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NEW ABC MULTICRITERIA CLASSIFICATION WITH ANALYTICAL HIERARCHY PROCESS: HOW TO ATTRIBUTE WEIGHTS AND FORCE CONSISTENCY OF PAIRWISE COMPARISONS MATRIX

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Resumo: *Multicriteria classification is usually a crucial step in the decision-making in the manufacturing and purchasing management process. For such classification, the attribution of weights to the criteria, as well as the attribution of weights to the products according to each criterion, strongly influences the coherence of the categorization. Saaty's Analytic Hierarchy Process (AHP) is an eminent method for assigning weights to multiple criteria. AHP's logic is not complicated at all. However, since criteria's pairwise comparison matrices are usually generated manually and based only on some employee know-how, there is high complexity in elaborating a consistent pairwise matrix, especially when comparing several criteria. This paper presents a constructive algorithm that can adjust inconsistent matrices, forcing such matrices to have a better consistency rate and a new procedure and equation for ABC multicriteria classification. We tested the proposed solutions by applying the AHP method for ABC multicriteria classification to companies in three sectors. As a result, we observed that the algorithm for forcing consistency adjusts the pairwise matrices in just a few seconds, avoiding the manual work of several hours and that the new solution method developed for multicriteria classification provided consistent results according to the analysis of company managers, showing to be essential resources for applying the AHP and ABC multicriteria classification methods.*

Palavras-chave: *ABC multicriteria classification, analytic hierarchy process, consistency rate, constructive algorithm, COPSolver library*

1. INTRODUCTION

"Manufacturing decisions can be classified into three categories: strategic, tactical and operational ... Operational decisions pertaining to issues such as order processing, detailed production scheduling, follow up, maintenance routines, and inventory control rules, drive the day to day activities" (Singhal *et al.*, 2013). Manufacturing decisions are closely related to sales decisions. "In today's competitive market the diversity in customer's need have resulted in a high level of variability in the products which have to be manufactured" (Ebrahimi *et al.*, 2014) or acquired from other companies. Such diversity brings to light the need for the use of complex techniques for purchasing / production management, especially at the operational decision level (Kiran, 2019). In such a scenario, prior optimized operational planning becomes impressible for better use of the productive capacity and to avoid investment losses in unnecessary or unprofitable material. And, given the wide variety of products, it is crucial to start any planning by understanding the importance of all products marked by the company.

One of the approaches that is widely applied to clustering products according to their importance is the multicriteria ABC classification. The scientific literature broadly emphasizes the value of multicriteria ABC classification for inventory management and presents several multicriteria methods. The Analytical Hierarchy Process is one of the most common techniques applied for this purpose (Flores *et al.*, 1992; Altay Guvenir and Erel, 1998; Lolli *et al.*, 2014; Balaji and Kumar, 2014). Some recent studies also emphasize the importance of applying multicriteria analysis to strategic planning (*e.g.*, Barbosa de Paula *et al.*, 2022; de Moura Pereira *et al.*, 2023; Mariano Ribeiro *et al.*, 2023). Odu (2019) emphasizes that, when applying some multicriteria methods, it is crucial to pay particular attention to the objectivity factors of criteria weights. The author provides a detailed overview of different weighting methods applicable to multicriteria techniques.

In this work, we present a study with three companies from three different sectors, which market a wide variety of

products, in some cases, highly personalized products. The interest of this study is to identify the principal products, that is, the products that each company must prioritize so that this information can guide the optimized operational planning. We opted for the method ABC for multicriteria classification and adopted the Analytic Hierarchy Process (AHP) (Saaty, 1987) to assign the weights to the different criteria. It is important to note that the Analytic Hierarchy Process derives the weights of each criterion based on the eigenvector of a pairwise comparison matrix, which is constructed manually according to an empirical evaluation. According to Saaty (1987), this matrix must be antisymmetric and have a consistency rate of less than 0.1. The author reports that a software package supporting the AHP, called Expert Choice, for the IBM PC, was used in his work for making eigenvector calculations and guiding the decision maker to improve matrix inconsistency if needed. During the execution of the work we present in this paper, we found that there is a substantial difficulty in the calculation of the eigenvector, as well as in the construction of consistent pairwise comparison matrices. Since we had no access to the Expert Choice software package, we developed an open-source COPSolver library for the Analytic Hierarchy Process and multicriteria ABC classification based on a simple algorithm for forcing the consistency of such matrices. We present this algorithm in this paper. We coupled the Eigen library from eigen.tuxfamily.org to COPSolver for the eigenvectors calculation of the matrices. Also, we identified that it is possible to use different criteria types (cumulative sum, qualitative, and binary) when assigning weights to ABC classification, depending on each specific criterion chosen, and we observed that such an assignment generates a bias in the multicriteria ABC classification. Therefore, we also developed a new methodology for assigning weights in a balanced way for ABC classification, and we proposed a new multicriteria weighting equation for the multicriteria classification COPSolver library. We also present both propositions in this paper, as well as an in-depth analysis of the results found by the new library developed for COPSolver.

The rest of this paper is structured as follows. Section 2 presents the algorithm developed to force the consistency of pairwise comparison matrices. Section 3 explains the proposed approach for assigning the weights for the ABC classification and the equation for calculating the weights for the multicriteria classification. Section 4 briefly exhibits COPSolver software and the new library developed for multicriteria classification. Section 5 presents the results and analysis informing about the precautions someone must have when elaborating the COPSolver input file for multicriteria classification. Section 6 reports the credits in carrying out this work. Sections 7 and 8 conclude this article with conclusions and acknowledgments, respectively.

2. ALGORITHM FOR FORCING LOW CONSISTENCY RATE

Algorithm (1) illustrates the method developed to reduce the consistency rate (CR). This algorithm takes as input the pairwise comparison matrix ($M[m_{ij}]$) and the tolerance (tol) defined for the consistency rate and returns the matrix adjusted as well as the CR of this new matrix (see Saaty (1987) for more information on calculating the consistency rate).

Algorithm 1 forceConsistency()

Require: $tol, M[m_{ij}]$
Ensure: $CR < tol$
  $n \leftarrow size(M[m_{ij}])$
  $CR \leftarrow$ consistencyRate($M[m_{ij}]$)
  topLeftCorner($CR, tol, M[m_{ij}]$)
  bottomLeftCorner($CR, tol, M[m_{ij}]$)
  return $CR, tol, M[m_{ij}]$

The topLeftCorner() function (alg. 3) performs a peer-to-peer comparison of each element of the pairwise matrix starting from the third row, $M[m_{\{sz\}j}]_{sz=3}^{n}$, with each element of the matrix $M[m_{jk}]_{j=1,k=j+1}^{n-1,n}$. In this comparison, the consistency of each pair is verified according to Alg. (2). If any inconsistency is found, the value of one of the elements is reduced or increased, seeking to improve the consistency rate. Initially, the reduction of values is done through the reduce() function. If, after the reduction, the convergence rate is still greater than the tolerance, the increment of values is made through the increase() function.

Algorithm 2 consistency checking

Require: $M[m_{ij}]$
  if $m_{\{sz\}j} * m_{jk} = m_{\{sz\}k}$ **then**
    $consistent \leftarrow 1$ ▷ values are consistent
  else
    $consistent \leftarrow 0$ ▷ values are not consistent
  end if
  return $consistent$

The bottomLeftCorner() function is similar to the topLeftCorner() function. In the topLeftCorner() function, the peer-to-peer comparison starts with the elements of the third row ($M[m_{\{sz\}j}]_{sz=3}$), and then the elements of the next rows are evaluated, following the order from top to bottom. In the case of the bottomLeftCorner() function, on the other hand, the

Algorithm 3 topLeftCorner()

Require: $CR, tol, M[m_{ij}]$
  if $CR \geq tol$ **then**
    for $sz \leftarrow 3, n$ **do**
      for $j \leftarrow 0, n-1$ **do**
        for $k \leftarrow j+1, n$ **do**
          $g \leftarrow 0$
          $s \leftarrow 0$
          if $m_{\{sz\}j} * m_{jk} > m_{\{sz\}k}$ **then**
            $g \leftarrow j$
            $s \leftarrow k$
          else if $m_{\{sz\}j} * m_{jk} < m_{\{sz\}k}$ **then**
            $g \leftarrow k$
            $s \leftarrow j$
          end if
          if $g > 0$ or $s > 0$ **then**
            reduce($CR, tol, sz, g, s, M[m_{ij}]$)
            if $CR \leq tol$ **then**
              break
            else if $m_{\{sz\}g} > m_{\{sz\}s}$ **then**
              increase(sz,g,s)
              if $CR \leq tol$ **then**
                break
              end if
            end if
          end if
        end for
        if $CR \leq tol$ **then**
          break
        end if
      end for
      if $CR \leq tol$ **then**
        break
      end if
    end for
  end if
  return $CR, tol, M[m_{ij}]$

Algorithm 4 reduce()

Require: $CR, tol, n, g, s, M[m_{ij}]$
  while $m_{ng} * m_{gs} > m_{ns}$ and $m_{ng} \neq 0$ **do**
    $auxCR \leftarrow CR$
    $m_{ng}++$
    $m_{gn}--$
    $CR \leftarrow$ consistencyRate($M[m_{ij}]$)
    if $CR > auxCR$ **then**
      $m_{ng}--$
      $m_{gn}++$
      $CR \leftarrow$ consistencyRate($M[m_{ij}]$)
      break
    else if $CR <= tol$ **then**
      break
    end if
  end while
  return $CR, tol, M[m_{ij}]$

Algorithm 5 increase()

Require: $CR, tol, n, g, s, M[m_{ij}], it(M[m_{ij}])$
  while $m_{ng} * m_{gs} < m_{ns}$ and $it(m_{ng}) \neq n-1$ **do**
    $auxCR \leftarrow CR$
    $m_{ns}++$
    $m_{sn}--$
    $CR \leftarrow$ consistencyRate($M[m_{ij}]$)
    if $CR > auxCR$ **then**
      $m_{ns}--$
      $m_{sn}++$
      $CR \leftarrow$ consistencyRate($M[m_{ij}]$)
      break
    else if $CR <= tol$ **then**
      break
    end if
  end while
  return $CR, tol, M[m_{ij}]$

pair-by-pair comparison is made starting with the elements of the anti-penultimate row ($sz = n-2$), then the elements of the previous rows are evaluated, following the order from bottom to top.

3. ON MULTICRITERIA ABC CLASSIFICATION

As discussed earlier, in our study, we observed that one of the crucial points for correctly applying multicriteria ABC classification is correctly attributing the weights for the initial ABC classification, that is, assign weights to each product according to each criterion.

When we built the input data file, we considered three types of criteria for ABC analysis, cumulative sum (for billing and lead time criteria), qualitative, and binary criteria. While we were testing the solver, we noticed that an incorrect assignment of the weights can generate a strong bias in the multicriteria classification, since the criterion with the top percentage difference will always be dominant.

Therefore, to assign the weights, three procedures were adopted, according to the different nature of each type of criterion used.

In the case of the binary criteria, the choice of a binary parameters (0 and 1) results in a distribution of the percentage among the criteria that are critical. This seems to be consistent with the desired goal. However, in the case of the other criteria types, the consistency is no longer so clear.

