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FIREWORK EXPLOSION CAN SOLVE THE SET COVERING PROBLEM

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Abstract

To solve the Set Covering Problem we will use a metaheuristic Fireworks Algorithm inspired by the fireworks explosion. Through the observation of the way that fireworks explode is much similar to the way that an individual searches the optimal solution in swarm. Fireworks algorithm (FWA) consists of four parts, i.e., the explosion operator, the mutation operator, the mapping rule and selection strategy. The Set Covering Problem is a formal model for many practical optimization problems. It consists in finding a subset of columns in a zero/one matrix such that they cover all the rows of the matrix at a minimum cost.

Keywords: Firework algorithm, Set Covering Problem, Metaheuristic.

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1. Introduction

Optimization problems have been mostly studied for their importance in practice, and many problems have been successfully

Inspired by the fireworks explosion in the night sky, a recent metaheuristic was proposed: Fireworks Algorithm (FWA). It is a swarm intelligence optimization algorithm, which seems quite efective solving optimization problem. When a firework explodes, a shower of sparks is shown in the adjacent area. Those sparks will explode again and generate other shows of sparks in a smaller area. Gradually, the sparks will search (almost) the entire search space ending (eventually) good enough solutions.

FWA in this work we propose an approach to solve the Weighted Set Covering Problem (WSCP). We are interested in to solve efficiently WSCP because it is a formal model for many practical optimization problems: crew scheduling, location of emergency facilities, production planning in industry, vehicle rout- ing, ship scheduling, network attack or defence, assembly line balancing, traffic assignment in satellite communication systems, simplifying boolean expressions, the calculation of bounds in integer programs, information retrieval, political dis- tricting, stock cutting, crew scheduling problems in airlines and other important real life situations.

This project seeks to provide a solution to SCP based metaheuristics fireworks behavior.

This document has eight major sections, the first section is defined the general and specific objectives, also presented the methodology used. In the second section shows the optimization about the complaxity of decision problems, optimizations methods, etc. In the third section, the state of the art, where a review of the literature as "SCP"has been solved before and what are the advantages of FWA is shown. In the fourth section formally we define "SCP". In the fifth section FWA explained, highlighting the parts of this technique. In the sixth section, explains the algorithm used and implemented to solve the "SCP". In the penultimate section disclosed the best results of the 65 instances, so in a last section conclusions from these results are presented.

2. Objetives

2.1. General Objectives

- Providing a solution to SCP with behavior-based metaheuristic fireworks.

2.2. Specific Objectives

- Study the SCP
- Understand the algorithm based on fireworks and therefore their advantages and disadvantages.
- Develop algorithm based algorithm fireworks that solve SCP
- Apply the algorithm to solve the 65 benchmark instances of SCP
- Analyzing results of experiments.

2.3. Methodology

The methodology of this work is based on three stages. The first on is focused on inquiring into the core subject of this work - the problem and the technique - and its related contents. This stage consists in researching the level of subject development, associated literature, known concepts, and previous works.

At the second stage, a solution is proposed, designed and implemented. Knowledge of previous stage, as standards and widely known concepts, is the foundation of the design . At this point novelty and innovation take places since - probably- the problem solution with this techniques is not fully documented or maybe some of its components are not documented at all at design level.

The third is based on experimenting and explanatory methods. The algorithm developed at previous stage is taken to work a different instances, as many as a suitable stock of results in built. Then, this stock of results is analyzed, explained and compared for building and conclusive result of this work.

2.4. Definition

Objective function : An equation that will be optimized given the constraints. The variables must be minimazadas or maximized using programming techniques. Value describing the quality of the solution.

Solution: Represented by a vector of n components ue n represents the variables.

Fitness: Is the value of the evaluation of the objective function in conjunction with the solution.

Domain: The set of values that can take the variables.

Restriction: A condition that must be met to satisfy the requirements of the problem.

Search Space: The set of all feasible solutions.

Parameters: are used within the context to set up a metaheuristic.

Global Optimal: A solution of the search space that has the best value of the objective function.

Local Optimum: a solution that has the best value of the objective function that all its neighbors.

Initial Population: These are individuals who began working for the solution of the problem.

3. Problem Definition

3.1. Set Covering Problem

The Set Covering Problem (SCP) consists in finding the minimum number of sets containing encased all elements of all sets. There are numerous applications of this type of problem being principalmes the selection of files in a database, simplification of Boolean expressions, balancing production Lienas, location of services, among others [23]. SCP presents a binary matrix (0.1) whose dimension depends on the problem to be solved, in a context where the matrix has hundreds of thousands of rows and columns are heuristics that reach the optimum, and in other cases where the matrix has thousands of rows and millions of column can be solved to obtain a value within 1 % around the optimum in reasonable execution time[10]. The SCP can be formally defined as follows. Let $A = (a_{ij})$ be an m-row, n-column, zero-one matrix. We say that a column j can cover a row if a_{ij} =1. Each column j is associated with a nonnegative real cost c_j. Let I={1,...,m} and J={1,...,n} be the row set and column set, respectively. The SCP calls for a minimum cost subset $S \subseteq J$, such that each row $i \in I$ is covered by at least one column $j \in S$. A mathematical model for the SCP is

$$v(\text{SCP}) = \min \sum_{j \in J} c_j x_j \tag{1}$$

subject to

$$\sum_{j \in J} a_{ij} x_j \geq 1, \quad \forall\, i \in I, \tag{2}$$

$$x_j \in \{0,1\}, \forall\, j \in J \tag{3}$$

The objective is to minimize the sum of the costs of the selected columns, where $x_j = 1$ if column j is in the solution, 0 otherwise. The restrictions ensure that each row i is covered by at least one column.

The SCP has been applied to many real world problems such as crew scheduling [1, 4, 15, 24, 25, 27, 30, 31, 34, 35], location of emergency facilities [28, 33, 36, 40], production planning in industry [37, 38, 39], vehicle routing [3, 18], ship scheduling [17, 7], network attack or defence [8], assembly line balancing [19, 32], traffic assignment in satellite communication systems

[29, 11], simplifying boolean expressions [9], the calculation of bounds in integer programs [12], information retrieval [13], political districting [20], stock cutting, crew scheduling problems in airlines [21] and other important real life situations.

3.2. Benchmark Example

The A matrix (problem matrix) is obtained from a txt file. The benchmark example of this file follows the same format as the bvenchmark ile from OR-Library of beasly. Table 2.1 show the file format.

```
3 5            } a)
 10 20 30
 40 50         } b)
2              } c)
2  4           } d)
3
1  4  5
1
3
```

Tabla 1: File benchmark example

the file format is:

a) Number of rows (m), number of column (n)

b) The cost of each column C_j, j=1,...,n

c) For each row i(i=1,...,m): the number of columns which cover

d) Row i followed by a list of column which cover row i

It means that the row 1 can cover 2 columns, columns 2 and 4. Row 2 can cover 3 columns, columns 1,4 and 5. Row 3 can cover 1 column, column 3.

