[[1]](#footnote-1)

Guía turística de viaje entre ciudades con modelo multi-criterio de optimización mínimo-máximo: Presupuesto VS Número de ciudades

Guzmán S. Autor y Manrique J. Autor

*Resumen*—Este artículo consiste en hacer una descripción de la implementación de un proceso de modelado y optimización en el desarrollo de una herramienta de software que sirve como guía en un viaje entre ciudades intentando maximizar la cantidad de lugares a visitar y minimizar el presupuesto que la persona gasta en el mismo. Partiendo de un modelado matemático, verificando en herramientas de métodos computacionales (GAMS) y generando metaheurísticas apropiadas se ilustra cómo implementar un proyecto de esta magnitud y qué sería necesario para llevarlo a la realidad.

*Términos clave*—Optimización multiobjetivo, algoritmos evolutivos, modelado matemático, transporte, guía turística

# INTRODUCCIÓN

B

REVE context del trabajo puesto que el desarrollo del problema y la motivación u objetivos se encuentran más adelante.

# DEFINICIÓN DEL PROBLEMA

# ESTABLECIMIENTO DE OBJETIVOS

# FORMULACIÓN Y PLANIFICACIÓN DEL MODELO

## Conceptualización del modelo

Restricciones y definición del modelo, junto con formulación matemática. Para las ecuaciones:

Number equations consecutively with equation numbers in parentheses flush with the right margin, as in (1). First use the equation editor to create the equation. Then select the “Equation” markup style. Press the tab key and write the equation number in parentheses. To make your equations more compact, you may use the solidus ( / ), the exp function, or appropriate exponents. Use parentheses to avoid ambiguities in denominators. Punctuate equations when they are part of a sentence, as in

 (1)

Be sure that the symbols in your equation have been defined before the equation appears or immediately following. Italicize symbols (*T* might refer to temperature, but T is the unit tesla). Refer to “(1),” not “Eq. (1)” or “equation (1),” except at the beginning of a sentence: “Equation (1) is ... .”

## Adquisición de Datos

Adquisición a mano de los datos junto con la posibilidad abierta de financiación para obtenerlos de APIs.

# TRADUCCIÓN DEL MODELO

Al considerarse que el problema expuesto no se puede similar de una forma tal que muestre resultados confiables de implementación, se desarrolló una meta-heurística para una resolución más eficiente para el problema en cuestión de tiempos.

# VERIFICACIÓN Y VALIDACIÓN

Para el proceso de verificación del modelo se manejó el lenguaje GAMS en el ambiente de desarrollo “gamside” que permitió traducir el modelo matemático para realizar una resolución por métodos numéricos, que, a pesar de no ser óptima, es capaz de encontrar respuestas para escenarios básicos del modelo planteado anteriormente a través del solucionador BONMIN de programación entera mixta no lineal.

Por su parte, la validación consistió en generar archivos de entrada para el programa en GAMS que representaran una serie de escenarios con sus respectivos escenarios teóricamente calculados sin ayuda de alguna herramienta tecnológica. Para cada uno de estos escenarios se realizó una prueba con el programa verificador y con el código de solución explicado en la sección V de este documento, para poder validar la metaheurística generada. A continuación, se presentan los resultados obtenidos:

1. *Escenarios base 1 (Funcionamiento básico)*
   1. P2=0
   2. Mind=1 y Maxd=1
   3. d=4
   4. n=4
   5. Resto de parámetros del modelo son aleatorios

RESULTADO ESPERADO: Se escogen las 4 ciudades con 1 día por cada una independiente del orden.

RESULTADO OBTENIDO DE GAMS:

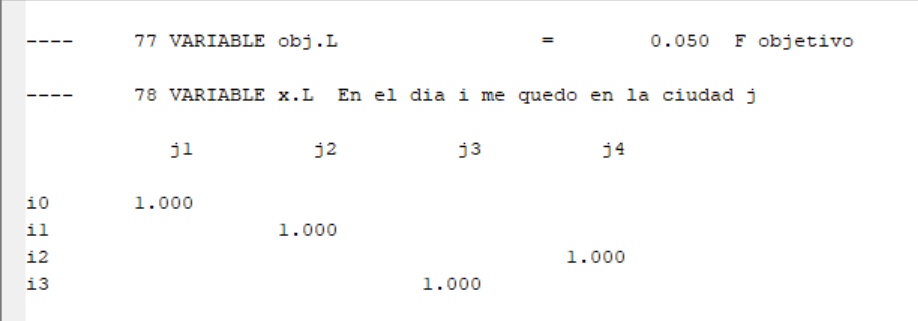


Fig . Resultado del escenario base 1 en GAMS

De lo anterior la ruta generada sería:

- Ciudad 1 a Ciudad 2.