We can verify this inconsistency through a brief analysis of the two criteria classified according to the cumulative sum. For the data collected from the furniture trades company, the product with the highest billing (242,280.00 reais) has a billing corresponding to 12% of the total amount; and a product with a longer lead time (30 days) represents 0.46% of the total lead time, that is, a percentage 0.25% higher than products with a lead time of 20 days (0.31%) and 0.35% higher than products with a lead time of 7 days (0.11%).

The question is: is the difference between the importance of a product with a 30-day lead time and a product with a 7-day lead time only 0.35%? This value can only be appreciated when compared with the difference in importance of 12% between the product with the highest and the product with the lowest billing.

Make a multicriteria classification for the billing and lead time criteria based only on the accumulated sum is like calculate a weighted average of the annual sales of vehicles and bananas, hoping that this average will have some meaning. For there to be real meaning in the weighted average found by the multicriteria method, it is necessary to apply some procedure to balance the weights assigned to each criterion.

Odu (2019) cites CRITIC as one of the methods applied for weight assignment in multicriteria classification. This method starts with normalizing the weights using the following equations:

$$\rho_{ij} = \frac{w_{ij} - w_j^{\min}}{w_j^{\max} - w_j^{\min}} \qquad i = 1, ..., m; j = 1, ..., n \qquad \text{for benefit criteria} \tag{1}$$

$$\rho_{ij} = \frac{w_j^{\max} - w_{ij}}{w_j^{\max} - w_j^{\min}} \qquad i = 1, ..., m; j = 1, ..., n \qquad \text{for cost criteria} \tag{2}$$

Where $w_j^{\min}$ and $w_j^{\max}$ are, respectively, the lowest and highest weights assigned to criterion j, w_{ij} is the weight and ρ_{ij} is the normalized weight of criteria j for product i.

The problem with this normalization method is that the largest values of the different criteria will have exactly the same weight. In the case of the companies studied, this may not correspond to the assessment of experts.

Algorithm 6 bottomLeftCorner()

Require: $CR, tol, M[m_{ij}]$
  if $CR \geq tol$ **then**
    for $sz \leftarrow n-2, 1$ **do**
      for $j \leftarrow 0, n-3$ **do**
        for $k \leftarrow j+1, n-2$ **do**
          $g \leftarrow 0$
          $s \leftarrow 0$
          if $m_{\{sz-1\}j} * m_{jk} > m_{\{sz-1\}k}$ **then**
            $g \leftarrow j$
            $s \leftarrow k$
          else if $m_{\{sz-1\}j} * m_{jk} < m_{\{sz-1\}k}$ **then**
            $g \leftarrow k$
            $s \leftarrow j$
          end if
          if $g > 0$ or $s > 0$ **then**
            reduce(sz-1,g,s)
            if $CR <= tol$ **then**
              break
            else if $m_{\{sz-1\}g} > m_{\{sz-1\}s}$ **then** encrease(sz-1,g,s)
              if $CR <= tol$ **then**
                break
              end if
            end if
          end if
        end for
        if $CR <= tol$ **then**
          break
        end if
      end for
      if $CR <= tol$ **then**
        break
      end if
    end for
  end if
  return $CR, tol, M[m_{ij}]$

The solution that we adopted in this work for multicriteria classification with lead time and billing criteria, was inspired on the work of Williams (1984). A single measure was adopted for these two criteria (lead time billing weight) dividing the billing by the complement of the lead time for each product and then normalizing the weights.

In the case of qualitative criteria, the initial ABC classification was made using three weights, one weight assigned to group A products, $w(A)$, a second weight assigned to group B products, $w(B)$, and a third weight assigned to products C, $w(C)$, where $w(A) > w(B) > w(C)$. For qualitative criteria, $w(A)$, $w(B)$ and $w(C)$ must be assigned using the following steps:

- order the products, in descending order, according to their respective values for lead time billing;
- classify products into three groups, A, B and C, for each qualitative criterion;
- do $w(C)$ = 0 for all group C products, for each qualitative criterion;
- for each qualitative criterion, do peer-to-peer comparison with the groups A and B products and the products ordered according to the lead time billing criterion, answering the following question: the degree of importance of the products of this group to the qualitative criterion is equivalent to what degree of importance of the other product evaluated according to the lead time billing criterion ?;
- assign to $w(A)$ and $w(B)$ the value of the lead time billing of the product with corresponding importance;

After the correct assignment of the weights for each product according to each criterion, Eqs. (3) and (4) can be used for calculation of multicriteria classification weights of each product, ρ_p:

$$LtBW(p) = \frac{\frac{b_p}{1+(lt^{\max}-lt_p)}}{\sum_{p=1}^{\text{NP}} \{\frac{b_p}{1+(lt^{\max}-lt_p)}\}}, \quad p = 1, ..., \text{NP} \tag{3}$$

$$\rho_p = (wb + wlt) * LtBW(p) + \sum_{q=1}^{\text{NQ}} w_{\sigma_q} * LtBW(e_{p\sigma_q}) + \sum_{b=1}^{\text{NB}} w_{\beta_b} * w_{p\beta_b}, \quad p = 1, ..., \text{NP} \tag{4}$$

where:
NP is the number of products;
NQ is the number of qualitative criteria;
NB is the number of binary criteria;
Σ is the set of qualitative criteria, $\Sigma = \{\sigma_q\}_{q=1}^{NQ}$;
B is the set of binary criteria, B $= \{\beta_b\}_{b=1}^{NB}$;
p is the index used to represent each product, $p = 1, ..., \text{NP}$;
c is the index used to represent each criterion of qualitative or binary type , $c \in \Sigma \cup \text{B}$;
$LtBW(p)$ is the lead time billing weight of product p;
b_p is the billing of product p;
lt_p is the of product p;
wb is the multicriteria weight of criterion billing.
wlt is the multicriteria weight of criterion lead time.
w_c is the multicriteria weight of criterion c.
w_{pc} is the normalized weight percentage of the product p according to criterion c;

4. COPSOLVER

COPSolver is a software originally developed by Fraga (2024) to solve several decision and optimization problems, especially in the area of combinatorial optimization. The software works with a modular system of libraries, in which each library is developed to solve a single type of specific problem, which makes the software very efficient and robust. The structure of the software allows high flexibility in the reuse of already developed codes, as is characteristic of the C++ language. The main difference is that in the case of COPSolver, objects are defined as problems, hence the term problem-oriented programming. Currently, the configuration file, config.txt, should be used to define the type of problem and the solution methodology addressed, as well as the values of the parameters that must be informed by the user. COPSolver software libraries usually use two input files which are config.txt and data.txt. For the software to work properly both files must be built following the predefined formats for each specific library.

To apply the methodology proposed in this article, the module 'COPSolver: library for solving the multicriteria classification problem' is being developed. In the case of this library, the configuration file must be prepared according to the template available at https://tbfraga.github.io/COPSolver/benchmarks/clssp/config.txt. A model for preparing the data.txt file for this same library is available at https://tbfraga.github.io/COPSolver/benchmarks/clssp/alexia/original-data/data.txt.

5. RESULTS AND DISCUSSIONS

5.1 Data Collected

To test the methodology proposed in this article, data were collected for constriction of the pairwise comparison matrix and for ABC classification, using the billing (bl) criterion and other criteria suggested by Flores and Whybark (1986): lead-time (lt); criticality (cr); obsolescence (ob); commonality (cm); substitutability (sb); and repairability (rp). To collect the data, we partnered with three companies from three different sectors: car mechanics; furniture trades; and plastic packaging manufacturing. Based on the data collected, three benchmarks were developed. The date.txt files corresponding to these three benchmarks are available at https://tbfraga.github.io/COPSolver/ benchmarks/. Appendice A presents the data.txt file elaborated with the data provided by the furniture trades company.

5.2 Analysis on the Algorithm for Adjusting Inconsistencies

Table 1 presents the modifications made by the software 'COPSolver: library for solving the multicriteria classification problem' in the pairwise comparisons matrix and the consequent changes in the consistency rate (CR) for the data collected from the three companies selected for this study.

This table clearly shows the inconsistencies before the modification and how the weight modifications made by the algorithm reflect the adjustments of these inconsistencies. For example, in the case of the plastic bag manufacturing company, the billing criterion has moderate importance over criticality criterion and very strong importance over lead time criterion. Also, the criticality criterion has moderate importance over lead time criterion. These statements are coherent. However, the vector of the weights of this matrix clearly shows that the criticality criterion is less relevant than the lead time criterion, which is inconsistent with the two first statements. The assignment of the other weights related to criteria criticality and lead time causes this inconsistency. We can see from the input data matrix that the obsolescence, replaceability, and repairability criteria are more important than the criticality criterion but less valuable than the lead-time criterion. According to the initial statement (that criticality is more relevant than lead time), this new statement generates the inconsistency of the pairwise comparisons matrix. As we can see in the adjusted matrix, the algorithm quickly corrects these inconsistencies and then the weight vector.

Table 1 also shows that the pairwise comparison weights are adjusted by the solver primarily according to the weights assigned to the first three criteria. Thus, although there is a change in the pairwise comparison weights, which may be significant, the weights assigned to the first three criteria are preserved. The algorithm will change the weights of the other criteria to force the consistency of the pairwise comparisons matrix. Another significant observation is that the algorithm stops when it reaches the desired consistency rate. So, it is more likely that the algorithm changes the weights related to the fourth criterion and the next ones. Therefore, in the preparation of the input file the data of the criteria must be informed in such a way that the criteria are ordered in descending order according to their respective relevance.

For the data presented in Tab. 1, there was no concern with the correct ordering of the criteria. Based on the results and previous observations, we have reordered the criteria using their respective weights, initially defined by the normalized eigenvector of the original pairwise comparisons matrix, w. Table 2 presents the modification of results after altering the criteria ordination on the input data.

Table 3 presents a comparison of the results using different methods on the data provided by the furniture trading company. In matrix PCM 02, the method used to force consistency was applied before the reordering of the criteria. In the case of matrix PCM 03, the same method was applied after reordering the criteria. This table also shows the matrix PCM 04 with adjustments made manually to the matrix PCM 01 after verifying the results found by COPSolver. As we can see, the COPSolver software provides an important help in the preparation of consistent pairwise comparison matrices. We also found that it is important to perform the ordering of the criteria before adjusting the matrix seeking better consistency, since the weights assigned to the most relevant criteria should preferably be maintained. It is possible to verify in these tables that the reordering before the application of the method to force consistency to be carried out in the weights relative to the least important criteria. Finally, we observe that the ordering of the criteria also helps in the manual adjustment of the pairwise comparison matrices, since the presentation of these tables with the ordered criteria facilitates the analysis of the weights. This is because, when ordered according to the relevance of the criteria, the elements of the pairwise comparison matrix have a trend of increasing order from left to right and decreasing order from top to bottom. For multicriteria classification of items, the pairwise comparison matrix PCM 03 was used. However, in practical cases it is important to have a final assessment of the responsible employee and the matrix used for ABC classification can be a final matrix manually updated by the employee based on the results found by COPSolver.

5.3 Analysis On The New ABC Multicriteria Classification Method

For analysis of the proposed new methodology for ABC muticriteria classification, we will be focusing on the presentation and analysis of the data provided by the furniture trades company.

Figure 1 presents part of a comparison of the results obtained for the data described above, by ABC classification for the criteria billing and the new ABC multicriteria with Analytic Hierarch Process. Appendice A shows the file AHP_Solution.txt, that presents the complete results found by the module 'COPSolver: library for solving the multicriteria classification problem'.