Table 3.2(a) shows the conversion of the columns that cover each row of the matrix one-zeros ($a_i j$). The matrix translates to level of constraints, we say that the rows are the restrictions (R_i). Table 3.2(b) shows the constraints. Table 2.2(c) shows the cost the vector c_j.

$$\text{Min Z} \sum_{j=1}^{5} c_j x_j \qquad (4)$$

(a) Matrix *aij*.

	c1	c2	c3	c4	c5
r1	0	1	0	1	0
r2	1	0	0	1	1
r3	0	0	1	0	0

(b) Constraints matrix.

$R_1 : x_2 + x_4 \geq 1;$
$R_2 : x_1 + x_4 + x_5 \geq 1;$
$R_3 : x_3 \geq 1;$

(c) Vector *cj*.

c1	c2	c3	c4	c5
10	20	30	40	50

Tabla 2: Matrix a_ij, its costraint and vector c_j.

It is generated a random initial solution "11001" and it is evaluated in (3,4) - objetive function, obtaining a cost of 80, since it occupying the columns 1 that cost 10, column 2 that cost 20 and column 5 that costs 50. Cost is calculated based on the solution, according to the columns that have activated.

to validate if the initial solution solution is feasible or not, the constraints must be checked. Is R_1 feasible? Yes, the constraint is satisfied. Is R_2 feasible? Yes, the constraint is satisfied. Is R_3 feasible? No, because $x_3 = 0$. And so on with each of the solutions. In this example, it is used a unique solution.

In order that R_3 to be feasible, the solution needs to be repaired. The solution is repaired by activating the 0 than 1. Once repaired the solution, constraints are checked again. The solution repaired "11101" is evaluated again in (3,4) having a cost of 110. For this case all constraints are fulfilled and it is a feasible solution, however an optimal solution has not found yet, because the column 1 and column 5 can cover the same row. Therefore a column mustbe removed. In terms of coverage , column 1 cost 10 and column 5 costs 50. In this case, it remains the column of lower cot and the others are discarded. The new solution "11100" evaluated in (3,4) has a cost of 60, being the global optimum for this benchmark example.

4. About the Optimization

4.1. Complexity of Decision Problems

The complexity of a problem is equivalent to the complexity of the best algorithm solving that problem. A problem is tractable (or easy) if there exists a polynomial-time algorithm to solve it. A problem is intractable (or difficult) if no polynomial-time algorithm exists to solve the problem.

An important aspect of computational theory is to categorize problems into complexity classes. A complexity class represents the set of all problems that can be solved using a given amount of computational resources (see Figura 1).

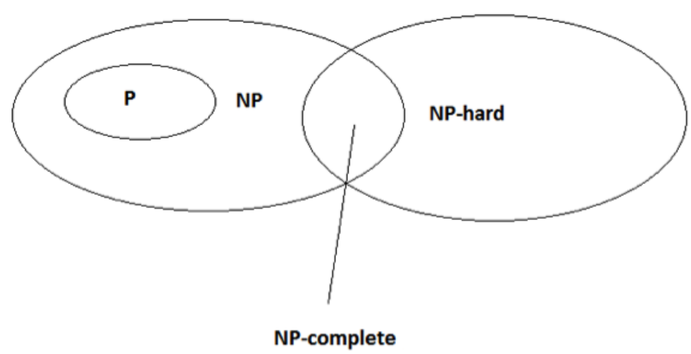

Figura 1: Complexity classes of decision problems.

The complexity class P represents the set of all decision problems that can be solved by a deterministic machine in polynomial time. A (deterministic) algorithm is polynomial for a decision problem A if its *worst* complexity is bounded by a polynomial function p(n) where n represents the size of the input instance I. Hence, the class P represents the family of problems where a known polynomial-time algorithm exists to solve the problem. Problems belonging to the class P are then relatively .ea sy"to solve.

The complexity class NP represents the set of all decision problems that can be solved by a nondeterministic algorithm14 in polynomial time. A nondeterministic algorithm contains one or more *choice* points in which multiple different continuations are possible without any specification of which one will be taken. It uses the primitives: choice that proposes a solution (oracle), check that verifies in polynomial time if a solution proposal (certificate) gives a positive or negative answer, *success* when the algorithm answers yes after the check application, and fail when the algorithm does not respond ɀes."Then, if the choice primitive proposes a solution that gives a ɀes.ªnswer and the oracle has the capacity to do it, then the computing complexity is polynomial.

A decision problem A ∈ NP is NP-complete if all other problems of class NP are reduced polynomially to the problem A. Figure 3 shows the relationship between P, NP, and NP-complete problems. If a polynomial deterministic algorithm exists to solve an NP-complete problem, then all problems of class NP may be solved in polynomial time.

NP-hard problems are optimization problems whose associated decision problems are NP-complete. Most of the real-world optimization problems are NP-hard for which provably efficient algorithms do not exist. They require exponential time (unless P = NP) to be solved in optimality. Metaheuristics constitute an important alternative to solve this class of problems.

4.2. Optimization Methods

When trying to solve a problem, each technique will fall in one of this two classifications: exact method or approximate method. Exact Methods obtain optimal solution and guarantee their optimality. For NP-complete problems, exact algorithms are nonpolymonial-time algorithms (unless P=NP). Approximate (or heuristic) methods generate high-quality solutions in reasonable time for practical use, but there is no guarantee of finding a global optimal solution.

4.2.1. Exact Methods

There exist several classical algorithms which are defined as an exact solving method: dynamic programming, branch and X family of algorithms (branch and bound, branch and cut, branch and price) and constraint programming.

Dynamic programming uses a recursive division of a problem, so it can get simpler sub-problems. This stagewise optimization method is the result of a sequence of partial decisions. The procedure avoids a total enumeration of the search space by pruning partial decision sequences that cannot lead to the optimal solution.

*The branch and bound algorithm and A** are based on an implicit enumeration if all solutions of the considered optimization problem. The search space is explored by dinamically building a tree whose root node represents the problem being solved and its while associated search space. The leaf nodes are the potential solutions and the internal nodes are subproblems of the total solution space. The pruning of the search tree is based on a bounding function that prunes subtrees that do not contain any optimal solution.

programming is a language built around concepts of tree search and logical implications. Optimization problems in constraint programming are modeled by means of a set of bariables linked by set of constraint. The variable take their values on a finite domain of integers. The constraints may have mathematical or symbolic forms.

Most of new solving techniques based on exact methods focus on divide-and-conquer strategy, applying its a algorithm to small instances of difficult problems. Table 3 shows, for some popular NP-hard optimizations problems, the order of magnitude of the maximal size of instances that state-of-art exact methods can solve to optimality.

Optimization Problems	Quadratic Assignment	Flow-Shop Scheduling (FSP)	Graph Coloring	Capacited Vehicle Routing
Size of the instances	30 objects	100 jobs /20 machines	100 nodes	60 clients

Tabla 3: Maximal size of instances that exact methods can solve to optimality

The syze of the instance is not the unique indicator that describes the difficulty of a problem, but also its structure. For a given problem, some small instances cannot be solved by an exact algorithm while some large instances may be solved exactly by the same algorithm.

