Highlights

A study on multicriteria ABC classification with analytical hierarchy process

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- generative method to force consistency of pairwise comparisons matrix;
- importance of the correct balance of product criteria weights assigning;
- importance of ABC multicriteria classification for forecasting.

A study on multicriteria ABC classification with analytical hierarchy process

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Abstract

Multicriteria classification is usualy very important to the decision-making in manufacturing management process. For such classification, the attribution of weights to the criteria strongly influences the coherence of the results found. Saaty's Analytic Hierarchy Process (AHP) is an important method for assigning weights to multiple criteria. AHP's logic is not complicated at all but, since matrices of pairwise comparisons of criteria are usually generated manually and based only on some employee know-how, there is a huge complexity on generating a consistent pairwise matrix. Especially when many criteria are used. This paper presents a constructive algorithm that can be used to adjust inconsistent matrices, forcing such matrices to have a better consistency rate. We tested this algorithm by applying the AHP method, for

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multicriteria ABC classification, to companies in two sectors. As a result we observed that the algorithm can adjust the pairwise matrices in just a few seconds, avoiding the manual work that would be done in weeks, therefore showing that it is an important resource for applying the AHP method. We also present in this paper an analysis of the importance of the attribution of the weights to the criteria and show how the multicriteria classification may influence the decision on the choice of the appropriate forecasting method.

Keywords: multicriteria classification, ABC classification, analytic hierarchy process, pairwise matrix consistency, COPSolver

1. Introduction

2. Algorithm for forcing pairwise matrix consistency

The algorithm is not represented correctly.

Changes will be made during the preparation of the article according to the module of software COPSolver: library for solving classification problems.

Algorithm 1 function $consistencyRate()$

Require: $[a_{ij}]_{i,j=1}^{n}, RI[x]_{x=1}^{10}$
$\lambda_{max} = mainEigenvalue([a_{ij}]_{i,j=1}^{n})$ [1]
$CI = (\lambda_{max} - n)/(n-1)$
$CR \leftarrow CI/RI[n]$
return CR

Algorithm 2 function *constructivelyForceConsistency*($[a_{ij}]_{i,j=1}^{n}$)

Require: $[a_{ij}]_{i,j=1}^{n}$
Ensure: $consistencyRate([a_{ij}]_{i,j=1}^{n}) \leq 0.1$
  $CR = consistencyRate([a_{ij}]_{i,j=1}^{n})$
  if $CR \leq 0.1$ **then**
    return $[a_{ij}]_{i,j=1}^{n}$
  else
    for $3 \leq k \leq n$ **do**
      $([a_{ij}]_{i,j=1}^{k}, CR) \leftarrow forceConsistency([a_{ij}]_{i,j=1}^{k})$
      if $CR \leq 0.1$ **then**
        break for
      end if
    end for
  end if
  return $([a_{ij}]_{i,j=1}^{n}, CR)$

2.1. Constructive algorithm

3. Tests and results

4. Conclusions and suggestions for future works

In this paper we presented ...

5. CRediT authorship contribution statement

T.B. Fraga: Conceptualization, Project administration, Supervision, Software, Methodology, Validation, Formal analysis, Writing – original draft, Writing – review & editing.