Table 1: **Pairwise comparisons matrix and consistency rate changes for three companies (results found by COPSolver) - legend: sb = substitutability; lt = lead-time; rp = repairability; cr = criticality; ob = obsolescence; bl = billing; cm = commonality; CR = consistence rate; w = normalized weights vector.**

original data

car mechanics company

CR = 0.216
$w = (0.35, 0.26, 0.18, 0.11, 0.05, 0.03, 0.01)$

	sb	lt	rp	cr	ob	bl	cm
sb	1.00	3.00	3.00	5.00	7.00	9.00	9.00
lt	0.33	1.00	3.00	5.00	7.00	9.00	9.00
rp	0.33	0.33	1.00	3.00	9.00	9.00	9.00
cr	0.20	0.20	0.33	1.00	5.00	9.00	9.00
ob	0.14	0.14	0.11	0.20	1.00	5.00	9.00
np	0.11	0.11	0.11	0.11	0.20	1.00	9.00
cm	0.11	0.11	0.11	0.11	0.11	0.11	1.00

furniture trades company

CR = 0.136
$w = (0.07, 0.13, 0.26, 0.03, 0.48, 0.03)$

	lt	rp	cr	cm	bl	ob
lt	1.00	0.20	0.14	7.00	0.11	5.00
rp	5.00	1.00	0.33	5.00	0.14	3.00
cr	7.00	3.00	1.00	9.00	0.33	9.00
cm	0.14	0.20	0.11	1.00	0.11	1.00
bl	9.00	7.00	3.00	9.00	1.00	9.00
ob	0.20	0.33	0.11	1.00	0.11	1.00

plastic packaging manufacturing company

CR = 0.625
$w = (0.39, 0.10, 0.22, 0.09, 0.12, 0.07)$

	bl	cr	lt	ob	sb	rp
bl	1.00	3.00	7.00	7.00	5.00	5.00
cr	0.33	1.00	3.00	0.20	0.20	0.20
lt	0.14	0.33	1.00	5.00	7.00	7.00
ob	0.14	5.00	0.20	1.00	0.33	3.00
sb	0.20	5.00	0.14	3.00	1.00	3.00
rp	0.20	5.00	0.14	0.33	0.33	1.00

adjusted

car mechanics company

CR = 0.085
$w = (0.37, 0.26, 0.12, 0.12, 0.06, 0.05, 0.02)$

	sb	lt	rp	cr	ob	co	cm
sb	1.00	3.00	3.00	3.00	7.00	9.00	9.00
lt	0.33	1.00	3.00	3.00	5.00	9.00	9.00
rp	0.33	0.33	1.00	1.00	3.00	3.00	9.00
cr	0.33	0.33	1.00	1.00	3.00	3.00	9.00
ob	0.14	0.20	0.33	0.33	1.00	1.00	9.00
np	0.11	0.11	0.33	0.33	1.00	1.00	9.00
cm	0.11	0.11	0.11	0.11	0.11	0.11	1.00

furniture trades company

CR = 0.096
$w = (0.09, 0.16, 0.35, 0.03, 0.35, 0.03)$

	lt	rp	cr	cm	bl	ob
lt	1.00	0.20	0.14	7.00	0.14	5.00
rp	5.00	1.00	0.33	5.00	0.33	3.00
cr	7.00	3.00	1.00	9.00	1.00	9.00
cm	0.14	0.20	0.11	1.00	0.11	1.00
bl	7.00	3.00	1.00	9.00	1.00	9.00
ob	0.20	0.33	0.11	1.00	0.11	1.00

plastic packaging manufacturing company

CR = 0.085
$w = (0.50, 0.18, 0.14, 0.06, 0.09, 0.03)$

	bl	cr	lt	ob	sb	rp
bl	1.00	3.00	7.00	9.00	5.00	9.00
cr	0.33	1.00	3.00	3.00	1.00	5.00
lt	0.14	0.33	1.00	3.00	3.00	7.00
ob	0.11	0.33	0.33	1.00	1.00	3.00
sb	0.20	1.00	0.33	1.00	1.00	3.00
rp	0.11	0.20	0.14	0.33	0.33	1.00

Based on the results found by COPSolver, we can verify that the ABC classification, considering only the billing criterion, does not follow the normal pattern defined by the Pareto's rule. However, when we use the new ABC multicriteria classification, it is possible to verify that the values are close to what is expected. It is also possible to verify in a very clear way that the approach used to measure the weights of the products produces much more relevant results than the simple random assignment of weights. This approach reduces the viez effect caused by the imbalance of weights and makes the final result carry important qualitative information provided by the responsible official, assigning the appropriate relevance of the different products, as well as the criteria analyzed.

Based on an evaluation of the final results by the participating company, it was possible to verify that these results were very coherent, offering the company very relevant information for the identification of products whose inventory must be maintained, receiving greater attention from the company, as well as for the adoption of more appropriate procedures for the correct control of the different items marketed by the company.

6. CONCLUSIONS AND FURTHER WORKS

In this article we present a new methodology for multicriteria ABC classification with Analytical Hierarchy Process which includes a procedure to force the consitences of the pairwise comparisons matrices, as well as a procedure for assigning weights to the products evaluated according to qualitative criteria and a new equation for calculating the weights of the products in the multicriteria classification. This methodology was tested using data provided by three companies, from three different sectors. As a result, we verified the importance and efficiency of the method developed to force the

Table 2: **Pairwise comparisons matrix and consistency rate changes for three companies (results found by COPSolver) - legend: sb = substitutability; lt = lead-time; rp = repairability; cr = criticality; ob = obsolescence; bl = billing; cm = commonality; CR = consistence rate; w = normalized weights vector.**

car mechanics company

original data reordered — CR = 0.216, $w = (0.35, 0.26, 0.18, 0.11, 0.05, 0.03, 0.01)$

	sb	lt	rp	cr	ob	bl	cm
sb	1.00	3.00	3.00	5.00	7.00	9.00	9.00
lt	0.33	1.00	3.00	5.00	7.00	9.00	9.00
rp	0.33	0.33	1.00	3.00	9.00	9.00	9.00
cr	0.20	0.20	0.33	1.00	5.00	9.00	9.00
ob	0.14	0.14	0.11	0.20	1.00	5.00	9.00
np	0.11	0.11	0.11	0.11	0.20	1.00	9.00
cm	0.11	0.11	0.11	0.11	0.11	0.11	1.00

adjusted — CR = 0.085, $w = (0.37, 0.26, 0.12, 0.12, 0.06, 0.05, 0.02)$

	sb	lt	rp	cr	ob	co	cm
sb	1.00	3.00	3.00	3.00	7.00	9.00	9.00
lt	0.33	1.00	3.00	3.00	5.00	9.00	9.00
rp	0.33	0.33	1.00	1.00	3.00	3.00	9.00
cr	0.33	0.33	1.00	1.00	3.00	3.00	9.00
ob	0.14	0.20	0.33	0.33	1.00	1.00	9.00
np	0.11	0.11	0.33	0.33	1.00	1.00	9.00
cm	0.11	0.11	0.11	0.11	0.11	0.11	1.00

furniture trades company

original data reordered — CR = 0.136, $w = (0.48, 0.26, 0.13, 0.07, 0.03, 0.03)$

	bl	cr	rp	lt	ob	cm
bl	1.00	3.00	7.00	9.00	9.00	9.00
cr	0.33	1.00	3.00	7.00	9.00	9.00
rp	0.14	0.33	1.00	5.00	3.00	5.00
lt	0.11	0.14	0.20	1.00	5.00	7.00
ob	0.11	0.11	0.33	0.20	1.00	1.00
sb	0.11	0.11	0.20	0.14	1.00	1.00

adjusted — CR = 0.082, $w = (0.49, 0.27, 0.11, 0.06, 0.05, 0.03)$

	bl	cr	rp	lt	ob	cm
bl	1.00	3.00	7.00	9.00	9.00	9.00
cr	0.33	1.00	3.00	7.00	9.00	9.00
rp	0.14	0.33	1.00	3.00	3.00	5.00
lt	0.11	0.14	0.33	1.00	1.00	7.00
ob	0.11	0.11	0.33	1.00	1.00	3.00
sb	0.11	0.11	0.20	0.14	0.33	1.00

plastic packaging manufacturing company

original data reordered — CR = 0.625, $w = (0.40, 0.22, 0.12, 0.07, 0.10, 0.10)$

	bl	lt	sb	rp	ob	cr
bl	1.00	7.00	5.00	5.00	7.00	3.00
lt	0.14	1.00	7.00	7.00	5.00	0.33
sb	0.20	0.14	1.00	3.00	3.00	5.00
rp	0.20	0.14	0.33	1.00	0.33	5.00
ob	0.14	0.20	0.33	3.00	1.00	5.00
cr	0.33	3.00	0.20	0.20	0.20	1.00

adjusted — CR = 0.094, $w = (0.56, 0.21, 0.08, 0.07, 0.07, 0.02)$

	bl	lt	sb	rp	ob	cr
bl	1.00	7.00	5.00	9.00	7.00	9.00
lt	0.14	1.00	3.00	5.00	5.00	9.00
sb	0.20	0.33	1.00	1.00	1.00	5.00
rp	0.11	0.20	1.00	1.00	1.00	5.00
ob	0.14	0.20	1.00	1.00	1.00	5.00
cr	0.11	0.11	0.20	0.20	0.20	1.00

matrices consistency. We also verified that the new methodology proposed for multicriteria ABC classification generated very coherent results, giving the appropriate importance to the products, according to all the evaluated criteria.

As further works, the methodologies developed and results found will be used as a basis for building a portfolio with the identification of product demand patterns and, subsequently, for the development of a combined methodology for demand forecasting of small companies.

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Table 3: **Pairwise comparisons matrix and consistency rate changes for three companies (results found by COPSolver) - legend: sb = substitutability; lt = lead-time; rp = repairability; cr = criticality; ob = obsolescence; bl = billing; cm = commonality; CR = consistence rate; w = normalized weights vector.**

furniture trades company

PCM 01 - original data reordered

CR = 0.136

$w = (0.48, 0.26, 0.13, 0.07, 0.03, 0.03)$

	bl	cr	rp	lt	ob	cm
bl	1.00	3.00	7.00	9.00	9.00	9.00
cr	0.33	1.00	3.00	7.00	9.00	9.00
rp	0.14	0.33	1.00	5.00	3.00	5.00
lt	0.11	0.14	0.20	1.00	5.00	7.00
ob	0.11	0.11	0.33	0.20	1.00	1.00
sb	0.11	0.11	0.20	0.14	1.00	1.00

PCM 02 - PCM 01 adjusted and than reordered

CR = 0.096

$w = (0.35, 0.35, 0.16, 0.09, 0.03, 0.03)$

	bl	cr	rp	lt	ob	cm
bl	1.00	1.00	3.00	7.00	9.00	9.00
cr	1.00	1.00	3.00	7.00	9.00	9.00
rp	0.33	0.33	1.00	5.00	3.00	5.00
lt	0.14	0.14	0.20	1.00	5.00	7.00
ob	0.11	0.11	0.33	0.20	1.00	1.00
sb	0.11	0.11	0.20	0.14	1.00	1.00

PCM 03 - PCM 01 reordered and than adjusted

CR = 0.082

$w = (0.49, 0.27, 0.11, 0.06, 0.05, 0.03)$

	bl	cr	rp	lt	ob	cm
bl	1.00	3.00	7.00	9.00	9.00	9.00
cr	0.33	1.00	3.00	7.00	9.00	9.00
rp	0.14	0.33	1.00	3.00	3.00	5.00
lt	0.11	0.14	0.33	1.00	1.00	7.00
ob	0.11	0.11	0.33	1.00	1.00	3.00
sb	0.11	0.11	0.20	0.14	0.33	1.00

PCM 01 - manually adjusted based on COPSolver results

CR = 0.082

$w = (0.50, 0.25, 0.12, 0.08, 0.03, 0.03)$

	bl	cr	rp	lt	ob	cm
bl	1.00	3.00	7.00	9.00	9.00	9.00
cr	0.33	1.00	3.00	5.00	9.00	9.00
rp	0.14	0.33	1.00	3.00	5.00	5.00
lt	0.11	0.20	0.33	1.00	5.00	5.00
ob	0.11	0.11	0.20	0.20	1.00	1.00
sb	0.11	0.11	0.20	0.20	1.00	1.00

8. CRediT AUTHORSHIP CONTRIBUTION STATEMENT

T.B. Fraga: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Data Curation, Writing – original draft, Writing – review & editing, Supervision, Project administration. B.M. Cavalcanti: Investigation. A.M.D.Silva: Investigation. E.L.R. Silva: Investigation.