Table 4 shows, for some popular optimization problems, small instances that are not solved exactly and large instances solved exactly by stateof-art exact optimization methods.

Optimization Problems	Sequencial Ordering Problem	Quadratic Assignment Problem	Graph Coloring
Size of some unsolved instances	53	30	125
Size of some solved instances	70	36	561

Tabla 4: The impact of the structure on the size of instances

4.2.2. Approximate Algorithms

Along with exact methods, it is defined a different type of algorithms, labeled as approximate methods, which are properly divided in two subclasses of algorithms: approximation algorithms and heuristic algorithms. Unlike heuristics, which usually find reasonably "good"solutions ina reasonable time, approximation algorithms provide provable solution quality and provable run-time bounds.

The bottom line of heuristic is: they find "good"solutions on large-size problem intances. They allow to obtain acceptable performance at acceptable costs in a wide range of problems. In general, heuristics do not have an approximation guarantee on the obtained solutions. They may be classified into two families: especific heuristics and metaheuristics. Specific heuristic are tailored and designed to solve a specific problem and/or intances. Metaheuristics are general-purpose algorithms that can be applied to solve almost any optimization problem. They may be viewed as upper level general methodologies that can be used as a guiding strategy in designing underlying heuristic to solve specific optimization problems.

A key aspect to differentiate approximation algorithms from heuristics, is that at the former there is a guarantee on the bound of the obtained solution from the global optinum. An $\in$ approximation algorithm generates an approximate solution α not less than factor $\in$ times the optimum solution s.

5. State of the Art

ï»¿ SCP is one of the oldest and most studied optimization problems in the mathematical programming literature. Many studies focus on solving SCP to optimality with exact algorithms. Before going deeper into the diverse SCP solutions with its characteristics, is always good to know a classification order to understand what kind of solution is being discussed.

5.1. Types of Solution

In general, metaheuristic algorithms can be divided into three categories.(i)Constructive metaheuristics: in each iteration, a new local optimum is found by constructing a new solution from scratch. A level of randomness is added to the construction step in order to avoid constructing the same solution over and over.(ii)Evolutionary algorithms: in each iteration, two or more solutions are combined to create a new solution.(iii)Local search: in each iteration, the current solution is replaced by one of its immediate neighbors (the solution is usually modified slightly). In the following sections, we review the literature of solving the SCP with metaheuristic approaches and analyze how each category of metaheuristics addresses solution infeasibility and set redundancy.

5.1.1. Constructive Metaheuristics

When the SCP is solved with constructive metaheuristics, the local optimums found at the end of each constructive iteration are usually feasible. In fact, the constructive iteration ends when all of the elements are covered. For this reason, these metaheuristics do not have to deal with the infeasibility issue. However, the local optimums are not necessarily free of redundant sets, and a redundancy removal heuristic is needed. Constructive metaheuristics for the SCP includes ant colony optimization [22, 2], MetaRaPS [16], and GRASP [14]. All of these metaheuristics use a dedicated redundancy removal operator that removes redundant sets at the end of each iteration.

5.1.2. Evolutionary Algorithms

Evolutionary algorithms for the SCP need to address both infeasibility and set redundancy issues. Most evolutionary algorithms that are used to solve the SCP are based on the genetic algorithm (GA). Most of the GAs use a binary string solution representation where if the set is part of the solution and otherwise. The infeasibility issue arises when the crossover or mutation operator of the GA produces a child (solution) that does not cover all of the elements. In fact, a simple bit flip from 1 to 0 during crossover or mutation can produce an infeasible solution. If a cost minimization objective function is used, infeasible solutions will be preferred over feasible ones because infeasible solutions are usually cheaper. Two main approaches have been used in the literature to address the infeasibility issue. The first approach uses a repair heuristic to transform infeasible solutions to feasible solutions before the evaluation step of the GA. A greedylike repair heuristic is usually used [6, 26]. In each iteration, the repair operator covers an uncovered element by selecting a new set that covers the element and adding it to the solution. In [26], all of the solutions are repaired for evaluation, but only 5By adding new sets, repair heuristics may introduce redundant sets into the solutions. For this reason, genetic algorithms that use a repair operator also use a redundancy removal procedure that is applied after the repair and just before evaluation. The second approach involves penalizing the objective value of infeasible solutions to drive the search toward the feasible region. A penalty term that makes infeasible solutions less attractive than feasible ones is added to the objective function. In , the same penalty is added to the objective value of all infeasible solutions. is high enough to guarantee that all feasible solutions have lower objective values than all infeasible solutions (). A drawback of using such an objective function is that infeasible solutions cannot be compared to each other because the objective function does not reflect the degree of infeasibility. Objective functions that penalize infeasible solutions while reflecting the degree of infeasibility are proposed in . the penalty attributed to an infeasible solution is proportional to the number of elements that are not covered in the solution. In , the penalty is proportional to the minimum cost it would take to cover all of the uncovered elements. In all discussed penalty approaches, the penalties are high enough to ensure that all infeasible solutions have higher objective values than all feasible ones. An immediate disadvantage of using such high penalties is that feasible solutions will always be preferred over infeasible ones. As a result, infeasible solutions will have low chances of surviving in the population, and the infeasible region of the search space will not be effectively explored.

5.1.3. Local Search

The feasibility constraint makes designing an effective local search metaheuristic for the SCP a difficult task. For this reason, fewlocalsearch only heuristics have been developed for the SCP . Instead, most of the local search algorithms have combined local search with other techniques such as Lagrangian relaxation,subgradient optimization, group theory, and linear programming. In [5], after noting the difficulty of defining a good neighbourhood to solve the unicost set covering problem with local search, the authors proposed that the problem could be transformed to an equivalent satisfiability problem (SAT) that can be solved more adequately with local search. Most local search algorithms for the SCP use a simple 1flip neighbourhood structure defined by moves that only add (remove) one set at a time to (from) the solution. When a local optimum is reached, which is usually a feasible solution, it is difficult to decide in which direction to continue the search. Two cases arise.(i)If the search space is restricted to the feasible region, only redundant sets are allowed to be removed. If no redundant sets exist in the solution, at least one redundant set must be added before a remove move is allowed to be performed. As a result, the infeasible region of the search space will not be explored and the search will tend to fall into local optimums and cycles. A more complex neighbourhood called flip is used in to make the search in the feasible region more effective. The flip neighbourhood of a given solution consists of all of the solutions that can be obtained by adding (removing) at most sets to (from) the solution. Eventhough the proposed heuristic is more effective than a simple 1flip heuristic, it is not sufficient to avoid local optimums and cycles and it is significantly slower than the 1flip heuristics.(ii)If the search space is not restricted to the feasible region, the cost minimization objective drives the search toward the infeasible region, by removing sets from the current configuration (to minimize the cost), and it is unclear when to restore feasibility. In such situations, penalty approaches are usually used to penalize infeasible solutions. If the penalty weights are too high, neighbors in the feasible region will be preferred over neighbors in the infeasible region, making the infeasible region unreachable. Lower or dynamic penalty weights are usually used to make the search more effective by allowing it to reach infeasible regions. If the penalty weights are too low, the final solution found is not guaranteed to be feasible. A tabu search heuristic that uses such low penalties is proposed in for the unicost set covering problem. A simple 1flip neighbourhood structure is used. The objective is to minimize where is the number of sets used in the solution and is the number of uncovered elements. If a set covers only one uncovered element, adding (removing) it to (from) the solution will not have any effect on the objective function. As a result, this set might be left out of the solution, making it infeasible. To overcome the fact that this objective function does not guarantee feasibility, the neighbourhood is restricted such that if a set is removed during one iteration, one or more sets must be added in the next iteration to restore feasibility. Eventhough such a low penalty approach allows the search to reach the infeasible region, additional neighbourhood restrictions are used to restore feasibility, and the infeasible region is only scratched. Dynamic penalty approaches, in which the penalty weights are repeatedly adjusted, are used to balance the search between the feasible and infeasible regions without using a repair operator or neighbourhood restrictions . The most frequent dynamic penalty approaches that have been used in the literature are based on Lagrangian relaxation and subgradient optimization. Dynamic penalty approaches can be very effective but are difficult to be designed and implemented.