- Ciudad 2 a Ciudad 4.

- Ciudad 4 a Ciudad 3.

Lo cual cumple con la estimación que habíamos generado antes.

1. *Escenario base 2 (Número de días):* 
   1. n=2
   2. mind=3
   3. maxd=5
   4. d=8
   5. s=1
   6. Puntaje(1)=10
   7. Puntaje(2)=1
   8. p1=1
   9. p2=0
   10. Los otros parámetros son aleatorios

RESULTADO ESPERADO: Se queda 5 días en la primera ciudad y 3 en la otra.

RESULTADO OBTENIDO CON GAMS:

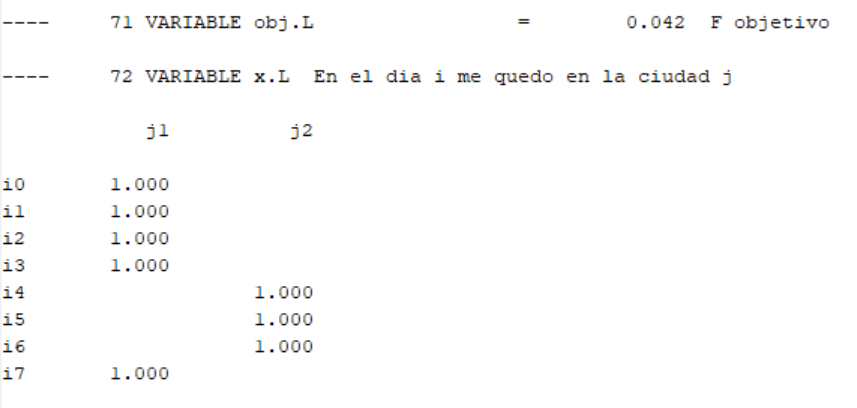


Fig 2. Resultado del escenario base 2 en GAMS

De la anterior imagen se ve que se queda 4 días en la ciudad 1, se desplaza 3 días a la ciudad 2, y se queda el último día en la ciudad 1. Esto cumple con las expectativas que se tienen del caso base.

1. *Escenario base 3 (Costo de vida promedio):*
   1. n=2
   2. mind=3
   3. maxd=5
   4. d=8
   5. s=1
   6. Los valores de la matriz de costos son iguales
   7. p1=0
   8. p2=1
   9. Los otros parámetros son aleatorios

RESULTADO ESPERADO: Se queda 5 días en la primera ciudad y 3 en la otra.

RESULTADO OBTENIDO EN GAMS:

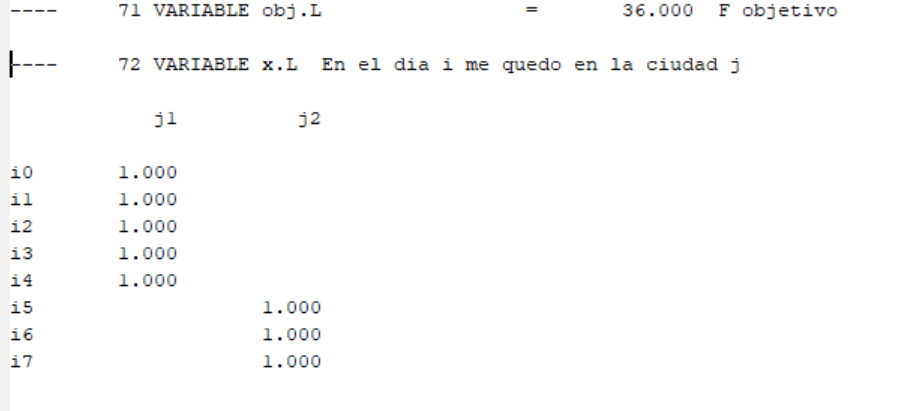


Fig 3. Resultado del escenario base 3

Se queda 5 días en la primera ciudad y luego tres en la segunda, justo como se esperaba.