9. COPYRIGHT LIABILITY

The authors are uniquely responsible for the content of this work.

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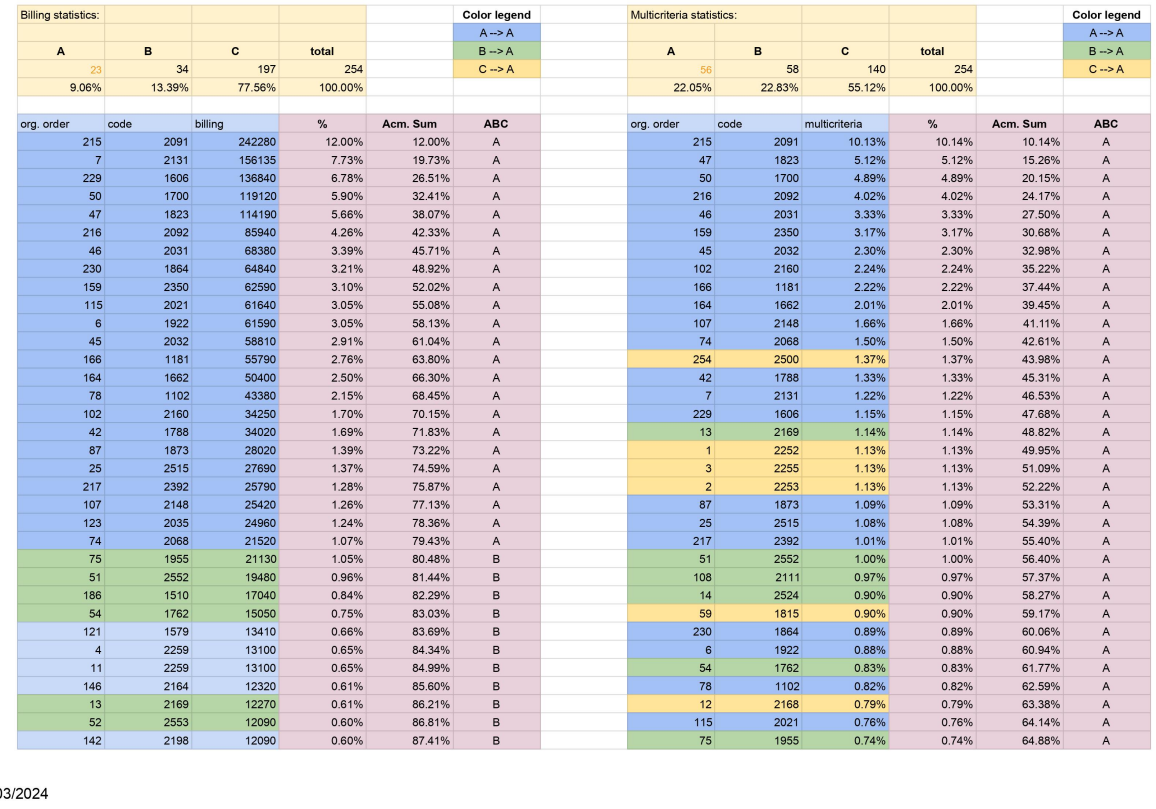

Billing statistics:					Color legend
					A --> A
A	B	C	total		B --> A
23	34	197	254		C --> A
9.06%	13.39%	77.56%	100.00%		

org. order	code	billing	%	Acm. Sum	ABC
215	2091	242280	12.00%	12.00%	A
7	2131	156135	7.73%	19.73%	A
229	1606	136840	6.78%	26.51%	A
50	1700	119120	5.90%	32.41%	A
47	1823	114190	5.66%	38.07%	A
216	2092	85940	4.26%	42.33%	A
46	2031	68380	3.39%	45.71%	A
230	1864	64840	3.21%	48.92%	A
159	2350	62590	3.10%	52.02%	A
115	2021	61640	3.05%	55.08%	A
6	1922	61590	3.05%	58.13%	A
45	2032	58810	2.91%	61.04%	A
166	1181	55790	2.76%	63.80%	A
164	1662	50400	2.50%	66.30%	A
78	1102	43380	2.15%	68.45%	A
102	2160	34250	1.70%	70.15%	A
42	1788	34020	1.69%	71.83%	A
87	1873	28020	1.39%	73.22%	A
25	2515	27690	1.37%	74.59%	A
217	2392	25790	1.28%	75.87%	A
107	2148	25420	1.26%	77.13%	A
123	2035	24960	1.24%	78.36%	A
74	2068	21520	1.07%	79.43%	A
75	1955	21130	1.05%	80.48%	B
51	2552	19480	0.96%	81.44%	B
186	1510	17040	0.84%	82.29%	B
54	1762	15050	0.75%	83.03%	B
121	1579	13410	0.66%	83.69%	B
4	2259	13100	0.65%	84.34%	B
11	2259	13100	0.65%	84.99%	B
146	2164	12320	0.61%	85.60%	B
13	2169	12270	0.61%	86.21%	B
52	2553	12090	0.60%	86.81%	B
142	2198	12090	0.60%	87.41%	B

Multicriteria statistics:					Color legend
					A --> A
A	B	C	total		B --> A
56	58	140	254		C --> A
22.05%	22.83%	55.12%	100.00%		

org. order	code	multicriteria	%	Acm. Sum	ABC
215	2091	10.13%	10.14%	10.14%	A
47	1823	5.12%	5.12%	15.26%	A
50	1700	4.89%	4.89%	20.15%	A
216	2092	4.02%	4.02%	24.17%	A
46	2031	3.33%	3.33%	27.50%	A
159	2350	3.17%	3.17%	30.68%	A
45	2032	2.30%	2.30%	32.98%	A
102	2160	2.24%	2.24%	35.22%	A
166	1181	2.22%	2.22%	37.44%	A
164	1662	2.01%	2.01%	39.45%	A
107	2148	1.66%	1.66%	41.11%	A
74	2068	1.50%	1.50%	42.61%	A
254	2500	1.37%	1.37%	43.98%	A
42	1788	1.33%	1.33%	45.31%	A
7	2131	1.22%	1.22%	46.53%	A
229	1606	1.15%	1.15%	47.68%	A
13	2169	1.14%	1.14%	48.82%	A
1	2252	1.13%	1.13%	49.95%	A
3	2255	1.13%	1.13%	51.09%	A
2	2253	1.13%	1.13%	52.22%	A
87	1873	1.09%	1.09%	53.31%	A
25	2515	1.08%	1.08%	54.39%	A
217	2392	1.01%	1.01%	55.40%	A
51	2552	1.00%	1.00%	56.40%	A
108	2111	0.97%	0.97%	57.37%	A
14	2524	0.90%	0.90%	58.27%	A
59	1815	0.90%	0.90%	59.17%	A
230	1864	0.89%	0.89%	60.06%	A
6	1922	0.88%	0.88%	60.94%	A
54	1762	0.83%	0.83%	61.77%	A
78	1102	0.82%	0.82%	62.59%	A
12	2168	0.79%	0.79%	63.38%	A
115	2021	0.76%	0.76%	64.14%	A
75	1955	0.74%	0.74%	64.88%	A

Figure 1: Comparison between the ABC classification for the billing criterion and the ABC multicriteria classification