5.2. Why FWA?

In the last section (Section 3.1), the reader is provided a review of the literature on how SCP has been solved before, but we have not talked about as FWA and FWA has advantages over other metaheuristics mentioned in the previous section

The advantages of FWA are separate in 6 parts as follow

5.2.1. Instantaneity

In each iteration, FWA calculates the number of sparks and the explosion amplitude, depending on the fitness values of the fireworks. Then, the sparks are produced by the explosion and mutation operators. Finally, the best spark is preserved at first, and then the other (N - 1) sparks are selected based on a selection strategy. The selected N sparks are treated as the fireworks for the next generation, whilst the rest of the sparks are no longer reserved. Sparks or fireworks are not kept, indicating the instantaneous characteristic of FWA

5.2.2. Simplicity

Like other swarm intelligence algorithms, each firework in FWA only percept its own information itself and its surrounding information, following simple rules to complete their missions. Overall, FWA is not complex, composing of simple individuals. Therefore, FWA is characteristic of simplicity.

5.2.3. Locality

In FWA, all the fireworks generate sparks within their amplitudes. Unless beyond the feasible region, sparks are confined within a certain range. Localized features of FWA reflects the powerful local search capabilities, as the algorithm can be used for local search in the latter of the search process. Therefore, FWA contains locality.

5.2.4. Diversity

Population diversity is vital to the performance of any swarm intelligence algorithm. By maintaining the population diversity, the algorithm can jump out of local optima, which makes the algorithm converges to the global optimal point whereas a generic optimization can hardly achieve. Therefore, swarm optimization algorithms are different from any generic optimization algorithm. The better the population diversity is, the wider the individuals are distributed. The optimal value might be easier to be found if a population is of strong diverse, as the convergence of the algorithm will not be affected significantly. Thus, population diversity is a very important part of the FWA. The diversities of FWA can be concluded as follows.

5.2.5. Extendibility

In FWA, the number of sparks are uncertain and able to be determined based on the complexity of the problem in hand. The number of fireworks and sparks can be more or less, as both increase and decrease the individuals can effectively solve the problem. Therefore, FWA has extendibility.

5.2.6. Adaptability

When solving problems using FWA, it is unnecessary for the problem to be of an explicit expression. The problem can be solved by calculating the fitness values only. Meanwhile, FWA can also solve the problems with explicit expressions, indicating its capability. Therefore, FWA is of adaptability and can be regarded as an adaptive algorithm

6. Fireworks Algorithm

ï»¿When a firework is set off, a shower of sparks will fill the local space around the firework. In our opinion, the explosion process of a firework can be viewed as a search in the local space around a specific point where the firework is set off through the sparks generated in the explosion. Mimicking the process of setting fireworks.

After a firework exploded, the sparks are appeared around a location. The process of exploding can be treated as searching the neighbor area around a specific location. Inspired by fireworks in real world, fireworks algorithm (FWA) is proposed. Fireworks algorithm utilizes N D-dimensional parameter vectors X_i^g as a basic population in each generation. Parameter i varied from 1 to N and parameter G stands for the index of generations.

Every individual in the population explodes and generates sparks around him/her. The number of sparks and the amplitude of each individual are determined by certain strategies. Furthermore, a Gaussian explosion is used to generate sparks to keep the diversity of the population. Finally, the algorithm keeps the best individual in the population and selects the rest (N - 1) individuals based on distance for next generation.

6.1. Parts of FWA

6.1.1. Operator Explosion

To initialize the algorithm is necessary to generate N fireworks, thus generating sparks fireworks explosion. In FWA, the operator explosion is key and play an important role.The explosion operator including explosion strength, explosion amplitude and displacement operation. The explosion strength is a core operation in explosion operator. It simulates the way of explosion of fireworks in real life. When a firework blasts, the firework vanished in one second and then many small bursts appear around it. Fireworks algorithm first determines the number of sparks, then calculates the amplitudes of each explosion.
Through the observations on the curves of some typical optimization functions, it can be seen that there are more points with good fitness values around the optima than that away from the optima. Therefore, the fireworks with better fitness values produce more sparks, avoiding swing around the optima but fail to locate it. For the fireworks with worse fitness values, their generated sparks are less in number and sparse in distribution, avoiding un-

necessary computing. The fireworks with worse fitness values are used to explore the feasible space, preventing the algorithm from premature convergence. Fireworks algorithm determines the number and amplitude of the fireworks according to their fitness values, letting the fireworks with better fitness values produce more sparks within a smaller amplitude and vice versa. The Explosion Amplitude through the observation on the curves of some typical optimization functions, the points around the local optima and global optima always have better fitness values. Therefore, by controlling the explosion amplitude, the amplitude of the fireworks with better fitness values gradually reducing, leading fireworks algorithm find the local optima and global optima. On the contrary, the fireworks with worse fitness values will explore the optima through a large amplitude. This is how the FWA controls the magnitude of the explosion amplitude.

After the calculation of explosion amplitude, it is necessary to determine the displacement within the explosion amplitude. FWA uses the random displacement. In this way, each firework has its own specific explosion number and amplitude of sparks. FWA generates different random displacements within each amplitude to ensure the diversity of population. Through the explosion operator, each firework generates a shower of sparks, helping finding the global optimal of an optimization function, this is called displacement operation

6.1.1.1. Explosion Strength

In the explosion strength, i.e., the number of sparks, is determined as follows.

$$S_i = m \frac{Y_{max} - f(x_i)}{\sum_{j=1}(Y_{max} - f(x_i))} \tag{5}$$

where S_i is the number of sparks for each individual or firework, m is a constant stands for the total number of sparks and $Y_{max}s$ means the fitness value of the worst individual among the N individuals in the population. Function f(x_i) represents the fitness for an individual x_i.

6.1.1.2. Explosion amplitude

The explosion amplitude is defined below.

$$A_i = A \frac{f(x_i) - Y_{min}}{\sum_{j=1}(f(x_i) - Y_{min})} \tag{6}$$

where A_i denotes the amplitude of each individual, A is a constant as the sum of all amplitudes, while Y_{min} means the fitness value of the best individual among the N individuals. The meaning of function f(x_i) is the same as aforementioned in Equation(5).

