for software implementation and solving computer-assisted. On the other hand, networking companies and public administration, as well as the development of the Internet, has led to major changes in manner and efficiency of work of the business system. It is enabled a simple and fast communication between various business entities, almost instantaneously transfer large amounts of data over large distances, easily publishing and updating the multimedia documents and their continuously global availability. Finally, almost instantaneous digital delivery of goods and services, as well as direct payments via the Internet, has become today almost usual way of business and communication.

For all these reasons, the Internet is becoming one of the most important tools used in the "exchange" of modern mathematical ideas, processes and solutions of different, even the most complex econometric problems. In this way, it allows the multiple positive effects of such a "connections", of which the most important are the following:

- The end-user can, by using simple searching the Internet, in an easy and fast way (almost instantly) get a solution of some kind of problem or, alternatively, an appropriate software application that will help him to solve this problem.
- WEB applications are publicly exposed and available, on the global level, to a very large number of potential users.
- It is possible the mutual interaction of users with the authors of applications, primarily in the form of suggestions, comments and possible improvements the offered solutions.
- The structure of the WEB application, designed to address a specific (econometric) problem, is usually divided so that it is a combination of passive parts (tutorials), and active software parts. In this way, it allows users to educate about certain issues they are interested in.

- ◆ Internet service allows to the authors of applications quickly and effectively sharing information and experiences, with the aim of finding optimal solutions possible.

Finally, let us point out that the creating the user-oriented Web applications are mainly based on a so-called Active Server Pages (ASP) technology. This technology provides, above all, the ability to easily complement and upgrade standard HTML pages with the active codes components. This, on the one hand, significantly facilitates the creation of such active Web pages. On the other hand, thus facilitating the work of end users who do not require a high level of knowledge of the authors' software and other applications to be able to use them successfully. In the following, we describe some of the procedures and ways to create ASP pages designed to solving two well-known econometric problems.

WEB APPLICATION FOR SOLVING THE PROBLEMS DYNAMIC PROGRAMMING

Dynamic programming is a special mathematical tool, which allows optimal planning so-called multiple of the stages of the management process. These include processes in these, using a series of stages gradually make a decision on how to control a given process. The main goal is to get to the final stage of the optimal management plan, which provides the best solution of the given problem. Thus, the management of that kind of processes can be implemented in the very different areas: economics, military, physics, biology, etc. Most of problems which appear in them can be interpreted in the form of multi-stages process, on which may be applied to *the dynamic programming method* (we write, shorter, *DP method*). For practical application of the DP requires that each considered process has a clear mathematical model, a precise definition of the objective function, which should to be maximized (minimized), as well as the set of constraints that must be taken into consideration during the implementation of the process. In certain cases it is possible to find an analytical solution of some problem, but the most common is the numerical algorithmic-access, with the application of the developed program.

The basic idea of algorithmic way of solving the DP problems is that the management of a process practically divided into several phases, and in each stage selects the optimal management, which allow for the optimal functioning of the process in the future. It is so-called *principle of optimality*, which was first introduced by Richard Bellman in the 1950s, a time when computer programming was an "esoteric" activity. Nowadays, it can be successfully used and software's implemented in solving a large (even and a very different) classes and kinds of problems. In the contemporary econometrics, such are the optimal investments planning, the optimal resources managements, and so on. In the free interpretation, the Bellman's principle can be formulated as a feature of the optimal strategy, regardless of the initial state and the previous solution, at each successive stage should be to determine the optimal strategy in relation to the immediately previ-

ously obtained optimal solutions. Bellman's principle can be expressed mathematically, using functional equations or recursive relations through which they can express the relationship between the objective function of the observed phases and goal features of the previous stages. We here describe the solving of DP problems, as well as its software implementation, in the case of investments optimization, for the case when the criterion (objective function) F is an additive type. Then, the basic functional relationships in the appropriate dynamic programming model are obtained by applying the mentioned principle of optimality, as follows.