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Appendices

A data.txt

```
// benchmark - multicriteria classification problem - alexia's data file

// number of criteria, UNSIGNED INT (NC):

6

// weight, DOUBLE (W_1,...,W_NC) / criterion MATRIX (NC x 5) (name STRING, mode STRING, valueA UNSIGNED INT, valueB UNSIGNED INT, valueC UNSIGNED

0       lead-times  acmSum        0.80      0.95  1.00
0    repairability   value    68380.00  21520.00  0.00
0      criticality   value   242000.00  61640.00  0.00
0      commonality   value     5300.00   1200.00  0.00
0          billing  acmSum        0.80      0.95  1.00
0     obsolescence  binary        1.00      0.00  0.00

// billing index:

4

// lead time index:

0

// lead time variance:

0

// ABC multicriteria criterion (name STRING, mode STRING, valueA UNSIGNED INT, valueB UNSIGNED INT, valueC UNSIGNED INT):

multicriteria acmSum  0.80  0.95  1.00

// pairwise comparison weight FLOAT (M_1_1,...,M_i_j,...,M_NC_NC):

0.2000 0.1428 7.0000 0.1111  5.0000
        0.3333 5.0000 0.1428  3.0000
                9.0000 0.3333  9.0000
                        0.1111  1.0000
                                9.0000

// number of data per criterion, UNSIGNED INT (ND):

254

// code (C_1,...,C_i,...,C_ND) + data, DOUBLE (D_1_1,...,D_i_j,...,D_ND_NC):

2252   7.00      0.00        0.00      0.00      720.00   1.00
2253   7.00      0.00        0.00      0.00        0.00   1.00
2255   7.00      0.00        0.00      0.00      600.00   1.00
2259   7.00      0.00        0.00   5300.00    13100.00   0.00
2132  20.00      0.00   242000.00      0.00     1100.00   0.00
1922  20.00      0.00   242000.00      0.00    61590.00   0.00
2131  20.00      0.00   242000.00      0.00   156135.00   0.00
1790  20.00      0.00   242000.00      0.00     1620.00   0.00
1810  30.00      0.00        0.00      0.00     8100.00   0.00
1806  30.00      0.00        0.00      0.00        0.00   0.00
2259   7.00      0.00        0.00   5300.00    13100.00   0.00
2168  30.00      0.00   242000.00      0.00     3195.00   0.00
2169  30.00      0.00   242000.00      0.00    12270.00   0.00
2524  30.00      0.00   242000.00      0.00     6160.00   0.00
2172  30.00      0.00   242000.00      0.00        0.00   0.00
2171  30.00      0.00   242000.00      0.00        0.00   0.00
1809  30.00      0.00        0.00      0.00      720.00   0.00
1813  30.00      0.00        0.00      0.00      840.00   0.00
2122  30.00      0.00        0.00   5300.00     1200.00   0.00
2120  30.00      0.00        0.00   5300.00      650.00   0.00
2340  30.00      0.00        0.00      0.00        0.00   0.00
1822  30.00      0.00        0.00      0.00        0.00   0.00
1956   7.00      0.00        0.00      0.00     2600.00   0.00
1957   7.00      0.00        0.00      0.00      550.00   0.00
2515  30.00      0.00        0.00      0.00    27690.00   0.00
2516  30.00      0.00        0.00      0.00        0.00   0.00
2463  30.00      0.00        0.00      0.00     1350.00   0.00
2175  30.00      0.00        0.00   5300.00     1850.00   0.00
2432  30.00      0.00        0.00      0.00     2550.00   0.00
2090  30.00      0.00        0.00      0.00     6700.00   0.00
2076  30.00      0.00        0.00      0.00     4100.00   0.00
2478  30.00      0.00        0.00      0.00        0.00   0.00
2444  30.00      0.00        0.00      0.00      500.00   0.00
2454  30.00      0.00        0.00      0.00     7400.00   0.00
2479  30.00      0.00        0.00      0.00        0.00   0.00
1771   7.00      0.00        0.00      0.00     8190.00   0.00
1833   7.00      0.00        0.00      0.00     2450.00   0.00
1017  30.00      0.00        0.00   5300.00     4100.00   0.00
2174  30.00      0.00        0.00      0.00        0.00   0.00
1789  30.00      0.00        0.00      0.00     1320.00   0.00
2077  30.00      0.00        0.00      0.00        0.00   0.00
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1788	30.00	0.00	0.00	0.00	34020.00	0.00
2455	30.00	0.00	0.00	0.00	780.00	0.00
2456	30.00	0.00	0.00	0.00	780.00	0.00
2032	30.00	0.00	0.00	0.00	58810.00	0.00
2031	30.00	0.00	242000.00	0.00	68380.00	0.00
1823	30.00	0.00	242000.00	0.00	114190.00	0.00
2329	7.00	21520.00	0.00	5300.00	750.00	0.00
1059	30.00	68380.00	0.00	5300.00	0.00	0.00
1700	30.00	68380.00	0.00	5300.00	119120.00	0.00
2552	30.00	68380.00	0.00	5300.00	19480.00	0.00
2553	30.00	68380.00	0.00	5300.00	12090.00	0.00
2491	30.00	68380.00	0.00	5300.00	0.00	0.00
1762	30.00	68380.00	0.00	5300.00	15050.00	0.00
1769	30.00	68380.00	0.00	5300.00	1440.00	0.00
1061	30.00	68380.00	61640.00	5300.00	5180.00	0.00
1292	30.00	68380.00	0.00	5300.00	5220.00	0.00
1069	30.00	68380.00	0.00	5300.00	270.00	0.00
1815	20.00	68380.00	242000.00	5300.00	0.00	0.00
2535	30.00	68380.00	0.00	5300.00	0.00	0.00
2536	30.00	68380.00	0.00	5300.00	0.00	0.00
2343	30.00	68380.00	0.00	5300.00	0.00	0.00
1770	20.00	68380.00	0.00	5300.00	1690.00	0.00
1969	20.00	68380.00	0.00	5300.00	0.00	0.00
1935	20.00	68380.00	0.00	5300.00	850.00	0.00
1934	20.00	68380.00	0.00	5300.00	0.00	0.00
2129	30.00	68380.00	0.00	5300.00	0.00	0.00
1844	20.00	68380.00	0.00	5300.00	0.00	0.00
2380	20.00	68380.00	0.00	5300.00	0.00	0.00
2435	30.00	68380.00	0.00	5300.00	0.00	0.00
2033	30.00	68380.00	0.00	5300.00	0.00	0.00
2366	30.00	68380.00	0.00	5300.00	0.00	0.00
2534	30.00	68380.00	0.00	5300.00	0.00	0.00
2068	30.00	0.00	242000.00	0.00	21520.00	0.00
1955	20.00	0.00	242000.00	0.00	21130.00	0.00
2461	30.00	0.00	0.00	0.00	600.00	0.00
2109	30.00	0.00	0.00	0.00	0.00	0.00
1102	20.00	0.00	242000.00	0.00	43380.00	0.00
2157	30.00	0.00	0.00	0.00	0.00	0.00
1824	30.00	0.00	0.00	0.00	0.00	0.00
1617	30.00	0.00	0.00	0.00	0.00	0.00
1825	30.00	0.00	0.00	0.00	0.00	0.00
2017	30.00	0.00	0.00	0.00	0.00	0.00
1058	30.00	0.00	0.00	0.00	150.00	0.00
2095	30.00	0.00	242000.00	0.00	0.00	0.00
2096	30.00	0.00	242000.00	0.00	0.00	0.00
1873	30.00	0.00	0.00	0.00	28020.00	0.00
1872	30.00	0.00	0.00	0.00	0.00	0.00
2370	30.00	0.00	0.00	0.00	0.00	0.00
1518	20.00	0.00	0.00	0.00	0.00	0.00
2472	30.00	0.00	0.00	0.00	0.00	0.00
2471	30.00	0.00	0.00	0.00	400.00	0.00
2473	30.00	0.00	0.00	0.00	700.00	0.00
2189	7.00	0.00	0.00	0.00	1100.00	0.00
2190	7.00	0.00	0.00	0.00	900.00	0.00
2191	7.00	0.00	0.00	0.00	1100.00	0.00
2544	30.00	0.00	0.00	5300.00	0.00	0.00
1373	30.00	0.00	0.00	1200.00	500.00	0.00
1078	30.00	0.00	0.00	1200.00	0.00	0.00
1566	30.00	0.00	0.00	1200.00	660.00	0.00
1378	30.00	0.00	0.00	1200.00	1150.00	0.00
2160	30.00	68380.00	242000.00	5300.00	34250.00	0.00
1816	30.00	0.00	0.00	0.00	1200.00	0.00
2039	30.00	0.00	0.00	0.00	6500.00	0.00
2056	30.00	0.00	0.00	0.00	1040.00	0.00
2139	30.00	0.00	0.00	0.00	1000.00	0.00
2148	30.00	0.00	242000.00	0.00	25420.00	0.00
2111	30.00	0.00	242000.00	0.00	7920.00	0.00
1857	30.00	0.00	242000.00	0.00	0.00	0.00
2182	30.00	0.00	242000.00	0.00	1200.00	0.00
1801	30.00	0.00	0.00	0.00	1200.00	0.00
2152	30.00	0.00	0.00	0.00	3300.00	0.00
1777	30.00	0.00	0.00	0.00	800.00	0.00
1958	7.00	0.00	0.00	0.00	1500.00	0.00
2021	7.00	0.00	242000.00	0.00	61640.00	0.00
2026	7.00	0.00	242000.00	0.00	0.00	0.00
1830	7.00	0.00	242000.00	0.00	0.00	0.00
2020	7.00	0.00	242000.00	0.00	0.00	0.00
2025	7.00	0.00	242000.00	0.00	0.00	0.00
1581	7.00	0.00	242000.00	0.00	2210.00	0.00
1579	7.00	0.00	0.00	0.00	13410.00	0.00
1842	7.00	0.00	242000.00	0.00	0.00	0.00
2035	7.00	0.00	242000.00	0.00	24960.00	0.00
1835	7.00	0.00	242000.00	0.00	0.00	0.00
2010	7.00	0.00	242000.00	0.00	0.00	0.00
2022	7.00	0.00	242000.00	0.00	0.00	0.00
1846	7.00	0.00	242000.00	0.00	0.00	0.00
1834	7.00	0.00	242000.00	0.00	0.00	0.00
1669	30.00	0.00	0.00	0.00	350.00	0.00
1670	30.00	0.00	0.00	0.00	1630.00	0.00
1664	30.00	0.00	0.00	0.00	2610.00	0.00
1665	30.00	0.00	0.00	0.00	2600.00	0.00
2156	30.00	0.00	0.00	1200.00	6355.00	0.00

2531	30.00	0.00	0.00	1200.00	650.00	0.00
2040	30.00	0.00	0.00	1200.00	0.00	0.00
1888	30.00	0.00	0.00	1200.00	200.00	0.00
2005	30.00	0.00	0.00	1200.00	850.00	0.00
1853	30.00	0.00	0.00	0.00	2225.00	0.00
1131	30.00	0.00	0.00	0.00	400.00	0.00
1569	30.00	0.00	0.00	0.00	0.00	0.00
2543	30.00	68380.00	0.00	1200.00	0.00	0.00
2198	7.00	0.00	0.00	0.00	12090.00	0.00
2405	30.00	0.00	0.00	0.00	0.00	0.00
2163	30.00	0.00	0.00	0.00	0.00	0.00
2165	30.00	0.00	0.00	0.00	0.00	0.00
2164	30.00	0.00	0.00	0.00	12320.00	0.00
2364	30.00	0.00	0.00	0.00	7290.00	0.00
2403	30.00	0.00	0.00	0.00	5400.00	0.00
1914	30.00	0.00	0.00	0.00	1320.00	0.00
2003	30.00	0.00	0.00	0.00	0.00	0.00
2395	30.00	0.00	0.00	0.00	4470.00	0.00
2173	30.00	0.00	0.00	0.00	1440.00	0.00
2538	30.00	0.00	0.00	0.00	5640.00	0.00
1519	30.00	0.00	0.00	0.00	1020.00	0.00
2375	30.00	0.00	0.00	0.00	0.00	0.00
2522	30.00	0.00	0.00	0.00	0.00	0.00
2377	30.00	0.00	0.00	0.00	5280.00	0.00
2349	30.00	21520.00	242000.00	0.00	0.00	0.00
2350	30.00	21520.00	242000.00	0.00	62590.00	0.00
1382	30.00	21520.00	0.00	0.00	8080.00	0.00
1291	30.00	21520.00	0.00	0.00	0.00	0.00
2498	30.00	21520.00	0.00	1200.00	0.00	0.00
2145	30.00	21520.00	0.00	1200.00	0.00	0.00
1662	30.00	0.00	0.00	5300.00	50400.00	0.00
1180	30.00	0.00	0.00	5300.00	5300.00	0.00
1181	30.00	0.00	0.00	5300.00	55790.00	0.00
1183	30.00	0.00	0.00	5300.00	0.00	0.00
2485	30.00	0.00	0.00	5300.00	1200.00	0.00
1410	30.00	0.00	0.00	5300.00	1750.00	0.00
2210	7.00	0.00	0.00	5300.00	0.00	0.00
1557	30.00	0.00	0.00	5300.00	0.00	0.00
1385	30.00	0.00	0.00	5300.00	200.00	0.00
1332	30.00	0.00	0.00	5300.00	400.00	0.00
2441	30.00	0.00	0.00	5300.00	0.00	0.00
1847	30.00	0.00	0.00	5300.00	0.00	0.00
1848	30.00	0.00	0.00	5300.00	1500.00	0.00
2520	30.00	0.00	0.00	5300.00	0.00	0.00
2166	30.00	0.00	0.00	5300.00	0.00	0.00
2167	30.00	0.00	0.00	5300.00	1000.00	0.00
1979	30.00	0.00	0.00	5300.00	7110.00	0.00
2042	30.00	0.00	0.00	5300.00	2460.00	0.00
1980	30.00	0.00	0.00	5300.00	3180.00	0.00
1859	30.00	0.00	0.00	0.00	2050.00	0.00
2049	30.00	0.00	0.00	0.00	0.00	0.00
2184	30.00	0.00	0.00	0.00	0.00	0.00
1510	30.00	0.00	0.00	0.00	17040.00	0.00
1663	30.00	0.00	0.00	0.00	0.00	0.00
1447	30.00	0.00	0.00	0.00	0.00	0.00
2512	30.00	0.00	0.00	0.00	0.00	0.00
1446	30.00	0.00	0.00	0.00	3000.00	0.00
1192	30.00	68380.00	0.00	0.00	0.00	0.00
1194	30.00	68380.00	0.00	0.00	0.00	0.00
1348	30.00	68380.00	0.00	0.00	0.00	0.00
2228	7.00	0.00	0.00	0.00	8030.00	0.00
2229	30.00	0.00	0.00	0.00	0.00	0.00
2124	30.00	0.00	0.00	0.00	0.00	0.00
1638	7.00	0.00	0.00	1200.00	1590.00	0.00
1634	7.00	0.00	0.00	5300.00	100.00	0.00
1415	30.00	68380.00	0.00	0.00	0.00	0.00
1394	30.00	68380.00	0.00	0.00	0.00	0.00
2540	30.00	0.00	0.00	5300.00	0.00	0.00
1921	30.00	0.00	0.00	0.00	1620.00	0.00
1367	30.00	0.00	0.00	0.00	0.00	0.00
1480	30.00	0.00	0.00	0.00	1020.00	0.00
2070	30.00	0.00	0.00	0.00	0.00	0.00
2363	30.00	0.00	0.00	0.00	3480.00	0.00
2508	30.00	0.00	0.00	0.00	0.00	0.00
2507	30.00	0.00	0.00	0.00	0.00	0.00
1653	30.00	0.00	0.00	0.00	0.00	0.00
1870	30.00	0.00	0.00	0.00	0.00	0.00
2183	30.00	0.00	0.00	0.00	0.00	0.00
2006	30.00	0.00	0.00	0.00	2300.00	0.00
1506	30.00	0.00	0.00	0.00	11240.00	0.00
2429	30.00	0.00	0.00	0.00	0.00	0.00
2091	30.00	0.00	242000.00	0.00	242280.00	0.00
2092	30.00	0.00	242000.00	0.00	85940.00	0.00
2392	30.00	0.00	0.00	0.00	25790.00	0.00
2391	30.00	0.00	0.00	0.00	7860.00	0.00
2233	7.00	0.00	0.00	0.00	0.00	0.00
2232	7.00	0.00	0.00	0.00	0.00	0.00
2235	30.00	0.00	0.00	0.00	1200.00	0.00
2453	30.00	0.00	0.00	0.00	0.00	0.00
2430	30.00	0.00	0.00	0.00	0.00	0.00
2431	30.00	0.00	0.00	0.00	0.00	0.00
2243	7.00	0.00	0.00	0.00	0.00	0.00

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2246   7.00      0.00        0.00      0.00        0.00   0.00
2348  20.00      0.00        0.00      0.00        0.00   0.00
1574  20.00      0.00        0.00      0.00        0.00   0.00
1606  20.00      0.00   242000.00      0.00   136840.00   0.00
1864  20.00      0.00   242000.00      0.00    64840.00   0.00
2446  30.00      0.00        0.00      0.00        0.00   0.00
2445  30.00      0.00        0.00      0.00        0.00   0.00
2321   7.00  68380.00        0.00   1200.00        0.00   0.00
1252  30.00      0.00        0.00      0.00     1000.00   0.00
1719  30.00  68380.00        0.00      0.00        0.00   0.00
2023   7.00      0.00        0.00   5300.00        0.00   0.00
2339  30.00  68380.00        0.00   5300.00        0.00   0.00
2041  30.00      0.00        0.00      0.00      280.00   0.00
2142  30.00  68380.00        0.00   1200.00      580.00   0.00
1701  30.00  68380.00        0.00      0.00     1740.00   0.00
1893  30.00  68380.00        0.00      0.00     1380.00   0.00
1767  30.00  68380.00        0.00      0.00     1740.00   0.00
1827  30.00  68380.00        0.00      0.00        0.00   0.00
1840  30.00  68380.00        0.00      0.00        0.00   0.00
2495  30.00  68380.00        0.00      0.00        0.00   0.00
2494  30.00  68380.00        0.00      0.00        0.00   0.00
2344  30.00  68380.00        0.00      0.00        0.00   0.00
1993  30.00  68380.00        0.00      0.00        0.00   0.00
2488  30.00  68380.00        0.00      0.00        0.00   0.00
2489  30.00  68380.00        0.00      0.00     1440.00   0.00
1793  30.00  68380.00        0.00      0.00        0.00   0.00
1940  30.00  68380.00        0.00      0.00        0.00   0.00
1939  30.00  68380.00        0.00      0.00        0.00   0.00
2500  30.00  68380.00        0.00   5300.00        0.00   1.00
```