6.1.1.3. Displacement operation

Displacement operation is to make displacement on each dimension of a firework and can be defined as

$$\triangle x_i^k = x_i^k + U(-A_i, A_i), \tag{7}$$

where U($-A_i$,A_i) denotes the uniform random number within the intervals of the amplitude A_i.

6.1.2. Mutation Operator

To further improve the diversity of a population, the Gaussian mutation is introduced to FWA. The way of producing sparks by Gaussian mutation is as follows: choose a firework from the current population, then apply Gaussian mutation to the firework in randomly selected dimensions.
For Gaussian mutation, the new sparks are generated between the best firework and the selected fireworks. Still, Gaussian mutation may produce sparks exceed the feasible space. When a spark lies beyond the upper or lower boundary, the mapping rule will be carried out to map the spark to a new location within the feasible space.

Suppose the position of current individual be stated as x_i^k , where i varies from 1 to N and k denotes the current dimension. The sparks of Gaussian explosion are calculated by

$$x_i^k = x_i^k * g, \tag{8}$$

where g is a random number in Gaussian distribution with mean 1 and variance 1 such as

$$g = N(1; 1). \tag{9}$$

7. Binarization Functions

The search space problems in real variables and contunias can be converted into binary problems. A binary search space structure has some limitations as may be considered a hypercube. Officers from a binary optimization algorithm can only go from corners near the farthest in the hypercube changing several bits. Therefore the design was modified binary version of FWA, which has changed the flow of the metaheuristic going through a binarization system.

In FWA originally fireworks can move around a continuous search space with Diminio in the real. Therefore, it means the position is updated on a binary search space, with only two numbers 1 and 0.

Basically in the space of discrete binary search, the position is updated according to changes in the values between 0 and 1.This change is generated by the vectors of probabilities. It is also necessary to update probability vectors for binarization functions peudan be compared correctly.

Binarization functions are likely to change the position of the vector elements 0 to 1 or vice versa. These functions fuerszan movement in a binary space.
In this binarization use 8 functions separated into 2 groups. The S-shaped functions *S-Shaped* and functions *V-Shaped*, detailed in equations.

7.1. Shaped Functions S

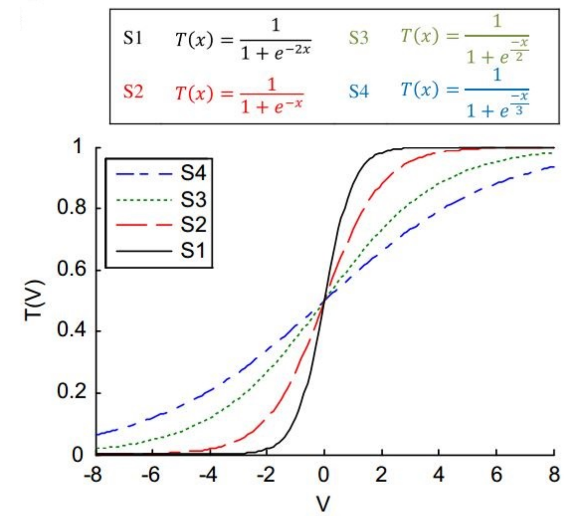

Figura 2: s-shaped family of transfer functions.

7.2. Shaped Functions V

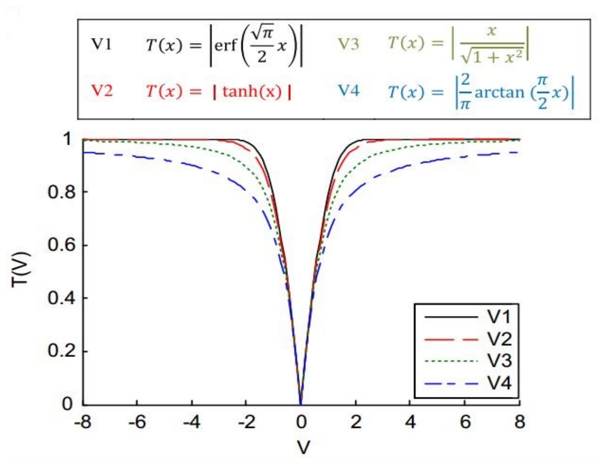

Figura 3: v-shaped family of transfer functions.

8. Binary Firework Algorithm

In this section it is presented the functioning of the algorithm.
In this section it is presented the functioning of the algorithm.

Step 1 Initialization the Firework parameters (initial amount of fireworks, mutation rate, number of iteration).

Step 2 Generate fireworks (at first, the number of fireworks will be given by the initial parameter).

Step 3 Calculate the amount and breadth of fireworks for each firework and also your fitness.

Step 4 Generate new solutions (fireworks) with the displacement operator equation.

Step 5 However, the operation of step 4, provides solutions to real numbers, and in this case (SCP) our solution must be in terms of 0 and 1. It is for this reason that the binarization of the solution is necessary. To fix this, we use the transfer functions that helps us define a chance to change an element of the solution to 1 to 0 , or vice versa.

Besides the Transfer functions, 5 discretization methods were used, Roulette wheel (10), Complement (11), Set the Best (12), Standard (13), Statics probability (14), these are showed below:

Roulette

$$p_i = \frac{f_i}{\sum_{j=1}^{k} f_j} \tag{10}$$

Complement

$$x_i^d(t+1) = \begin{cases} complement(x_i^k) & \text{if } rand \leq V_i^d(t+1) \\ 0 & \text{otherwise} \end{cases} \tag{11}$$

Set the Best

$$x_i^d(t+1) = \begin{cases} x_{best}^k & \text{if } rand \leq V_i^d(t+1) \\ 0 & \text{otherwise} \end{cases} \tag{12}$$

Standard

$$x_i^d(t+1) = \begin{cases} 1 & \text{if } rand \leq V_i^d(t+1) \\ 0 & \text{otherwise} \end{cases} \tag{13}$$

Statics probability

$$x_i^d(t+1) = \begin{cases} x_i^d & \text{if } V_i^d(t+1) \leq \alpha \\ x_{best}^d & \text{if } \alpha \leq V_i^d(t+1) \leq \frac{1}{2}(1+\alpha) \\ x_1^d & \text{if } \frac{1}{2}(1+\alpha) \leq V_i^d(t+1) \end{cases} \tag{14}$$

Step 6 Fireworks mutate randomly selected (The quantity index indicating initialized in step 1).

Step 7 Again with new fireworks (generated and mutated) is calculated the fitness and is necessary to keep the minimum to be compared in a next iteration. the number of iterations is given in the initialization parameters.

8.1. Pseudo Code of FWA

In this section we review the pseudocode FWA.