1. *Escenario base 4 (Costo de transporte):*
   1. n=3
   2. mind=|
   3. maxd=1
   4. d=3
   5. s=1
   6. p2=1
   7. p1=0



Fig 4. Tabla de costos del escenario base 4.

* 1. Costo de vida promedio es igual para todas las ciudades
  2. Los otros parámetros del modelo son aleatorios

RESULTADO ESPERADO: Va de la ciudad 1 a la 2 y luego a la 3.

RESULTADO OBTENIDO DE GAMS:

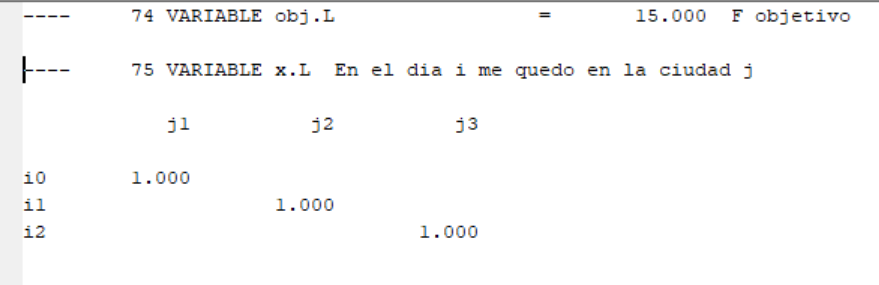


Fig 5. Resultado obtenido del escenario base 4 en GAMS

De acuerdo con la anterior imagen, como fue de esperarse se desplaza de la ciudad 1 a la 2, y de la ciudad 2 a la 3.

1. *Escenario intermedio:*
   1. n=10
   2. 5 ciudades tienen un costo de vida alto y puntajes bajos (Ciudad 1 a 5)
   3. 5 ciudades tienen un costo de vida bajo y puntajes altos (Ciudad 6 a 10).
   4. Costos de transporte iguales.
   5. d=15
   6. maxd=3
   7. mind=1
   8. p1=0.5
   9. p2=0.5
   10. s: Una ciudad de las baratas (6 a 10).
   11. Los otros parámetros son aleatorios

RESULTADO ESPERADO: Irse por las ciudades más baratas.

RESULTADO OBTENIDO DE GAMS:

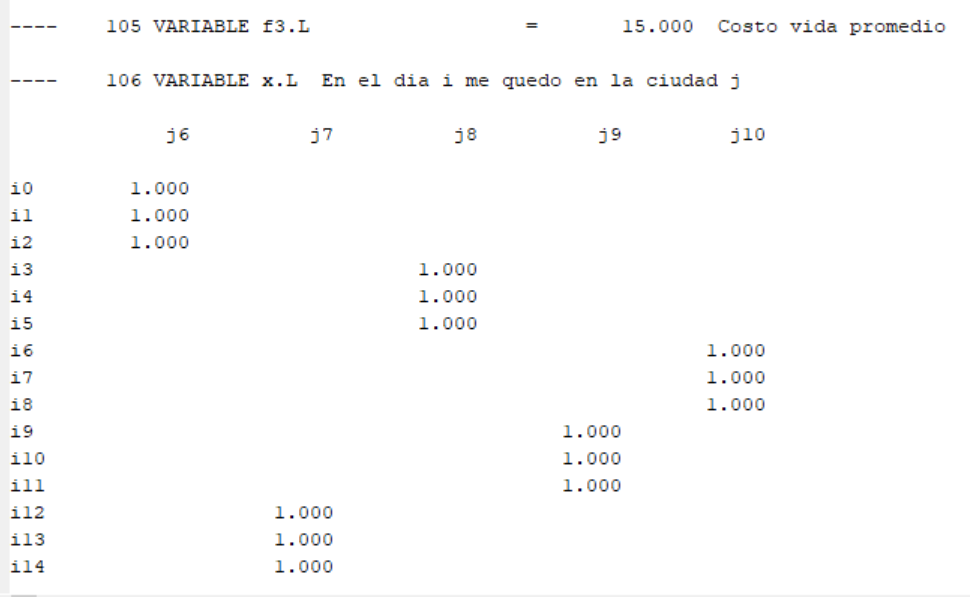


Fig 6. Resultado obtenido del escenario intermedio en GAMS

Como era de esperarse, solo se estuvo en las 5 ciudades más baratas.