Algorithm 3 function $forceConsistency([a_{ij}]_{i,j=1}^{k})$

Require: $[a_{ij}]_{i,j=1}^{n} \quad | \quad consistencyRate([a_{ij}]_{i,j=1}^{n-1}) \leq 0.1$
Ensure: $consistencyRate([a_{ij}]_{i,j=1}^{n}) \leq 0.1$
  $CR \leftarrow consistencyRate([a_{ij}]_{i,j=1}^{n})$
  for $j \leq n-2$ **do**
    for $j+1 \leq k \leq n-1$ **do**
      $g \leftarrow 0$
      $s \leftarrow 0$
      if $a_{nj} > a_{nk}$ and $a_{jk} \leq 1$ **then**
        $g \leftarrow j$
        $s \leftarrow k$
      else if $a_{nj} < a_{nk}$ and $a_{jk} \geq 1$ **then**
        $g \leftarrow k$
        $s \leftarrow j$
      end if
      if $g \neq 0$ **then**
        $([a_{ij}]_{i,j=1}^{n}, CR) \leftarrow reduce([a_{ij}]_{i,j=1}^{n}, g, s)$
        if $CR \geq 0.1$ **then**
          $([a_{ij}]_{i,j=1}^{n}, CR) \leftarrow encrease([a_{ij}]_{i,j=1}^{n}, g, s)$
        end if
      end if
      if $CR \leq 0.1$ **then**
        break for
      end if
    end for
    if $CR \leq 0.1$ **then**
      break for
    end if
  end for
  return $([a_{ij}]_{i,j=1}^{n}, CR)$

Algorithm 4 function $reduce([a_{ij}]_{i,j=1}^{n}, g, s)$

Require: $g, s < n; [a_{ij}]_{i,j=1}^{n}$
  while $a_{ng} > a_{ns}$ **do**
    $a_{ng} \leftarrow a_{ng}^{--}$
    $a_{gn} \leftarrow a_{gn}^{++}$
    $aux_{CR} = consistencyRate([a_{ij}]_{i,j=1}^{n})$
    if $aux_{CR} < CR$ **then**
      $CR = aux_{CR}$
      if $CR \leq 0.1$ **then**
        break
      end if
    else
      $a_{ng} \leftarrow a_{ng}^{++}$
      $a_{gn} \leftarrow a_{gn}^{--}$
      break
    end if
  end while
  return $([a_{ij}]_{i,j=1}^{n}, CR)$

6. Acknowledgments

References

Flores, B. E., Whybark, D. C. (1987). Implementing Multiple Criteria ABC Analysis. *Journal of Operations Management*, Vol. 7 (1,2), pp. 79–85.

Fraga, T.B. (2023). COPSolver: open source software for solving combinatorial optimization and other decision problems - library for solving the multicriteria classification problem, in press.

Algorithm 5 function $increase([a_{ij}]_{i,j=1}^{n}, g, s)$

Require: $g, s < n; [a_{ij}]_{i,j=1}^{n}$
  while $a_{ng} > a_{ns}$ **do**
    $a_{ns} \leftarrow a_{ns}^{++}$
    $a_{sn} \leftarrow a_{sn}^{--}$
    $aux_{CR} = consistencyRate([a_{ij}]_{i,j=1}^{n})$
    if $aux_{CR} < CR$ **then**
      $CR = aux_{CR}$
      if $CR \leq 0.1$ **then**
        break
      end if
    else
      $a_{ns} \leftarrow a_{ns}^{--}$
      $a_{sn} \leftarrow a_{sn}^{++}$
      break
    end if
  end while
  return $([b_{ij}]_{i,j=1}^{n}, CR)$

Algorithm 6 function a_{ij}^{++}

Require: $a_{ij} \quad | \quad a_{ij} \in \{1/9, 1/7, 1/5, 1/3, 1, 3, 5, 7, 9\}$
  if $a_{ij} \geq 1$ and $a_{ij} \neq 9$ **then**
    $a_{ij} \leftarrow a_{ij} + 2$
  else if $a_{ij} < 1$ **then**
    $a_{ij} \leftarrow 1/(1/a_{ij} - 2)$
  end if
  return a_{ij}

Algorithm 7 function a_{ij}^{--}

Require: $a_{ij} \quad | \quad a_{ij} \in \{1/9, 1/7, 1/5, 1/3, 1, 3, 5, 7, 9\}$
  if $a_{ij} \geq 3$ **then**
    $a_{ij} \leftarrow b_{ij} - 2$
  else if $a_{ij} \leq 1$ and $a_{ij} \neq 1/9$ **then**
    $a_{ij} \leftarrow 1/(1/a_{ij} + 2)$
  end if
  return a_{ij}