We look at the dynamics of investment M different values (levels) of capital in the amount of $b_1,\ldots, b_M$ monetary units in N potential, various projects. If for each project $j=1,2,\ldots,N$ assign amount of funds of x_j units, and with investing in him a profit of $f(x_j)$ units, gross profit (expressed by the objective function F) will be

$$F = f(x_1) + \cdots + f(x_N). \qquad (1)$$

Then, it is necessary to find the optimal values $x_1, \ldots, x_N$ for which objective function F reaches a maximum value with the given constrains:

$$x_1 + \cdots x_k \leq b_k, \quad k = 1,\ldots, N. \qquad (2)$$

For each b_k, $k = 1,\ldots, N$ we introduce the sequence of functions $F_k(b_k)$, as

$$F_k = \max_{x_k \leq b_k}\{f_k(x_k) + F_{k-1}(b_k - x_k)\}, \qquad (3)$$

where $F_0(b_0) = 0$. Equations (3) are popularly called *the Bellman's equations*. Based on them, the initial problem with N variables $x_1,\ldots, x_N$ is decomposed on the N simpler cases, i.e. on the N equations with (the only) one variable x_k. In this way, the final, optimal solution of the DP problem can be obtained in N iterative stages. Thereat, function F_1 is determined directly, while the other functions $F_2, \ldots, F_N$ are determined by the recurrent formula (3). Thus, in the last iteration is obtained the optimal value

$$F^* = F_N(b_N), \qquad (4)$$

which maximizing the objective function F, specified in Eq.(1).

The procedure described above can be easily shown in the form of algorithms, and the appropriate programming procedure to implement and solved using computer. The basic algorithmic steps such procedures consists of the following programming elements:

Step 1: Input the number of investment levels (M) and the number of projects (N).

Step 2: Input the values of capital for each investment levels and the appropriate, expected profits of the investment in each project, individually.

Step 3: Compute, using the Bellman's equations, the maximum of the objective function F^* and, at the same time, all values of investments of amounts of each of the projects.

Step 4: Find, by using "the opposite recursion", the optimal values of investments x_j, $j=1,2,\ldots,N$.

Step 5: Show all results of dynamic analysis, the optimal values, especially.

The Fig.1 shows the code of "the central part" of the software implementation of the previous algorithm (Step 3 and Step 4). The application itself, called *Dynamic Programming solver,* is written in *VBA* (*Visual Basic for Application*) programming language. It represents a complete and comprehensive software tool which completely solves the DP problem of the optimal investment, i.e. for the entered values (Step 1 and Step 2), the application determines the optimal plan investment for which achieves maximum profit.

Fig. 1. VBA source code for solving the DP problem.
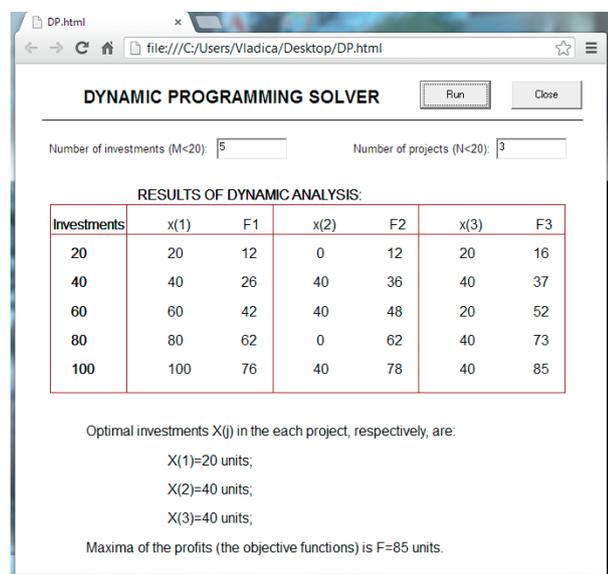
Fig. 2. User-oriented application with optimal solution of the DP problem.

Namely, by using ASP technology and the transformation of the VBA code in the VBScript programming language, it is possible to easily connect it with HTML tags (see, for instance [5]). In that way, all calculated parameters and the basic properties of the observed DP problem are given in the form of report, i.e. the appropriate HTML page. As an illustration, Fig. 2 shows such report which determines the optimal plan for investing the funds in the amount of 100 units in three different projects. The maximum profit is 85 units and it achieved for the values of investments $x_1 = 20$; $x_2 = x_3 = 40$ units in each project, respectively.

