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# Applying Ms.Excel to solve linear programming problems In integrated teaching of economic mathematics

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***Abstract:*** *Integrated theme teaching is a new way of bringing practical value education and is a teaching perspective that aims to shape and develop in students the necessary competencies including competence use knowledge to effectively solve practical problems. The ability to apply that knowledge shown in this article is to help students in economics major when approaching Mathematics Economics, they can apply Ms.Excel to solve linear planning problems besides simple algorithms.*

***Keywords:*** *Integrated teaching; ability to apply knowledge; linear planning problems; Excel software.*

## 1. Introduction

In the trend of strengthening cooperation, exchange in training activities and employment within the region and globally, as well as the requirement to improve training quality, innovating teaching methods with a learner-centered competency approach has become one of the essential tasks for the entire education sector, especially universities. On the other hand, in the context of globalization and the current Fourth Industrial Revolution, employers' demands are increasingly higher. Workers are not only required to have knowledge but also need soft skills, proficiency in applying information technology, and, most importantly, the ability to utilize these knowledge and skills to address practical tasks effectively, ensuring the highest productivity. Therefore, the requirement is that to survive and keep pace with the development trends of society, universities in particular and the education system in general must innovate education toward a learner-centered competency approach.

With the competition in production and business activities, business managers are constantly required to choose solutions and make quick, accurate, and timely decisions while dealing with constraints and limitations related to the company's potential, market conditions, as well as natural and social circumstances. Therefore, in teaching the subject of Economic Mathematics to students in economics-related fields, determining the optimal solution based on predefined objectives is extremely important. If all factors (variables) related to capabilities, goals, and decision-making are linearly correlated, we can entirely use linear planning models to describe, analyze, and find solutions for that optimization problem. And solving linear planning problems will be carried out using the Solver tool in Ms.Excel, in addition to the familiar solution method of the monomorphic algorithm [2].

## 2. Research content

### *2.1. Concept of integrated teaching*

The concept of integrated teaching has been approached from various perspectives. The UNESCO Coordinated Program Conference, Paris 1972, provided a definition: *Integrated teaching of sciences is a way of presenting scientific concepts and principles that allows for the expression of the fundamental unity of scientific thought, avoiding overemphasizing or too early distinguishing the differences between various scientific fields*.

### *2.2. Recall Linear Programming Problems*

*2.2.1. General Form of Linear Programming Problems*

Objective function:

$$f\left(x_1, x_2, ...., x_n\right) = \sum_{j=1}^{n} c_j x_j \to \max(\min)$$

With constraints (conditions):

$$\sum_{j=1}^{n} a_{ij} x_j = b_i \quad \left(i \in I_1\right); \quad \sum_{j=1}^{n} a_{ij} x_j \geq b_i \quad \left(i \in I_2\right)$$

$$\sum_{j=1}^{n} a_{ij} x_j \leq b_i \quad \left(i \in I_3\right)$$

$x_j \leq 0$ or $x_j \geq 0$, $x_j$ with arbitrary markings (*)

In there: $I_1$, $I_2$, $I_3$ is a set of indices ($I_1$, $I_2$, $I_3$ inconvertible), symbol $I = I_1 \cup I_2 \cup I_3$

$a_{ij}$, $b_i$, $c_j$ bwith $i \in I, j = \overline{1,n}$ are constants (can be parameters), $n$ is the number of variables. $x_j$ with $j = \overline{1,n}$ are variables (unknowns of the problem), (*) are called sign constraints.

*2.2.2. Constructing linear programming problems in Excel*

Constructing the problem in Excel is similar to

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formulating the problem when solving it using the monomorphic algorithm. After analyzing the given problem, we organize the data into an Excel spreadsheet. Specifically, consider the following example.