B AHP_solution.txt

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COPSolver benchmark - multicriteria classification - Fraga's ABC + AHP solution - alexia's data file

Statistic :

A: 22.05%; B: 22.83%; C: 55.12%;

Number of data :

254

--> Fraga's ABC Multicriteria Classification With Analytic Hierarchy Process

(code | ABC | weight | sum | org order) :

2091   A   10.13 %   10.13 %     214
1823   A    5.12 %   15.25 %      46
1700   A    4.89 %   20.14 %      49
2092   A    4.02 %   24.16 %     215
2031   A    3.33 %   27.50 %      45
2350   A    3.17 %   30.67 %     158
2032   A    2.30 %   32.97 %      44
2160   A    2.24 %   35.21 %     101
1181   A    2.22 %   37.43 %     165
1662   A    2.01 %   39.43 %     163
2148   A    1.66 %   41.09 %     106
2068   A    1.50 %   42.59 %      73
2500   A    1.37 %   43.96 %     253
1788   A    1.33 %   45.29 %      41
2131   A    1.22 %   46.51 %       6
1606   A    1.15 %   47.65 %     228
2169   A    1.14 %   48.80 %      12
2252   A    1.13 %   49.93 %       0
2255   A    1.13 %   51.05 %       2
2253   A    1.13 %   52.18 %       1
1873   A    1.09 %   53.27 %      86
2515   A    1.08 %   54.36 %      24
2392   A    1.01 %   55.36 %     216
2552   A    1.00 %   56.36 %      50
2111   A    0.97 %   57.34 %     107
2524   A    0.90 %   58.24 %      13
1815   A    0.90 %   59.14 %      58
1864   A    0.89 %   60.04 %     229
1922   A    0.88 %   60.92 %       5
1762   A    0.83 %   61.75 %      53
1102   A    0.82 %   62.56 %      77
2168   A    0.79 %   63.35 %      11
2021   A    0.76 %   64.12 %     114
1955   A    0.74 %   64.85 %      74
2349   A    0.73 %   65.58 %     157
2553   A    0.71 %   66.29 %      51
2182   A    0.71 %   67.00 %     109
2035   A    0.70 %   67.71 %     122
1790   A    0.67 %   68.38 %       7
2132   A    0.67 %   69.04 %       4
1581   A    0.67 %   69.71 %     119
1510   A    0.67 %   70.38 %     185
2172   A    0.66 %   71.04 %      14
2171   A    0.66 %   71.70 %      15
2095   A    0.66 %   72.37 %      84
2096   A    0.66 %   73.03 %      85
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1857	A	0.66 %	73.69 %	108
2026	A	0.66 %	74.36 %	115
1830	A	0.66 %	75.02 %	116
2020	A	0.66 %	75.68 %	117
2025	A	0.66 %	76.35 %	118
1842	A	0.66 %	77.01 %	121
1835	A	0.66 %	77.67 %	123
2010	A	0.66 %	78.34 %	124
2022	A	0.66 %	79.00 %	125
1846	A	0.66 %	79.66 %	126
1834	B	0.66 %	80.33 %	127
1061	B	0.61 %	80.94 %	55
2164	B	0.48 %	81.42 %	145
1292	B	0.44 %	81.86 %	56
1506	B	0.44 %	82.30 %	212
1382	B	0.38 %	82.68 %	159
1810	B	0.32 %	83.00 %	8
1979	B	0.32 %	83.31 %	179
2391	B	0.31 %	83.62 %	217
1769	B	0.30 %	83.91 %	54
2454	B	0.29 %	84.20 %	33
2364	B	0.28 %	84.49 %	146
1701	B	0.27 %	84.76 %	239
1767	B	0.27 %	85.02 %	241
2090	B	0.26 %	85.29 %	29
2489	B	0.26 %	85.54 %	249
2156	B	0.26 %	85.80 %	132
1893	B	0.25 %	86.06 %	240
2039	B	0.25 %	86.31 %	103
1069	B	0.25 %	86.56 %	57
1180	B	0.25 %	86.80 %	164
1770	B	0.24 %	87.05 %	62
1935	B	0.24 %	87.29 %	64
1059	B	0.24 %	87.53 %	48
2491	B	0.24 %	87.77 %	52
2535	B	0.24 %	88.01 %	59
2536	B	0.24 %	88.25 %	60
2343	B	0.24 %	88.48 %	61
1969	B	0.24 %	88.72 %	63
1934	B	0.24 %	88.96 %	65
2129	B	0.24 %	89.20 %	66
1844	B	0.24 %	89.44 %	67
2380	B	0.24 %	89.68 %	68
2435	B	0.24 %	89.92 %	69
2033	B	0.24 %	90.16 %	70
2366	B	0.24 %	90.40 %	71
2534	B	0.24 %	90.63 %	72
2339	B	0.24 %	90.87 %	236
2142	B	0.23 %	91.11 %	238
2538	B	0.22 %	91.33 %	152
2403	B	0.21 %	91.54 %	147
2543	B	0.21 %	91.75 %	140
2321	B	0.21 %	91.96 %	232
2377	B	0.21 %	92.16 %	156
1192	B	0.20 %	92.36 %	190
1194	B	0.20 %	92.56 %	191
1348	B	0.20 %	92.76 %	192
1415	B	0.20 %	92.97 %	198
1394	B	0.20 %	93.17 %	199
1719	B	0.20 %	93.37 %	234
1827	B	0.20 %	93.57 %	242
1840	B	0.20 %	93.77 %	243
2495	B	0.20 %	93.97 %	244
2494	B	0.20 %	94.17 %	245
2344	B	0.20 %	94.37 %	246
1993	B	0.20 %	94.57 %	247
2488	B	0.20 %	94.77 %	248
1793	B	0.20 %	94.97 %	250
1940	C	0.20 %	95.17 %	251
1939	C	0.20 %	95.38 %	252
1017	C	0.20 %	95.57 %	37
2395	C	0.17 %	95.75 %	150
1980	C	0.16 %	95.91 %	181
2076	C	0.16 %	96.07 %	30
2363	C	0.14 %	96.21 %	205
2042	C	0.13 %	96.34 %	180
2152	C	0.13 %	96.47 %	111
1446	C	0.12 %	96.59 %	189
2175	C	0.11 %	96.70 %	27
1410	C	0.11 %	96.80 %	168
2329	C	0.10 %	96.91 %	47
1664	C	0.10 %	97.01 %	130
1665	C	0.10 %	97.11 %	131
2432	C	0.10 %	97.21 %	28
1848	C	0.10 %	97.31 %	175
2006	C	0.09 %	97.40 %	211
1853	C	0.09 %	97.48 %	137
2122	C	0.08 %	97.57 %	18
2485	C	0.08 %	97.65 %	167
1859	C	0.08 %	97.73 %	182
2167	C	0.08 %	97.81 %	178
2498	C	0.07 %	97.88 %	161