WEB APPLICATION FOR THE MODEL OF GAMES THEORY

In solving the contemporary econometric problems as, for example, an optimization of various conflicts situations in the market, game theory is widely used (see, for instance [1-4]) and is thus closely related to decision theory. The final outcome of the conflict depends primarily on the selection and combination of strategies that are positioned two antagonistic sides chosen. The choice of inappropriate strategies and, accordingly, the wrong business decisions in such circumstances, certainly result in a decrease in demand, and loss of market position that a company has. Mathematical models created in game theory allows the analysis of different situations in which the outcome of the game by two or more players do not depend only on one of them, but the expected reactions of other participants in the game. Therefore, if we are to compare this with the decision-making managers, it is clear that their decisions are clearly interdependent. From the perspective of game theory, the main goal of every player is a timely response to action opponents in order to achieve a better result. Then, the fundamental problem is how to find the appropriate criteria for the selection of so-called, *the optimal strategy* for each participant (the player) in the game.

The main feature of which will be further considered in the following simulation consists of the following assumptions:

- ◆ Two players in the conflict situation have access to a finite number of different strategies whose choice of different events occurring in the game. In addition, the gain of one player is equivalent to the loss of another, and collectively, the gain of both players is zero. All strategies, as well as the individual gains of one, or the loss of another player, enter *the game matrix payments $A = [a_{ij}]_{mxn}$*.
- ◆ If the game matrix *A* there is no saddle point, players have not the choice of optimal (pure) strategies that enable a single set limit profit or loss. Determining the optimal strategies of players then are based on introduction the random elements in the game, i.e. the formation of a series of probability with which each of them chooses a particular strategy. Suppose that the first player, who have *m* strategies, each of which can choose with probabilities $p_1, ..., p_m$, and denote the appropriate probabilities of selection one of *n* strategies of other player with $q_1, ..., q_n$.
- ◆ Suppose that the first player chooses the optimal strategies whose provides him certain, guaranteed gain, and, similarly, the second player, assuming

the rational behavior, by choosing an optimal strategies whose provides maximum value of him loss. In this way, these strategies determine *the optimal value of the game*, denoted as v .

Finally, immediately prior to application of the model of the game theory in marketing decision, it is necessary to designate the percentage value of the market share, which represents the elements of the matrix payment A. These values, in general, cannot be safely and reliably. For this reason, they are usually defined as random variables that are at least approximately normally distributed. Density function in this case is given by

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} \cdot e^{-\frac{(x-\mu)^2}{2\sigma^2}} , \quad x \in \mathbf{R} \qquad (5)$$

where μ and σ are the parameters of normal distribution which need to be determined. In the next step, using a software application that simulates the decision-making model, we can access to linear programming (LP) program, which is implemented as a series of T successive simulations. Each simulation individually, i.e. all realized values of the variables a_{ij} represents the probability of changes in market share expressed as a percentage, which appears as a last combination of appropriate strategies first and second players in the game. By solving this model, we come to the optimal strategies, determined on the basis of a given set of simulations. Obviously, obtained strategies are somewhat various and that enabling the formation of their frequency distribution. After that, the optimal strategies of the appropriate model are determined as the means of the established distribution.

The percentage of participation, where we assume that the random variables that they represent a normal distribution whose parameters have to be estimated on the basis of relevant data, while generating appropriate numerical values can be realized with appropriate software package on the computer. For this purpose, we have created the necessary conditions for the application of the above procedure to find the optimal strategies of the two opposing companies. Formally, this procedure can be shown by the algorithm which consists of the following iterative steps (see [6] for the most details):

Step 1: For $k = 1,2,...,T$ repeat the following steps.

Step 2: Compute the k-th realization of the game's matrix $A = [a_{ij}]_{mxn}$, and denote such realization as $A[k]$.

Step 3: If $\tau = \min_{i,j} a_j [k] < 0$, then $A[k] \leftarrow A[k] + |\tau|$.