__Example 1:__ Given the linear programming problem

Objective function:

$$f\left(x\right)=2x_1+8x_2-5x_3+15x_4\rightarrow \max$$

With constraints (conditions):

$$\begin{cases} 3x_1 & -x_2 & +x_3 & +10x_4 & =5 \\ x_1 & +2x_2 & +x_3 & +5x_4 & \geq 9 \\ 2x_1 & +10x_2 & +2x_3 & -5x_4 & \leq 26 \end{cases}$$

$$x_j \geq 0,\ j=\overline{1,4}$$

__Organize data on Excel spreadsheets__

- *Decision variables:* are entered in cells B2:E2. The starting values are 0

- *Objective function f(x):* has a value based on the initial values of the variables. Formula in cell F3

- *Constraints:* Enter the coefficients of the constraint relations in cells B5:E7. Calculate the left-hand side of the constraints using formulas in cells F5:F7. Enter the right-hand side values of the constraints in cells G5:G7

| | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| 1 | Variables | x1 | x2 | x3 | x4 | | | |
| 2 | | 0 | 0 | 0 | 0 | Objective function | | |
| 3 | Coefficients of the objective function | 2 | 8 | -5 | 15 | 0 | | |
| 4 | Constraints | | | | | Left side | Right side | |
| 5 | Constraint 1 | 3 | -1 | 1 | 10 | 0 | 5 | |
| 6 | Constraint 2 | 1 | 2 | 1 | 5 | 0 | 9 | |
| 7 | Constraint 3 | 2 | 10 | 2 | -5 | 0 | 26 | |
| 8 | Recipes | | | | | | | |
| 9 | Objective function | F3=B3*$B$2+C3*$C$2+D3*$D$2+E3*$E$2 | | | | | | |
| 10 | Constraints | F5=B5*$B$2+C5*$C$2+D5*$D$2+E5*$E$2 | | | | | | |
| 11 | | F6=B6*$B$2+C6*$C$2+D6*$D$2+E6*$E$2 | | | | | | |
| 12 | | F7=B7*$B$2+C7*$C$2+D7*$D$2+E7*$E$2 | | | | | | |
| 13 | | | | | | | | |

*Figure 1.1: Organizing data on a spreadsheet*

After entering the data into the spreadsheet, we proceed to solve the problem: In cell F3, select **Data\Solver**. The **Solver Parameters** dialog box will appear

In there: ***- Set Objective:*** Enter the cell containing the absolute address of the target function

***- To:*** Define the constraints for the objective function or the target value to achieve for the objective function: ***Max, Min,*** or ***Value of***, depending on the requirements of the problem

***- By Changing Variable Cells:*** Enter the absolute addresses of the cells containing the initial values of the variables

***- Subject to the Constraints:*** Enter the problem constraints

<u>With example 1, we declare parameters for Solver as follows:</u>

+ The address of the objective function F3 is passed into ***Set Objective***

+ Choose ***Max*** at ***To*** for ***Solver*** to find the maximum solution for the objective function

+ Enter the addresses of the decision variables B2:E2 in ***By Changing Variable Cells***

+ Add constraints to the ***Subject to the Constraints*** by clicking the ***Add*** button. The ***Add Constraint*** panel appears and includes the following parameters:

***- Cell Reference:*** The cell or range of cells containing the formula for the constraint

- *Mark box:* Allows us to choose the mark of the corresponding constraints

***- Constraint:*** The cell contains the right side value of the corresponding constraints (we can also directly enter the right side value of the corresponding constraint)

<u>For example 1, the constraints of the problem are entered as follows:</u>

+ Sign constraints: because $x_j \geq 0$, $j = \overline{1,4}$ so we select the address range containing the variable B2:E2 in ***Cell Reference***, select the sign ≥ and enter 0 in ***Constraint***

+ Continue to select ***Add*** to continue entering equation and inequality constraints

+ Click ***OK*** to finish declaring the constraints. However, to edit a constraint, select the constraint and click ***Change***. To delete a constraint, select it from the ***Subject to the Constraints*** list and click ***Delete***

+ After completing, we select ***Solve*** to run *Solver*, the result dialog box appears and gives us two options as follows:

