[[1]](#footnote-1)

Title of your optimization case study

First author, Second author

*Abstract*— This report describes the guidelines for writing the report for the optimization project. This document must be used as a template to present the work developed. If possible, no changes must be made in the format to guarantee uniformity and homogeneity. The name of the document to send via email must be CaseStudyTitle\_SurmaneStudent1\_SurmaneStudent2.doc. The document cannot be submitted on paper. This abstract must briefly describe the content of the case study and the results and conclusions drawn. Before writing the report, it is advisable to consider the grading criteria in section VIII. The maximum extent of the report is six pages.

*Keywords* — Words or short sentences descriptive of the content of the report.

# Problem Statement

I

n this section, the statement of the problem is presented, as it is written in the document of the case studies.

# Description and Hypotheses

In your own words, this section describes the interpretation of the case study statement and any modeling hypothesis you have made.

In optimization models, it is essential to determine if the model is linear, integer linear, non-linear, etc. In this section, you can reference similar works found in the technical revision of the problem, as it is done now; see [1]. In addition, you can compare them to your formulations.

# Mathematical Formulation of the Optimization Problem

Use the Microsoft Equations Editor or write the equations in this document (Insert New Equation).

Below, the nomenclature for the mathematical formulation of the problem is presented, separating sets, parameters, variables, etc.

## Sets

You present the sets used in the following parameters, variables, and equations here. Writing the sets in alphabetical order is advisable to ease the search.

$i$ origin cities

$j$ destination cities

## Parameters

These are the known data of the problem. They could also be immediate calculations drawn from them. A descriptive text must be included with each parameter and its units. Writing the parameters in alphabetical order is advisable to ease the search. Using the numerical values of the parameters is not convenient because they appear in the statement and the code.

$a\_{i}$ supply of product in origin $i$ [boxed]

$b\_{j}$ demand of a product in the destination $j$ [boxes]

$c\_{ij}$ unitary cost from origin $i$ to destination $j$ [€/box]

## Variables

They define the meaning of the variables of the problem. Units in which each variable is expressed must be included. To facilitate the Reading of the equations, it could be convenient to use lowercase letters in the parameters and capital letters for the variables. Writing the variables in alphabetical order is advisable to ease the search.

$X\_{ij}$ boxes transported from origin $i$ to destination $j$ [boxed]

## Equations

A brief description of its meaning and the units in which it is expressed is included for each equation. Equations must be numbered in order, with their number in brackets adjusted to the right-hand side, as in (1). Check that all the symbols in the equation (sets, parameters, variables) have been previously defined.

For each origin, the total amount supplied to all destinations must equal the supply available in that origin [boxes].

$\sum\_{j=1}^{n}X\_{ij}=a\_{i} ∀i$

For each destination, the total amount received all the origins must be equal to the demand in that destination [boxes].

$\sum\_{i=1}^{m}X\_{ij}=b\_{j} ∀j$

The boxes transported must be non-negative [boxes].

$X\_{ij}\geq 0$

## Objective Function

For the objective function, a brief description of its meaning and the units in which it is expressed is.

The objective function corresponds to minimizing the total transport cost [€].

$\min\_{X\_{ij}}\sum\_{i=1}^{m}\sum\_{j=1}^{n}c\_{ij}X\_{ij}$

# Code

This section presents the code of the mathematical model. When writing any code, it is vital to readability and legibility. For that reason, it is advisable to use names or acronyms with the correct meaning, the structure of the code with indentation, the use of capital or lowercase letters according to some criteria (for instance, variables with capital letters, commands and parameters with lowercase letters) and the systematic and generous inclusion of explanatory comments along with the code.

Do not write lines with more than 70 characters to fit the code format in this document. Copy the code in GAMS using CNTRL-Alt-C and then paste it in RTF format in the Word document Word to keep the colors from GAMS. Use the font Consolas with a size of 6 pt so the code suits aesthetically.

$TITLE MODELO DE TRANSPORTE

*\* breve descripción del problema matemático*

*\* nombres de los autores*

*\* fecha*

**SETS**

 I fábricas de envasado / VIGO, ALGECIRAS /

 J mercados de consumo / MADRID, BARCELONA, VALENCIA /

**PARAMETERS**

 A(i) capacidad de producción de la fábrica i [cajas]

 / VIGO 350

 ALGECIRAS 700 /

 B(j) demanda del mercado j [cajas]

 / MADRID 400

 BARCELONA 450

 VALENCIA 150 /

**TABLE** C(i,j) coste unitario transporte entre i y j [€ por caja]

 MADRID BARCELONA VALENCIA

VIGO 0.06 0.12 0.09

ALGECIRAS 0.05 0.15 0.11

**VARIABLES**

 X(i,j) cajas transportadas entre fábrica i y mercado j [cajas]

 CT coste de transporte [miles de euros]