Step 4: Find the minimum of objective function $F_1(\mathbf{x})$ under linear constrains $A[k]^T \cdot \mathbf{x} \geq \mathbf{1}_{n\times1}$. Denote the solution of this minimization problem as $\mathbf{x}^*[k]$ and obtained minimum as $F_1(\mathbf{x}^*) = F_1^*[k]$.

Step 5: Similarly as above, solve a dual problem, i.e. find the maximum of function $F_2(\mathbf{y})$ under constrains $A[k] \cdot \mathbf{y} \leq \mathbf{1}_{m\times1}$ and denote this solution as $\mathbf{y}^*[k]$.

Step 6: Compute $\mathbf{p}[k] = v[k] \cdot \mathbf{x}[k]$ and $\mathbf{q}[k] = v[k] \cdot \mathbf{y}[k]$, where $v^*[k] = F_1^*[k]^{-1}$.

After that, we can make the statistical analysis of obtained results, i.e. find the empirical distributions of vector sequences $\mathbf{p}[k]$, $\mathbf{q}[k]$, and numeric sequence $v[k]$. As an estimates of the optimal strategies of the both players and the game's value, we take, usually, theirs mean values, respectively. Software's implementation of the mentioned algorithm is realized by the original authors' procedure written in statistical programming language "R". For this purpose, we used a random numbers generators algorithm to generate the members of matrix sequence $A[k]$, as well as the Nelder-Mead's method of constrained optimization, also implemented in R. Using these procedures, after $T = 100$ simulations of normal distributed random variables a_{ij}, we obtained the estimated values of optimal strategies $\mathbf{p}^*$ and $\mathbf{q}^*$, as well as estimates of the optimal game's value v .

This procedure also shows the empirical distributions of realizations of $\mathbf{p}^*$ and $\mathbf{q}^*$, interpreted as realizations of some random variables with the appropriate (unknown) distribution. It gives the empirical distributions (histograms with the appropriate empirical densities functions) of the obtained estimates as a separate graphic file (Fig.3), as well as the summary statistics of obtained results. In this way, the structure of the problem itself, as well as the output results, is much complicated. Because of this, as a fundamental, this raises the following question: How to describe the essence of this procedure, and at the same collect all the outputs obtained from it?

One way of solving this problem, like as in the case of the previous problem, is to connect the R source code, i.e. the procedure itself, with HTML. Creating such, synthetic code is possible only recently, and it is closely related with the works of Xie and some other authors. Namely, they created a whole set of specific, additional R-packages [7-9] whose provide a general purpose tools for dynamic
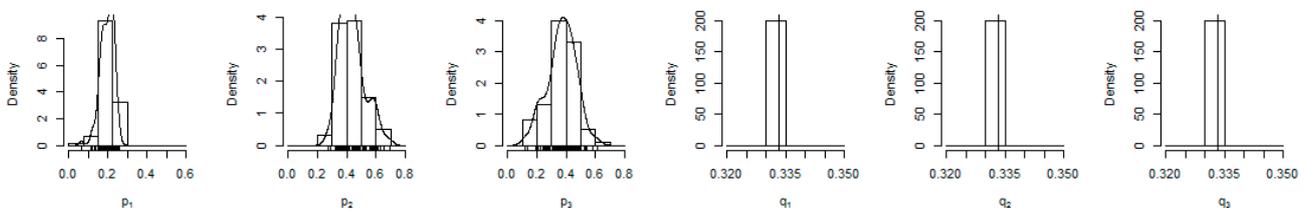

Fig.3. Empirical densities of the optimal strategies generated using "R" source code.

report generation in R, which can be used to HTML output. The patterns of code expressions can be customized, and, in that way, R source code is evaluated, based on a different design with more features.

In the following, we describe in details the procedure of creating such output in the case of our source code in R, which we called, for simplicity, *Games*:

♦ Firstly, using so-called "knitr"-package, we can create a file with *.Rhtml extension. This file, similarly as in *.asp files, combines the R source code with HTML-tags (Fig.4). In this way, we can upgrade the comments and some others additional files whose will help to the better communication with other users. The R source code is placed inside on so-called "vignettes".