2145	C	0.07	%	97.95	%	162
1670	C	0.06	%	98.02	%	129
2120	C	0.06	%	98.08	%	19
1921	C	0.06	%	98.14	%	201
1291	C	0.06	%	98.21	%	160
2259	C	0.06	%	98.27	%	3
2259	C	0.06	%	98.33	%	10
2173	C	0.06	%	98.38	%	151
1332	C	0.05	%	98.43	%	172
1378	C	0.05	%	98.49	%	100
2463	C	0.05	%	98.54	%	26
1789	C	0.05	%	98.59	%	39
1914	C	0.05	%	98.64	%	148
1816	C	0.05	%	98.69	%	102
1801	C	0.05	%	98.74	%	110
2235	C	0.05	%	98.78	%	220
1385	C	0.05	%	98.83	%	171
2005	C	0.04	%	98.87	%	136
2056	C	0.04	%	98.91	%	104
1519	C	0.04	%	98.95	%	153
1480	C	0.04	%	98.99	%	203
2139	C	0.04	%	99.03	%	105
1252	C	0.04	%	99.07	%	233
1634	C	0.04	%	99.11	%	197
2544	C	0.04	%	99.15	%	96
1183	C	0.04	%	99.19	%	166
2210	C	0.04	%	99.22	%	169
1557	C	0.04	%	99.26	%	170
2441	C	0.04	%	99.30	%	173
1847	C	0.04	%	99.34	%	174
2520	C	0.04	%	99.38	%	176
2166	C	0.04	%	99.41	%	177
2540	C	0.04	%	99.45	%	200
2023	C	0.04	%	99.49	%	235
1566	C	0.03	%	99.52	%	99
2531	C	0.03	%	99.56	%	133
1813	C	0.03	%	99.59	%	17
1777	C	0.03	%	99.62	%	112
2455	C	0.03	%	99.65	%	42
2456	C	0.03	%	99.68	%	43
1373	C	0.03	%	99.71	%	97
1809	C	0.03	%	99.74	%	16
2473	C	0.03	%	99.77	%	92
2461	C	0.02	%	99.79	%	75
1579	C	0.02	%	99.81	%	120
2198	C	0.02	%	99.83	%	141
2444	C	0.02	%	99.85	%	32
1888	C	0.02	%	99.87	%	135
2471	C	0.02	%	99.88	%	91
1131	C	0.02	%	99.90	%	138
1669	C	0.01	%	99.91	%	128
1771	C	0.01	%	99.93	%	35
2228	C	0.01	%	99.94	%	193
1638	C	0.01	%	99.95	%	196
2041	C	0.01	%	99.96	%	237
1078	C	0.01	%	99.97	%	98
2040	C	0.01	%	99.98	%	134
1058	C	0.01	%	99.98	%	83
1956	C	0.00	%	99.99	%	22
1833	C	0.00	%	99.99	%	36
1958	C	0.00	%	99.99	%	113
2189	C	0.00	%	100.00	%	93
2191	C	0.00	%	100.00	%	95
2190	C	0.00	%	100.00	%	94
1957	C	0.00	%	100.00	%	23
1806	C	0.00	%	100.00	%	9
2340	C	0.00	%	100.00	%	20
1822	C	0.00	%	100.00	%	21
2516	C	0.00	%	100.00	%	25
2478	C	0.00	%	100.00	%	31
2479	C	0.00	%	100.00	%	34
2174	C	0.00	%	100.00	%	38
2077	C	0.00	%	100.00	%	40
2109	C	0.00	%	100.00	%	76
2157	C	0.00	%	100.00	%	78
1824	C	0.00	%	100.00	%	79
1617	C	0.00	%	100.00	%	80
1825	C	0.00	%	100.00	%	81
2017	C	0.00	%	100.00	%	82
1872	C	0.00	%	100.00	%	87
2370	C	0.00	%	100.00	%	88
1518	C	0.00	%	100.00	%	89
2472	C	0.00	%	100.00	%	90
1569	C	0.00	%	100.00	%	139
2405	C	0.00	%	100.00	%	142
2163	C	0.00	%	100.00	%	143
2165	C	0.00	%	100.00	%	144
2003	C	0.00	%	100.00	%	149
2375	C	0.00	%	100.00	%	154
2522	C	0.00	%	100.00	%	155
2049	C	0.00	%	100.00	%	183
2184	C	0.00	%	100.00	%	184

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1663   C     0.00 %  100.00 %     186
1447   C     0.00 %  100.00 %     187
2512   C     0.00 %  100.00 %     188
2229   C     0.00 %  100.00 %     194
2124   C     0.00 %  100.00 %     195
1367   C     0.00 %  100.00 %     202
2070   C     0.00 %  100.00 %     204
2508   C     0.00 %  100.00 %     206
2507   C     0.00 %  100.00 %     207
1653   C     0.00 %  100.00 %     208
1870   C     0.00 %  100.00 %     209
2183   C     0.00 %  100.00 %     210
2429   C     0.00 %  100.00 %     213
2233   C     0.00 %  100.00 %     218
2232   C     0.00 %  100.00 %     219
2453   C     0.00 %  100.00 %     221
2430   C     0.00 %  100.00 %     222
2431   C     0.00 %  100.00 %     223
2243   C     0.00 %  100.00 %     224
2246   C     0.00 %  100.00 %     225
2348   C     0.00 %  100.00 %     226
1574   C     0.00 %  100.00 %     227
2446   C     0.00 %  100.00 %     230
2445   C     0.00 %  100.00 %     231

--> ABC matrix (by criterion)

code lead-time-billing, 0.55       criticality, 0.27     repairability, 0.11      obsolescence, 0.05       commonality, 0.02 :