Algorithm 1 $FWA()$

Generate N Firework
Calculate Fitness of each firework X_i with $i = ()1, ..., N)$
Calculate maximum value of fitness
Calculate minimum value of fitness
While (number of iteration <m (maximum iterations) **do**
Calculate number of spark of each firework and sum total of sparks s
calculate amplitude of each firework X_i
While number of iteration <s **do**
Generate sparks S_i from quantity and amplitude firework X_i
end while;
Binarizing sparks S_i
// m is the number of sparks generated by Gaussian mutation
for $k = 1 \to m$ **do**
Randomly select a firework X_i and generate a spark
end for;
$X_i = S_i$
Calculate the New Fitness of each firework X_i
save minimum of all fireworks
end while;

9. Results

Table 5 and 5 show the best result obtained over the 65 instances with different methods. The quality of a solution is evaluated using the relative percentage deviation (RPD). The RPD value quantifies the deviation of the objective value Z from Z_{opt} which in our case is the best known cost value for each instance. We report the minimum, maximum, and average of the obtained solutions. to compute RPD we use $Z = Min$, calculate as follows:

$$RPD = \frac{(Z - Z_{opt})}{Z_{opt}} * 100 \tag{15}$$

Experimental results over the 65 instances of SCP.

Instance	method of discretization	Transfer functions	Opt.	Min.	Man.	Avg.	RPD
4.1	Standar	S1	429	436	437	436.7	1,61
4.2	Standar	S3	512	533	536	534.6	3,94
4.3	Standar	S1	516	526	526	526	1,90
4.4	The Best	V3	494	505	532	523.85	2,18
4.5	The Best	V2	512	517	527	525.7	0,97
4.6	The Best	V2	560	564	607	598.55	0,71
4.7	The Best	V2	430	434	447	444.2	0,92
4.8	Standar	V2	492	499	509	505,8	1,42
4.9	The Best	V3	641	670	697	691.9	4,33
4.10	The Best	V3	514	538	572	560.85	4,46
5.1	Roulette	V4	253	274	280	279.65	7,66
5.2	Standar	V2	302	312	317	314,4	3,31
5.3	Standar	V2	226	233	247	236,7	3,10
5.4	Standar	V2	242	246	251	248,5	1,65
5.5	Roulette	V2	211	219	225	224.7	3,65
5.6	Standar	V2	213	230	247	237,1	7,98
5.7	Standar	V2	293	311	315	314,9	6,14
5.8	Roulette	V1	288	302	316	314.8	4,64
5.9	Roulette	V1	279	292	315	312.65	4,45
5.10	Roulette	S1	265	275	280	279.05	3,64
6.1	Roulette	S2	138	147	152	151.45	6,12
6.2	Standar	V2	146	151	155	153,9	3,42
6.3	Standar	V2	145	150	160	156	3,45
6.4	Roulette	S1	131	134	140	139.5	2,24
6.5	Standar	V2	161	175	184	180,1	8,70
A.1	Standar	V2	253	257	261	260,4	1,58
A.2	Standar	V2	252	269	277	274	6,75
A.3	Roulette	S1	232	249	252	205,8	7,33
A.4	Roulette	S2	234	242	294	259.5	3,31
A.5	Standar	V2	236	239	241	240,3	1,27
B.1	Standar	V2	69	79	86	83,7	14,49
B.2	Standar	V2	76	83	88	87,03	9,21
B.3	Roulette	S1	80	84	100	85.8	4,76
B.4	Standar	V2	79	83	84	83,9	5,06
B.5	Standar	V2	72	72	78	77,23	0,00

Tabla 5: Experimental results over the first 35 instances of SCP.

Instance	Methods of discretization	Transfer functions	Opt.	Min.	Man.	Avg.	RPD
C.1	Standar	V2	227	234	235	234,8	3,08
C.2	Standar	V2	219	231	236	235,1	5,48
C.3	Standar	V2	243	264	270	269,2	8,64
C.4	Standar	V2	219	239	246	244,6	9,13
C.5	Standar	V2	215	219	223	221,5	1,86
D.1	Roulette	S1	60	61	92	63.95	1,64
D.2	Standar	V2	66	71	73	72,5	7,58
D.3	Roulette	V4	72	78	79	78.9	7,69
D.4	Standar	V2	62	65	68	63,3	4,84
D.5	Roulette	V2	61	64	66	65.55	4,69
NRE.1	The Best	V3	29	30	30	30	3,33
NRE.2	Roulette	V3	30	34	35	34.95	11,76
NRE.3	Standar	V2	27	30	34	32	11,11
NRE.4	Standar	V2	28	32	33	32,8	14,29
NRE.5	Standar	V2	28	29	30	29,9	3,57
NRF.1	Roulette	S1	29	30	112	36.5	3,33
NRF.2	Standar	V2	15	17	18	17,9	13,33
NRF.3	Roulette	S1	14	17	180	33.45	17,65
NRF.4	Roulette	S1	14	16	18	17.75	12,50
NRF.5	Roulette	S1	13	16	16	16	18,75
NRG.1	Standar	V2	176	193	196	194,6	9,66
NRG.2	Standar	V2	154	166	168	167,3	7,79
NRG.3	Standar	V2	166	170	180	179,4	2,41
NRG.4	Standar	V2	168	180	184	182,1	7,14
NRG.5	Standar	V2	168	185	188	186,9	10,12
NRH.1	Standar	V2	63	71	73	72,4	12,70
NRH.2	Standar	V2	63	66	67	66,9	4,76
NRH.3	Roulette	S2	59	66	69	68.85	10,61
NRH.4	Roulette	S2	58	66	68	67.8	12,12
NRH.5	Standar	V2	55	60	61	60,9	9,09

Tabla 6: Experimental results over the 30 instances of SCP.

10. Conclussions

10.1. About the Work

According to the five specific objetives of this work. it is conclude that compliance is given fully to all of them, because it was achieved to study, research and develop the proposed algorithm (problem and technique), evaluating the transfer functions family and the results compared with literature.

Considering the experiments, the initial parameters depend on the instance to solve the SCP, as we advance in the instances, it is necessary to increase the number of iterations increase the percentage of mutated sparks and the number of fireworks. This is because the firework must travel or generate more sparks to find a lower value, that is, we need to explore more on solutions.

We conclude that the technique based metaheuristic fireworks if it works, but there is a considerable loss of information, the binarizing the solution binarization function. This means that success will not occur in instances. This loss of information exists because binarization function gives us sparks are not valid because they do not meet the restrictions of the SCP, then the algorithm generates sparks until it finds a spark valid, if not generate a certain number of iterations valid sparks, mutates the spark generated algorithm to be certain it is valid and not be in a loop. However, it opens the door for future research, not only because we can use this technique binarization, but we can combine this technique with repair techniques.

from the experimental results it is concluded that the metaheuristic behaves good in almost all instances, highlighting , finding the best solution known (B.5) and in many other intancias it was a point of getting the best optimal known. We can also see that the RPD average of all instances is 6.11 percent.

The effectiveness of the proposed approach was tedted on benchmark problems and the obtained results sow that Binary Firework Algorithms is a good alternative to solve the SCP, being the main use of this metaheuristic for continous domains.

10.2. Personal Experience

Such work , which is much research, are always a challenge. The subject and everything that involves a job is unknown. Despite that in the beginning everything was frustration to completely ignore the subject, one can draw positive lessons as it was possible to achieve the objectives. Clearly , this experience helps a lot in the near future employment or academic .