***- Keep Solver Solution:*** Keep the results and print out the spreadsheet

***- Restore Original Values:*** Cancels the results just found and returns the variables to their original state

***- Save Scenario:*** Save the results you just found as a scenario so you can review them later.

In example problem 1, we choose ***Keep Solver Solution***, then click ***OK***. The result table is obtained

| | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| 1 | Variables | x1 | x2 | x3 | x4 | | | |
| 2 | | 0 | 3 | 0 | 0.8 | Objective function | | |
| 3 | Coefficients of the objective function | 2 | 8 | -5 | 15 | 36 | | |
| 4 | Constraints | | | | | Left side | Right side | |
| 5 | Constraint 1 | 3 | -1 | 1 | 10 | 5 | 5 | |
| 6 | Constraint 2 | 1 | 2 | 1 | 5 | 10 | 9 | |
| 7 | Constraint 3 | 2 | 10 | 2 | -5 | 26 | 26 | |
| 8 | Recipes | | | | | | | |
| 9 | Objective function | F3=B3*$B$2+C3*$C$2+D3*$D$2+E3*$E$2 | | | | | | |
| 10 | Constraints | F5=B5*$B$2+C5*$C$2+D5*$D$2+E5*$E$2 | | | | | | |
| 11 | | F6=B6*$B$2+C6*$C$2+D6*$D$2+E6*$E$2 | | | | | | |
| 12 | | F7=B7*$B$2+C7*$C$2+D7*$D$2+E7*$E$2 | | | | | | |
| 13 | | | | | | | | |

*Figure 1.8: Results table of example problem 1*

**Thus:** The extreme solution found is $X$ = (0;3;0;0.8) and the maximum value of the objective function $f(x)$ is 36.

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### *2.3. Extending the problem*

**<u>Example 2:</u>** A factory plans to produce 5 types of products $S_j (j = \overline{1,5})$. All 5 of these products use 4 main raw materials $NVL_i (i = \overline{1,4})$. The raw material consumption, profit and reserve limit are as follows:

| | $S_1$ | $S_2$ | $S_3$ | $S_4$ | $S_5$ | Reserved |
|---|---|---|---|---|---|---|
| $NVL_1$ | 2 | 5 | 6 | 8 | 4 | *1200* |
| $NVL_2$ | 3 | 1 | 5 | 6 | 1 | *800* |
| $NVL_3$ | 7 | 5 | 4 | 5 | 2 | *2000* |
| $NVL_4$ | 8 | 5 | 7 | 9 | 1 | *1865* |
| Profit | *300* | *250* | *500* | *150* | *320* | |

*<u>Requirement:</u>* Develop a production plan so that the factory achieves the greatest total profit.

***<u>Solution:</u>*** **<u>*</u> Construct the problem**

Call $x_j (j = \overline{1,5})$ is the output of the product type $j$ to be produced ($x_j \geq 0$). So the factory's production plan is $X = (x_1, x_2, x_3, x_4, x_5)$.

Objective function

$$f(x) = 300x_1 + 250x_2 + 500x_3 + 150x_4 + 320x_5 \rightarrow \max$$

Constraints

$$\begin{cases} 2x_1 + 5x_2 + 6x_3 + 8x_4 + 4x_5 \leq 1200 \\ 3x_1 + x_2 + 5x_3 + 6x_4 + x_5 \leq 800 \\ 7x_1 + 5x_2 + 4x_3 + 5x_4 + 2x_5 \leq 2000 \\ 8x_1 + 5x_2 + 7x_3 + 9x_4 + x_5 \leq 1865 \end{cases}$$

***Organize data on spreadsheets and solve problems using Excel**

- *Decision variable (Product quantity):* entered in cells B3:F3. The starting values are 0.

- *Objective function f(x) (Profit):* has a value based on the initial values of the variables. Formula in cell G4.

- *Constraints:* enter the coefficients of the constraints in cells B6:F9. Calculate the left side of the constraints according to the formula in cells G6:G9. Enter the values of the right side of the constraints in cells H6:H9.

| | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| 1 | Develop production plans to achieve maximum profit | | | | | | | |
| 2 | | x1 (S1) | x2 (S2) | x3 (S3) | x4 (S4) | x5 (S5) | | |
| 3 | Product quantity | 0 | 0 | 0 | 0 | 0 | Objective function | |
| 4 | Profit | 300 | 250 | 500 | 150 | 320 | 0 | |
| 5 | Constraints | | | | | | Left side | Right side |
| 6 | Constraint 1 | 2 | 5 | 6 | 8 | 4 | 0 | 1200 |
| 7 | Constraint 2 | 3 | 1 | 5 | 6 | 1 | 0 | 800 |
| 8 | Constraint 3 | 7 | 5 | 4 | 5 | 2 | 0 | 2000 |
| 9 | Constraint 4 | 8 | 5 | 7 | 9 | 1 | 0 | 1865 |
| 10 | Recipes | | | | | | | |
| 11 | Objective function | | G4=B4*$B$3+C4*$C$3+D4*$D$3+E4*$E$3+F4*$F$3 | | | | | |
| 12 | Constraints | | G6=B6*$B$3+C6*$C$3+D6*$D$3+E6*$E$3+F6*$F$3 | | | | | |
| 13 | | | G7=B7*$B$3+C7*$C$3+D7*$D$3+E7*$E$3+F7*$F$3 | | | | | |
| 14 | | | G8=B8*$B$3+C8*$C$3+D8*$D$3+E8*$E$3+F8*$F$3 | | | | | |
| 15 | | | G9=B9*$B$3+C9*$C$3+D9*$D$3+E9*$E$3+F9*$F$3 | | | | | |

*Figure 2.1: Set up example problem 2 on the spreadsheet*

*** Solve the problem:**

- In cell G4, execute the command ***Data\Solver***. Then fill in all the problem data in the ***Solver Parameters*** dialog box as follows

- After declaring the parameters of the problem, select ***Solver*** and we get the result table:

| | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| 1 | Develop production plans to achieve maximum profit | | | | | | | |
| 2 | | x1 (S1) | x2 (S2) | x3 (S3) | x4 (S4) | x5 (S5) | | |
| 3 | Product quantity | 200 | 0 | 0 | 0 | 200 | Objective function | |
| 4 | Profit | 300 | 250 | 500 | 150 | 320 | 124000 | |
| 5 | Constraints | | | | | | Left side | Right side |
| 6 | Constraint 1 | 2 | 5 | 6 | 8 | 4 | 1200 | 1200 |
| 7 | Constraint 2 | 3 | 1 | 5 | 6 | 1 | 800 | 800 |
| 8 | Constraint 3 | 7 | 5 | 4 | 5 | 2 | 1800 | 2000 |
| 9 | Constraint 4 | 8 | 5 | 7 | 9 | 1 | 1800 | 1865 |
| 10 | Recipes | | | | | | | |
| 11 | Objective function | | G4=B4*$B$3+C4*$C$3+D4*$D$3+E4*$E$3+F4*$F$3 | | | | | |
| 12 | Constraints | | G6=B6*$B$3+C6*$C$3+D6*$D$3+E6*$E$3+F6*$F$3 | | | | | |
| 13 | | | G7=B7*$B$3+C7*$C$3+D7*$D$3+E7*$E$3+F7*$F$3 | | | | | |
| 14 | | | G8=B8*$B$3+C8*$C$3+D8*$D$3+E8*$E$3+F8*$F$3 | | | | | |
| 15 | | | G9=B9*$B$3+C9*$C$3+D9*$D$3+E9*$E$3+F9*$F$3 | | | | | |

*Figure 2.3: Table of results for example 2*

**Thus:** The optimal solution of the problem is $X =$ (200; 0; 0; 0; 200) with the objective function being 124000. Or the factory's optimal production plan is to produce 200 units of product 1 and 200 units of product 5, then the optimal profit achieved is 124.000 currency units. No raw materials are wasted.

## 3. Conclusion

Many studies and practical experiences in education have shown that there are various teaching methods to achieve the proposed educational goals, among which integrated teaching is one of the methods that can help achieve the goal of developing learners' competencies. Correctly understanding and implementing the integrated teaching process can bring specific results to each subject area within a unified framework of disciplines. Therefore, applying MS.Excel to solve linear programming problems in integrated teaching for Economic Mathematics not only helps students enhance their ability to apply technology and simplifies linear programming problems significantly but also carries profound economic implications. It transforms the 'dry' numbers in mathematical models used in teaching into more dynamic and engaging content, making teaching and learning more appealing and bringing mathematics closer to real-life applications.

## References

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