2091         A       17.18 %         A        2.42 %         C        0.00 %         C        0.00 %         C        0.00 %
1823         A        8.10 %         A        2.42 %         C        0.00 %         C        0.00 %         C        0.00 %
1700         A        8.44 %         C        0.00 %         A        1.88 %         C        0.00 %         A        1.63 %
2092         A        6.09 %         A        2.42 %         C        0.00 %         C        0.00 %         C        0.00 %
2031         A        4.85 %         A        2.42 %         C        0.00 %         C        0.00 %         C        0.00 %
2350         A        4.44 %         A        2.42 %         B        0.59 %         C        0.00 %         C        0.00 %
2032         A        4.17 %         C        0.00 %         C        0.00 %         C        0.00 %         C        0.00 %
2160         A        2.43 %         A        2.42 %         A        1.88 %         C        0.00 %         A        1.63 %
1181         A        3.96 %         C        0.00 %         C        0.00 %         C        0.00 %         A        1.63 %
1662         A        3.57 %         C        0.00 %         C        0.00 %         C        0.00 %         A        1.63 %
2148         A        1.80 %         A        2.42 %         C        0.00 %         C        0.00 %         C        0.00 %
2068         A        1.53 %         A        2.42 %         C        0.00 %         C        0.00 %         C        0.00 %
2500         C        0.00 %         C        0.00 %         A        1.88 %         A       25.00 %         A        1.63 %
1788         A        2.41 %         C        0.00 %         C        0.00 %         C        0.00 %         C        0.00 %
2131         A        1.01 %         A        2.42 %         C        0.00 %         C        0.00 %         C        0.00 %
1606         B        0.88 %         A        2.42 %         C        0.00 %         C        0.00 %         C        0.00 %
2169         B        0.87 %         A        2.42 %         C        0.00 %         C        0.00 %         C        0.00 %
2252         C        0.00 %         C        0.00 %         C        0.00 %         A       25.00 %         C        0.00 %
2255         C        0.00 %         C        0.00 %         C        0.00 %         A       25.00 %         C        0.00 %
2253         C        0.00 %         C        0.00 %         C        0.00 %         A       25.00 %         C        0.00 %
1873         A        1.99 %         C        0.00 %         C        0.00 %         C        0.00 %         C        0.00 %
2515         A        1.96 %         C        0.00 %         C        0.00 %         C        0.00 %         C        0.00 %
2392         A        1.83 %         C        0.00 %         C        0.00 %         C        0.00 %         C        0.00 %
2552         A        1.38 %         C        0.00 %         A        1.88 %         C        0.00 %         A        1.63 %
2111         B        0.56 %         A        2.42 %         C        0.00 %         C        0.00 %         C        0.00 %
2524         B        0.44 %         A        2.42 %         C        0.00 %         C        0.00 %         C        0.00 %
1815         C        0.00 %         A        2.42 %         A        1.88 %         C        0.00 %         A        1.63 %
1864         B        0.42 %         A        2.42 %         C        0.00 %         C        0.00 %         C        0.00 %
1922         B        0.40 %         A        2.42 %         C        0.00 %         C        0.00 %         C        0.00 %
1762         A        1.07 %         C        0.00 %         A        1.88 %         C        0.00 %         A        1.63 %
1102         B        0.28 %         A        2.42 %         C        0.00 %         C        0.00 %         C        0.00 %
2168         B        0.23 %         A        2.42 %         C        0.00 %         C        0.00 %         C        0.00 %
2021         C        0.18 %         A        2.42 %         C        0.00 %         C        0.00 %         C        0.00 %
1955         C        0.14 %         A        2.42 %         C        0.00 %         C        0.00 %         C        0.00 %
2349         C        0.00 %         A        2.42 %         B        0.59 %         C        0.00 %         C        0.00 %
2553         B        0.86 %         C        0.00 %         A        1.88 %         C        0.00 %         A        1.63 %
2182         C        0.09 %         A        2.42 %         C        0.00 %         C        0.00 %         C        0.00 %
2035         C        0.07 %         A        2.42 %         C        0.00 %         C        0.00 %         C        0.00 %
1790         C        0.01 %         A        2.42 %         C        0.00 %         C        0.00 %         C        0.00 %
2132         C        0.01 %         A        2.42 %         C        0.00 %         C        0.00 %         C        0.00 %
1581         C        0.01 %         A        2.42 %         C        0.00 %         C        0.00 %         C        0.00 %
1510         A        1.21 %         C        0.00 %         C        0.00 %         C        0.00 %         C        0.00 %
2172         C        0.00 %         A        2.42 %         C        0.00 %         C        0.00 %         C        0.00 %
2171         C        0.00 %         A        2.42 %         C        0.00 %         C        0.00 %         C        0.00 %
2095         C        0.00 %         A        2.42 %         C        0.00 %         C        0.00 %         C        0.00 %
2096         C        0.00 %         A        2.42 %         C        0.00 %         C        0.00 %         C        0.00 %
1857         C        0.00 %         A        2.42 %         C        0.00 %         C        0.00 %         C        0.00 %
2026         C        0.00 %         A        2.42 %         C        0.00 %         C        0.00 %         C        0.00 %
1830         C        0.00 %         A        2.42 %         C        0.00 %         C        0.00 %         C        0.00 %
2020         C        0.00 %         A        2.42 %         C        0.00 %         C        0.00 %         C        0.00 %
2025         C        0.00 %         A        2.42 %         C        0.00 %         C        0.00 %         C        0.00 %
1842         C        0.00 %         A        2.42 %         C        0.00 %         C        0.00 %         C        0.00 %
1835         C        0.00 %         A        2.42 %         C        0.00 %         C        0.00 %         C        0.00 %
2010         C        0.00 %         A        2.42 %         C        0.00 %         C        0.00 %         C        0.00 %
2022         C        0.00 %         A        2.42 %         C        0.00 %         C        0.00 %         C        0.00 %
1846         C        0.00 %         A        2.42 %         C        0.00 %         C        0.00 %         C        0.00 %
1834         C        0.00 %         A        2.42 %         C        0.00 %         C        0.00 %         C        0.00 %
1061         B        0.37 %         B        0.62 %         A        1.88 %         C        0.00 %         A        1.63 %
2164         B        0.87 %         C        0.00 %         C        0.00 %         C        0.00 %         C        0.00 %
1292         B        0.37 %         C        0.00 %         A        1.88 %         C        0.00 %         A        1.63 %
1506         B        0.80 %         C        0.00 %         C        0.00 %         C        0.00 %         C        0.00 %
1382         B        0.57 %         C        0.00 %         B        0.59 %         C        0.00 %         C        0.00 %
1810         B        0.57 %         C        0.00 %         C        0.00 %         C        0.00 %         C        0.00 %
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1979	B	0.50 %	C	0.00 %	C	0.00 %	C	0.00 %	A	1.63 %
2391	B	0.56 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
1769	C	0.10 %	C	0.00 %	A	1.88 %	C	0.00 %	A	1.63 %
2454	B	0.52 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
2364	B	0.52 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
1701	C	0.12 %	C	0.00 %	A	1.88 %	C	0.00 %	C	0.00 %
1767	C	0.12 %	C	0.00 %	A	1.88 %	C	0.00 %	C	0.00 %
2090	B	0.47 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
2489	C	0.10 %	C	0.00 %	A	1.88 %	C	0.00 %	C	0.00 %
2156	B	0.45 %	C	0.00 %	C	0.00 %	C	0.00 %	B	0.37 %
1893	C	0.10 %	C	0.00 %	A	1.88 %	C	0.00 %	C	0.00 %
2039	B	0.46 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
1069	C	0.02 %	C	0.00 %	A	1.88 %	C	0.00 %	A	1.63 %
1180	B	0.38 %	C	0.00 %	C	0.00 %	C	0.00 %	A	1.63 %
1770	C	0.01 %	C	0.00 %	A	1.88 %	C	0.00 %	A	1.63 %
1935	C	0.01 %	C	0.00 %	A	1.88 %	C	0.00 %	A	1.63 %
1059	C	0.00 %	C	0.00 %	A	1.88 %	C	0.00 %	A	1.63 %
2491	C	0.00 %	C	0.00 %	A	1.88 %	C	0.00 %	A	1.63 %
2535	C	0.00 %	C	0.00 %	A	1.88 %	C	0.00 %	A	1.63 %
2536	C	0.00 %	C	0.00 %	A	1.88 %	C	0.00 %	A	1.63 %
2343	C	0.00 %	C	0.00 %	A	1.88 %	C	0.00 %	A	1.63 %
1969	C	0.00 %	C	0.00 %	A	1.88 %	C	0.00 %	A	1.63 %
1934	C	0.00 %	C	0.00 %	A	1.88 %	C	0.00 %	A	1.63 %
2129	C	0.00 %	C	0.00 %	A	1.88 %	C	0.00 %	A	1.63 %
1844	C	0.00 %	C	0.00 %	A	1.88 %	C	0.00 %	A	1.63 %
2380	C	0.00 %	C	0.00 %	A	1.88 %	C	0.00 %	A	1.63 %
2435	C	0.00 %	C	0.00 %	A	1.88 %	C	0.00 %	A	1.63 %
2033	C	0.00 %	C	0.00 %	A	1.88 %	C	0.00 %	A	1.63 %
2366	C	0.00 %	C	0.00 %	A	1.88 %	C	0.00 %	A	1.63 %
2534	C	0.00 %	C	0.00 %	A	1.88 %	C	0.00 %	A	1.63 %
2339	C	0.00 %	C	0.00 %	A	1.88 %	C	0.00 %	A	1.63 %
2142	C	0.04 %	C	0.00 %	A	1.88 %	C	0.00 %	B	0.37 %
2538	B	0.40 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
2403	B	0.38 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
2543	C	0.00 %	C	0.00 %	A	1.88 %	C	0.00 %	B	0.37 %
2321	C	0.00 %	C	0.00 %	A	1.88 %	C	0.00 %	B	0.37 %
2377	B	0.37 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
1192	C	0.00 %	C	0.00 %	A	1.88 %	C	0.00 %	C	0.00 %
1194	C	0.00 %	C	0.00 %	A	1.88 %	C	0.00 %	C	0.00 %
1348	C	0.00 %	C	0.00 %	A	1.88 %	C	0.00 %	C	0.00 %
1415	C	0.00 %	C	0.00 %	A	1.88 %	C	0.00 %	C	0.00 %
1394	C	0.00 %	C	0.00 %	A	1.88 %	C	0.00 %	C	0.00 %
1719	C	0.00 %	C	0.00 %	A	1.88 %	C	0.00 %	C	0.00 %
1827	C	0.00 %	C	0.00 %	A	1.88 %	C	0.00 %	C	0.00 %
1840	C	0.00 %	C	0.00 %	A	1.88 %	C	0.00 %	C	0.00 %
2495	C	0.00 %	C	0.00 %	A	1.88 %	C	0.00 %	C	0.00 %
2494	C	0.00 %	C	0.00 %	A	1.88 %	C	0.00 %	C	0.00 %
2344	C	0.00 %	C	0.00 %	A	1.88 %	C	0.00 %	C	0.00 %
1993	C	0.00 %	C	0.00 %	A	1.88 %	C	0.00 %	C	0.00 %
2488	C	0.00 %	C	0.00 %	A	1.88 %	C	0.00 %	C	0.00 %
1793	C	0.00 %	C	0.00 %	A	1.88 %	C	0.00 %	C	0.00 %
1940	C	0.00 %	C	0.00 %	A	1.88 %	C	0.00 %	C	0.00 %
1939	C	0.00 %	C	0.00 %	A	1.88 %	C	0.00 %	C	0.00 %
1017	B	0.29 %	C	0.00 %	C	0.00 %	C	0.00 %	A	1.63 %
2395	B	0.32 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
1980	B	0.23 %	C	0.00 %	C	0.00 %	C	0.00 %	A	1.63 %
2076	B	0.29 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
2363	B	0.25 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
2042	C	0.17 %	C	0.00 %	C	0.00 %	C	0.00 %	A	1.63 %
2152	B	0.23 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
1446	B	0.21 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
2175	C	0.13 %	C	0.00 %	C	0.00 %	C	0.00 %	A	1.63 %
1410	C	0.12 %	C	0.00 %	C	0.00 %	C	0.00 %	A	1.63 %
2329	C	0.00 %	C	0.00 %	B	0.59 %	C	0.00 %	A	1.63 %
1664	B	0.19 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
1665	C	0.18 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
2432	C	0.18 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
1848	C	0.11 %	C	0.00 %	C	0.00 %	C	0.00 %	A	1.63 %
2006	C	0.16 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
1853	C	0.16 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
2122	C	0.09 %	C	0.00 %	C	0.00 %	C	0.00 %	A	1.63 %
2485	C	0.09 %	C	0.00 %	C	0.00 %	C	0.00 %	A	1.63 %
1859	C	0.15 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
2167	C	0.07 %	C	0.00 %	C	0.00 %	C	0.00 %	A	1.63 %
2498	C	0.00 %	C	0.00 %	B	0.59 %	C	0.00 %	B	0.37 %
2145	C	0.00 %	C	0.00 %	B	0.59 %	C	0.00 %	B	0.37 %
1670	C	0.12 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
2120	C	0.05 %	C	0.00 %	C	0.00 %	C	0.00 %	A	1.63 %
1921	C	0.11 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
1291	C	0.00 %	C	0.00 %	B	0.59 %	C	0.00 %	C	0.00 %
2259	C	0.04 %	C	0.00 %	C	0.00 %	C	0.00 %	A	1.63 %
2259	C	0.04 %	C	0.00 %	C	0.00 %	C	0.00 %	A	1.63 %
2173	C	0.10 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
1332	C	0.03 %	C	0.00 %	C	0.00 %	C	0.00 %	A	1.63 %
1378	C	0.08 %	C	0.00 %	C	0.00 %	C	0.00 %	B	0.37 %
2463	C	0.10 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
1789	C	0.09 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
1914	C	0.09 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
1816	C	0.09 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
1801	C	0.09 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
2235	C	0.09 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
1385	C	0.01 %	C	0.00 %	C	0.00 %	C	0.00 %	A	1.63 %

2005	C	0.06 %	C	0.00 %	C	0.00 %	C	0.00 %	B	0.37 %
2056	C	0.07 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
1519	C	0.07 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
1480	C	0.07 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
2139	C	0.07 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
1252	C	0.07 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
1634	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	A	1.63 %
2544	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	A	1.63 %
1183	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	A	1.63 %
2210	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	A	1.63 %
1557	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	A	1.63 %
2441	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	A	1.63 %
1847	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	A	1.63 %
2520	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	A	1.63 %
2166	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	A	1.63 %
2540	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	A	1.63 %
2023	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	A	1.63 %
1566	C	0.05 %	C	0.00 %	C	0.00 %	C	0.00 %	B	0.37 %
2531	C	0.05 %	C	0.00 %	C	0.00 %	C	0.00 %	B	0.37 %
1813	C	0.06 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
1777	C	0.06 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
2455	C	0.06 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
2456	C	0.06 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
1373	C	0.04 %	C	0.00 %	C	0.00 %	C	0.00 %	B	0.37 %
1809	C	0.05 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
2473	C	0.05 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
2461	C	0.04 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
1579	C	0.04 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
2198	C	0.04 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
2444	C	0.04 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
1888	C	0.01 %	C	0.00 %	C	0.00 %	C	0.00 %	B	0.37 %
2471	C	0.03 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
1131	C	0.03 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
1669	C	0.02 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
1771	C	0.02 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
2228	C	0.02 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
1638	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	B	0.37 %
2041	C	0.02 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
1078	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	B	0.37 %
2040	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	B	0.37 %
1058	C	0.01 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
1956	C	0.01 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
1833	C	0.01 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
1958	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
2189	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
2191	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
2190	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
1957	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
1806	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
2340	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
1822	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
2516	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
2478	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
2479	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
2174	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
2077	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
2109	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
2157	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
1824	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
1617	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
1825	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
2017	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
1872	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
2370	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
1518	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
2472	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
1569	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
2405	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
2163	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
2165	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
2003	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
2375	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
2522	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
2049	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
2184	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
1663	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
1447	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
2512	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
2229	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
2124	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
1367	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
2070	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
2508	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
2507	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
1653	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
1870	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
2183	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
2429	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
2233	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
2232	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
2453	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
2430	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %

2431	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
2243	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
2246	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
2348	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
1574	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
2446	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %
2445	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %	C	0.00 %