# DISEÑO EXPERIMENTAL

El diseño experimental propuesto consiste en implementar un escenario real con un número de 25 ciudades de España y datos recolectados manualmente de Numbeo y Google para mirar el comportamiento del modelo y correrlo variando los parámetros p1 y p2 lo más que se pueda.

# ANÁLISIS DE RESULTADOS

The word “data” is plural, not singular. The subscript for the permeability of vacuum µ0 is zero, not a lowercase letter “o.” The term for residual magnetization is “remanence”; the adjective is “remanent”; do not write “remnance” or “remnant.” Use the word “micrometer” instead of “micron.” A graph within a graph is an “inset,” not an “insert.” The word “alternatively” is preferred to the word “alternately” (unless you really mean something that alternates). Use the word “whereas” instead of “while” (unless you are referring to simultaneous events). Do not use the word “essentially” to mean “approximately” or “effectively.” Do not use the word “issue” as a euphemism for “problem.” When compositions are not specified, separate chemical symbols by en-dashes; for example, “NiMn” indicates the intermetallic compound Ni0.5Mn0.5 whereas “Ni–Mn” indicates an alloy of some composition NixMn1-x.

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Prefixes such as “non,” “sub,” “micro,” “multi,” and “ultra” are not independent words; they should be joined to the words they modify, usually without a hyphen. There is no period after the “et” in the Latin abbreviation “*et al.*” (it is also italicized). The abbreviation “i.e.,” means “that is,” and the abbreviation “e.g.,” means “for example” (these abbreviations are not italicized).

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Fig. 1. Magnetization as a function of applied field. Note that “Fig.” is abbreviated. There is a period after the figure number, followed by two spaces. It is good practice to explain the significance of the figure in the caption.

TABLE I

Units for Magnetic Properties

|  |  |  |
| --- | --- | --- |
| Symbol | Quantity | Conversion from Gaussian and  CGS EMU to SI a |
| Φ | magnetic flux | 1 Mx → 10−8 Wb = 10−8 V·s |
| *B* | magnetic flux density,  magnetic induction | 1 G → 10−4 T = 10−4 Wb/m2 |
| *H* | magnetic field strength | 1 Oe → 103/(4π) A/m |
| *m* | magnetic moment | 1 erg/G = 1 emu  → 10−3 A·m2 = 10−3 J/T |
| *M* | magnetization | 1 erg/(G·cm3) = 1 emu/cm3  → 103 A/m |
| 4π*M* | magnetization | 1 G → 103/(4π) A/m |
| σ | specific magnetization | 1 erg/(G·g) = 1 emu/g → 1 A·m2/kg |
| *j* | magnetic dipole  moment | 1 erg/G = 1 emu  → 4π × 10−10 Wb·m |
| *J* | magnetic polarization | 1 erg/(G·cm3) = 1 emu/cm3  → 4π × 10−4 T |
| χ*,* κ | susceptibility | 1 → 4π |
| χρ | mass susceptibility | 1 cm3/g → 4π × 10−3 m3/kg |
| μ | permeability | 1 → 4π × 10−7 H/m  = 4π × 10−7 Wb/(A·m) |
| μr | relative permeability | μ → μr |
| *w, W* | energy density | 1 erg/cm3 → 10−1 J/m3 |
| *N, D* | demagnetizing factor | 1 → 1/(4π) |

Vertical lines are optional in tables. Statements that serve as captions for the entire table do not need footnote letters.

aGaussian units are the same as cg emu for magnetostatics; Mx = maxwell, G = gauss, Oe = oersted; Wb = weber, V = volt, s = second, T = tesla, m = meter, A = ampere, J = joule, kg = kilogram, H = henry.

# CONCLUSIONES

BIBLIOGRAFÍA

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2. J. H. Davis and J. R. Cogdell, “Calibration program for the 16-foot antenna,” Elect. Eng. Res. Lab., Univ. Texas, Austin, Tech. Memo. NGL-006-69-3, Nov. 15, 1987.

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   T. C. Author is with the Electrical Engineering Department, University of Colorado, Boulder, CO 80309 USA, on leave from the National Research Institute for Metals, Tsukuba, Japan (e-mail: author@nrim.go.jp). [↑](#footnote-ref-1)