The students are used to perform practical work throughout college life there are very few instances to Develop research , it is for reason esta esta Because doubly valuable experience in the day to day is Necessary to study the unknown or innovation or Also be out of the comfort zone and do something that you are not expert.

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11. annexed

Instance	Opt.	Min.	Man.	Avg.	RPD
4.1	429	443	449	448,6	3,26
4.2	512	549	559	557,75	7,23
4.3	516	532	537	536,45	3,10
4.4	494	515	532	529,55	4,25
4.5	512	526	527	526,95	2,73
4.6	560	598	607	606	6,79
4.7	430	447	447	447	3,95
4.8	492	509	509	509	3,46
4.9	641	685	697	695,1	6,86
4.10	514	551	572	570,1	7,20
5.1	253	280	280	280	10,67
5.2	302	317	317	317	4,97
5.3	226	247	247	247	9,29
5.4	242	251	251	251	3,72
5.5	211	225	225	225	6,64
5.6	213	247	247	247	15,96
5.7	293	315	315	315	7,51
5.8	288	316	316	316	9,72
5.9	279	315	315	315	12,90
5.10	265	280	280	280	5,66
6.1	138	152	152	152	10,14
6.2	146	160	160	160	9,59
6.3	145	160	160	160	10,34
6.4	131	140	140	140	6,87
6.5	161	183	186	185,8	13,66
A.1	253	261	261	261	3,16
A.2	252	277	277	277	9,92
A.3	232	252	252	252	8,62
A.4	234	250	250	250	6,84
A.5	236	241	241	241	2,12
B.1	69	86	86	86	24,64
B.2	76	88	88	88	15,79
B.3	80	85	85	85	6,25
B.4	79	84	84	84	6,33
B.5	72	78	78	78	8,33

Tabla 7: Standard V1.

Instance	Opt.	Min.	Man.	Avg.	RPD
C.1	227	235	235	235	3,52
C.2	219	236	236	236	7,76
C.3	243	270	270	270	11,11
C.4	219	246	246	246	12,33
C.5	215	223	223	223	3,72
D.1	60	62	62	62	3,33
D.2	66	74	74	74	12,12
D.3	72	79	79	79	9,72
D.4	62	68	68	68	9,68
D.5	61	66	66	66	8,20
NRE.1	29	30	30	30	3,45
NRE.2	30	35	35	35	16,67
NRE.3	27	34	34	34	25,93
NRE.4	28	33	33	33	17,86
NRE.5	28	30	30	30	7,14
NRF.1	14	17	17	17	21,43
NRF.2	15	18	18	18	20,00
NRF.3	14	17	17	17	21,43
NRF.4	14	18	18	18	28,57
NRF.5	13	16	16	16	23,08
NRG.1	176	196	196	196	11,36
NRG.2	154	168	168	168	9,09
NRG.3	166	180	180	180	8,43
NRG.4	168	184	184	184	9,52
NRG.5	168	189	189	189	12,50
NRH.1	63	73	73	73	15,87
NRH.2	63	67	67	67	6,35
NRH.3	59	69	69	69	16,95
NRH.4	58	68	68	68	17,24
NRH.5	55	61	61	61	10,91

Tabla 8: Standard V1.

Instance	Opt.	Min.	Man.	Avg.	RPD
4.1	429	442	449	446,7	3,03
4.2	512	541	559	545,1	5,66
4.3	516	527	537	529	2,13
4.4	494	513	530	527,5	3,85
4.5	512	518	527	521,5	1,17
4.6	560	578	607	603,8	3,21
4.7	430	435	447	438,2	1,16
4.8	492	499	509	505,8	1,42
4.9	641	682	695	693,1	6,40
4.10	514	548	571	545,3	6,61
5.1	253	274	280	277,8	8,30
5.2	302	312	317	314,4	3,31
5.3	226	233	247	236,7	3,10
5.4	242	246	251	248,5	1,65
5.5	211	219	225	223,1	3,79
5.6	213	230	247	237,1	7,98
5.7	293	311	315	314,9	6,14
5.8	288	302	316	311,9	4,86
5.9	279	299	315	300,6	7,17
5.10	265	275	280	274,2	3,77
6.1	138	147	152	150,2	6,52
6.2	146	151	155	153,9	3,42
6.3	145	150	160	156	3,45
6.4	131	134	140	137,9	2,29
6.5	161	175	184	180,1	8,70
A.1	253	257	261	260,4	1,58
A.2	252	269	277	274	6,75
A.3	232	249	252	205,8	7,33
A.4	234	242	249	245,9	3,42
A.5	236	239	241	240,3	1,27
B.1	69	79	86	83,7	14,49
B.2	76	83	88	87,03	9,21
B.3	80	84	85	84,9	5,00
B.4	79	83	84	83,9	5,06
B.5	72	72	78	77,23	0,00

Tabla 9: Standard V2.

Instance	Opt.	Min.	Man.	Avg.	RPD
C.1	227	234	235	234,8	3,08
C.2	219	231	236	235,1	5,48
C.3	243	264	270	269,2	8,64
C.4	219	239	246	244,6	9,13
C.5	215	219	223	221,5	1,86
D.1	60	61	62	61,1	1,67
D.2	66	71	73	72,5	7,58
D.3	72	78	79	78,9	8,33
D.4	62	65	68	63,3	4,84
D.5	61	64	66	66,3	4,92
NRE.1	29	30	30	30	3,45
NRE.2	30	34	35	34,3	13,33
NRE.3	27	30	34	32	11,11
NRE.4	28	32	33	32,8	14,29
NRE.5	28	29	30	29,9	3,57
NRF.1	14	16	17	16,8	14,29
NRF.2	15	17	18	17,9	13,33
NRF.3	14	17	17	17	21,43
NRF.4	14	16	18	16,8	14,29
NRF.5	13	16	16	16	23,08
NRG.1	176	193	196	194,6	9,66
NRG.2	154	166	168	167,3	7,79
NRG.3	166	170	180	179,4	2,41
NRG.4	168	180	184	182,1	7,14
NRG.5	168	185	188	186,9	10,12
NRH.1	63	71	73	72,4	12,70
NRH.2	63	66	67	66,9	4,76
NRH.3	59	66	69	68,7	11,86
NRH.4	58	66	68	66,9	13,79
NRH.5	55	60	61	60,9	9,09

Tabla 10: Standard V2.