**POSITIVE** **VARIABLE** X

**EQUATIONS**

 COSTE coste total de transporte [€]

 CAPACIDAD(i) capacidad máxima de cada fábrica i [cajas]

 DEMANDA(j) satisfacción demanda de cada mercado j [cajas] ;

COSTE .. CT =E= **SUM**[(i,j), C(i,j) \* X(i,j)] ;

CAPACIDAD(i) .. **SUM**[j, X(i,j)] =L= A(i) ;

DEMANDA(j) .. **SUM**[i, X(i,j)] =G= B(j) ;

**MODEL** TRANSPORTE / COSTE, CAPACIDAD, DEMANDA /

**SOLVE** TRANSPORTE USING LP MINIMIZING CT

# Results

In this section, the results and their analysis are presented. Remember that this is a crucial stage in the development of mathematical models. For that reason, it must be elaborated carefully. Using tables, see Table 1, or illustrations, see Fig. 1, that facilitate their understanding is highly advisable.

|  |  |  |
| --- | --- | --- |
|  | Destination 1 | Destination 2 |
| Origin 1 | 32 | 5 |
| Origin 2 | 12 | 6 |

Table 1. Boxes transported among origins and destinations.



Fig. 1. Graphic with the transport decisions

Before analyzing the results, you must check that they make sense, reason their meaning, and using sensitivity analysis to changes in the input parameters. Keep track of all the tests developed in the verification stage.

You must answer all the questions about the results that appear in the case study statement. In optimization, a post-optimality analysis must be carried out.

When the model's size is too big to use the student version of GAMS, you can use the online solvers available ([https://neos-server.org/neos/solvers/milp:Gurobi/GAMS.html](https://neos-server.org/neos/solvers/milp%3AGurobi/GAMS.html)).

For small mixed-integer linear problems (MIP), set the relative tolerance to 0. This tolerance is the relative difference between the integer solution offered by the solver and the optimal integer solution. The solver provides the optimal solution when this relative tolerance is set to 0. On the contrary, the solver stops when the relative tolerance is satisfied. Its default value is 0.1. The way to do this in GAMS is:

option OptCR=0 ;

This instruction must be written in any part of the code but always before the SOLVE.

If you use integer variables that can take values greater than 100, you must update their upper bound, as the default upper bound for integer variables is set to 100.

# Extension of the Case Study

This section describes the extensions to the original statement of the problem that the working group has considered reasonable to analyze. Own initiative would be evaluated as you, the group, have complete freedom to propose any extension. The study and quality of the extension would also be assessed.

The extensions can be, for instance, parametric sensitivity analysis, creative changes in the problem statement, and referenced comments of possible real applications that briefly adhere to the problem statement.

# Conclusions

This section summarizes the work developed, briefly commenting on the optimal decisions achieved and the extensions proposed to the original model.

# Evaluation Criteria

The evaluation criteria for this work are as follows:

* Style/Format (1 points): the visual style and format of the document will be evaluated; is everything nicely aligned or are there errors in the style? avoid orthographical mistakes; all the figures/tables must have captions and be referenced in the text; quality of the images/tables; a visually appealing, professional document.
* Model formulation (3 points): most notably, the model (the mathematical formulation) is correct and logical, and all constraints/ variables/ parameters are explained precisely; meaning that all of the necessary constraints are there and none is missing; if the formulation is correct and precise then modeling elegance/efficiency are also valued; are the constraints general or hard-coded; are the parameters general or hard-coded; are you using integer variables when continuous variables suffice, etc.
* Code (2 points): this section only refers to the GAMS code; is it correct, and if yes, do you follow a coding standard (simple, neat, clean, and tidy code); is the code general or hard-coded; use the same symbols in the mathematical formulation and the code.
* Results (2 points): are the model results presented in an acceptable and digestible manner (absolutely no copy/paste of the lst file); are there tables and figures that help in the discussion and make it easy to understand; are the results correct and well-explained; validation of the results of the model, analysis of feasibility problems or scalability of the model.
* Extension (2 points): is there an extension of the basic work; how original/difficult is the extension (it is not the same to change one number in a constraint and then to come up with a whole new set of constraints with a different but interesting meaning); is the extension only conceptual or has it been coded, and new results have been presented.

# Use of a Generative AI

We allow generative AI (ChatGPT, for example) for developing the case study, but this must be explicitly mentioned in the report, and all the prompts must appear in an Annex. Not satisfying this condition will be considered plagiarism.

References

1. Reference technical papers or books consulted, if any. Otherwise, eliminate the References section. See as an example the following reference.
2. Reference any generative AI, including version number.
3. P. Linares, A. Ramos, P. Sánchez, A. Sarabia, *Optimization cases* <https://pascua.iit.comillas.edu/aramos/simio/apuntes/a_casos.pdf>, 2006.
1. Put the submission date in this footnote: October 29, 2023, for example. [↑](#footnote-ref-1)