♦ In the following step, popularly named "kniting", a simple caching mechanism is provided to transform *.Rhtml file to WEB page with the standard *.html extension (Fig.5). The main function in the "knitr"-package, named knit(), input R-document and write HTML-output (Fig.6).

♦ During the mentioned process, R code can be reformatted by the "formatR"-package so that long lines are automatically wrapped, with indent and spaces being added, and comments being preserved.

♦ Finally, the third, "highr"-package provides that syntax highlighting for R source code. Almost all common graphics devices, including those in R-base and add-on, are also built-in in the final, outputted HTML-file with "directly" publishing opportunities (Fig.7).

We should point out that the output document, produced with this process, is a specific synthesis of three different programming areas: R source code, output results obtained by this code, and the authors' comments in textual (or some other) form. In that way, the output file can be used as specific tutorial about the way in which this R-procedure solves a given problem, etc.

Fig. 4. R source code with HTML-tags.

Fig. 5. Kniting-process.
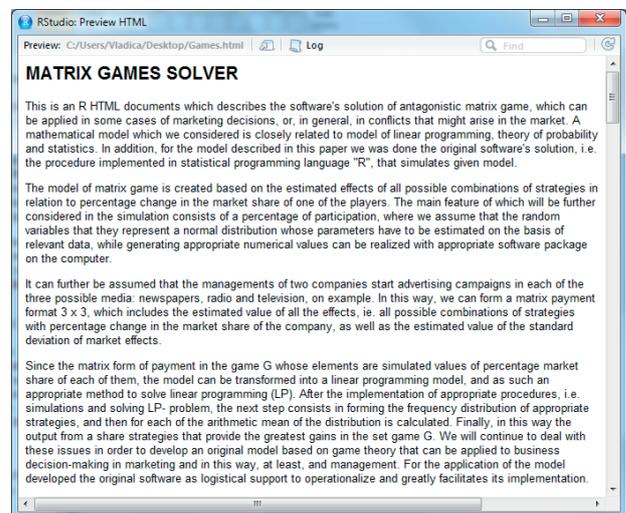
Fig. 6. Output preview as HTML-file.
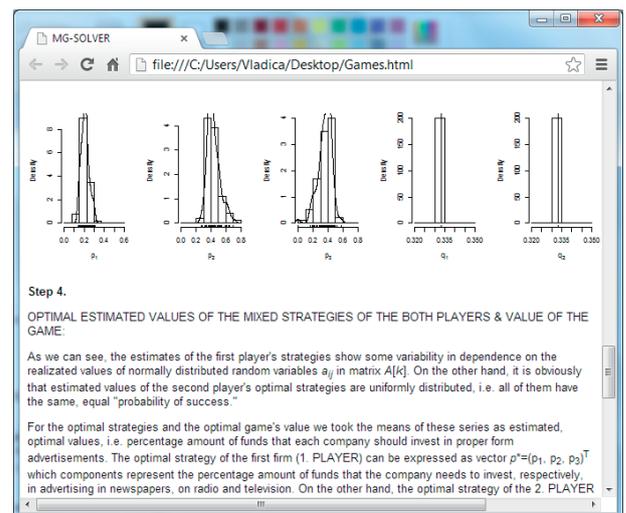
Fig. 7. Combined and designed view of the obtained results.

CONCLUSION

This paper describes only few of the lots of possible applications of the ASP technologies in solving econometric

problems. Most of these problems, by their characteristics, belong to the areas of (linear or nonlinear) programming, and they are closely "directed" to computer-aided solvers. For these purposes, ASP technologies provide the greats opportunities which are primarily reflected in connecting (often a very complex) programming procedures to the Internet, i.e. the appropriate WEB environments. One of the most features of ASP pages is their easy connectivity to databases (MS SQL, Access, Oracle, or any database that supports the ODBC standard). Dynamic data updating from databases to HTML pages opens up a variety of new advanced features for usage the ASP technology in econometrics. First of all, it allows a very fast and efficient work with a large number of data (time series, for example). Finally, ASP technology represents, in some way, a unique scripting language that allows us "free choice" of the syntax in which we want to make the source code. In this way, different approaches to building active WEB-solvers are enabled.

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