Instance	Opt.	Min.	Man.	Avg.	RPD
4.1	429	449	449	449	4,66
4.2	512	559	559	559	9,18
4.3	516	537	537	537	4,07
4.4	494	529	532	531,65	7,09
4.5	512	527	527	527	2,93
4.6	560	601	607	606,25	7,32
4.7	430	447	447	447	3,95
4.8	492	501	509	508,6	1,83
4.9	641	685	697	696,3	6,86
4.10	514	561	572	571,4	9,14
5.1	253	280	280	280	10,67
5.2	302	317	317	317	4,97
5.3	226	246	247	246,95	8,85
5.4	242	251	251	251	3,72
5.5	211	225	225	225	6,64
5.6	213	240	247	246,65	12,68
5.7	293	315	315	315	7,51
5.8	288	315	316	315,85	9,38
5.9	279	315	315	315	12,90
5.10	265	280	280	280	5,66
6.1	138	152	152	152	10,14
6.2	146	154	160	159,7	5,48
6.3	145	160	160	160	10,34
6.4	131	140	140	140	6,87
6.5	161	181	186	185,35	12,42
A.1	253	261	261	261	3,16
A.2	252	277	277	277	9,92
A.3	232	252	252	252	8,62
A.4	234	250	250	250	6,84
A.5	236	241	241	241	2,12
B.1	69	86	86	86	24,64
B.2	76	88	88	88	15,79
B.3	80	85	85	85	6,25
B.4	79	84	84	84	6,33
B.5	72	78	78	78	8,33

Tabla 11: Standard V3.

Instance	Opt.	Min.	Man.	Avg.	RPD
C.1	227	235	235	235	3,52
C.2	219	236	236	236	7,76
C.3	243	270	270	270	11,11
C.4	219	246	246	246	12,33
C.5	215	223	223	223	3,72
D.1	60	62	62	62	3,33
D.2	66	74	74	74	12,12
D.3	72	79	79	79	9,72
D.4	62	68	68	68	9,68
D.5	61	66	66	66	8,20
NRE.1	29	30	30	30	3,45
NRE.2	30	35	35	35	16,67
NRE.3	27	34	34	34	25,93
NRE.4	28	33	33	33	17,86
NRE.5	28	30	30	30	7,14
NRF.1	14	17	17	17	21,43
NRF.2	15	18	18	18	20,00
NRF.3	14	17	17	17	21,43
NRF.4	14	18	18	18	28,57
NRF.5	13	16	16	16	23,08
NRG.1	176	196	196	196	11,36
NRG.2	154	168	168	168	9,09
NRG.3	166	180	180	180	8,43
NRG.4	168	184	184	184	9,52
NRG.5	168	189	189	189	12,50
NRH.1	63	73	73	73	15,87
NRH.2	63	67	67	67	6,35
NRH.3	59	69	69	69	16,95
NRH.4	58	68	68	68	17,24
NRH.5	55	61	61	61	10,91

Tabla 12: Standard V3.

Instance	Opt.	Min.	Man.	Avg.	RPD
4.1	429	449	449	449	4,66
4.2	512	559	559	559	9,18
4.3	516	537	537	537	4,07
4.4	494	532	532	532	7,69
4.5	512	527	527	527	2,93
4.6	560	607	607	607	8,39
4.7	430	447	447	447	3,95
4.8	492	509	509	509	3,46
4.9	641	697	697	697	8,74
4.10	514	572	572	572	11,28
5.1	253	280	280	280	10,67
5.2	302	317	317	317	4,97
5.3	226	247	247	247	9,29
5.4	242	251	251	251	3,72
5.5	211	225	225	225	6,64
5.6	213	247	247	247	15,96
5.7	293	315	315	315	7,51
5.8	288	316	316	316	9,72
5.9	279	315	315	315	12,90
5.10	265	280	280	280	5,66
6.1	138	152	152	152	10,14
6.2	146	160	160	160	9,59
6.3	145	160	160	160	10,34
6.4	131	140	140	140	6,87
6.5	161	186	186	186	15,53
A.1	253	261	261	261	3,16
A.2	252	277	277	277	9,92
A.3	232	252	252	252	8,62
A.4	234	250	250	250	6,84
A.5	236	241	241	241	2,12
B.1	69	86	86	86	24,64
B.2	76	88	88	88	15,79
B.3	80	85	85	85	6,25
B.4	79	84	84	84	6,33
B.5	72	78	78	78	8,33

Tabla 13: Standard V4.

Instance	Opt.	Min.	Man.	Avg.	RPD
C.1	227	235	235	235	3,52
C.2	219	236	236	236	7,76
C.3	243	270	270	270	11,11
C.4	219	246	246	246	12,33
C.5	215	223	223	223	3,72
D.1	60	62	62	62	3,33
D.2	66	74	74	74	12,12
D.3	72	79	79	79	9,72
D.4	62	68	68	68	9,68
D.5	61	66	66	66	8,20
NRE.1	29	30	30	30	3,45
NRE.2	30	35	35	35	16,67
NRE.3	27	34	34	34	25,93
NRE.4	28	33	33	33	17,86
NRE.5	28	30	30	30	7,14
NRF.1	14	17	17	17	21,43
NRF.2	15	18	18	18	20,00
NRF.3	14	17	17	17	21,43
NRF.4	14	18	18	18	28,57
NRF.5	13	16	16	16	23,08
NRG.1	176	196	196	196	11,36
NRG.2	154	168	168	168	9,09
NRG.3	166	180	180	180	8,43
NRG.4	168	184	184	184	9,52
NRG.5	168	189	189	189	12,50
NRH.1	63	73	73	73	15,87
NRH.2	63	67	67	67	6,35
NRH.3	59	69	69	69	16,95
NRH.4	58	68	68	68	17,24
NRH.5	55	61	61	61	10,91

Tabla 14: Standard V4.

Instance	Opt.	Min.	Man.	Avg.	RPD
4.1	429	436	437	436.7	1,61
4.2	512	546	557	550.7	6,23
4.3	516	526	526	526	1,90
4.4	494	518	561	545.5	4,63
4.5	512	523	623	544.2	2,10
4.6	560	590	723	610.5	5,08
4.7	430	451	458	453.1	4,66
4.8	492	611	611	611	19,48
4.9	641	685	764	751.4	6,42
4.10	514	551	631	580.55	6,72
5.1	253	278	15519	1718.85	8,99
5.2	302	317	14744	1206.9	4,73
5.3	226	247	15043	1275.15	8,50
5.4	242	251	13292	1103.6	3,59
5.5	211	225	19994	2949.85	6,22
5.6	213	245	15818	2566.85	13,06
5.7	293	313	18482	3328.85	6,39
5.8	288	315	1831	488.15	8,57
5.9	279	307	17593	1901.85	9,12
5.10	265	280	15150	1236.95	5,36
6.1	138	152	8128	2601.65	9,21
6.2	146	154	7977	1941.7	5,19
6.3	145	168	7769	1627.85	13,69
6.4	131	140	8255	2136.1	6,43
6.5	161	181	8048	1779.9	11,05
A.1	253	261	30015	8254.65	3,07
A.2	252	289	29826	10438.15	12,80
A.3	232	251	20686	5809.45	7,57
A.4	234	350	27513	8206.65	33,14
A.5	236	246	24947	7447.3	4,07
B.1	69	318	21589	13275.1	78,30
B.2	76	234	26757	13889.3	67,52
B.3	80	8857	23701	17757.2	99,10
B.4	79	216	24555	14306.45	63,43
B.5	72	124	22933	14657.55	41,94

Tabla 15: Standard S1.

Instance	Opt.	Min.	Man.	Avg.	RPD
C.1	227	236	30019	11643.45	3,81
C.2	219	587	34745	17578.9	62,69
C.3	243	480	31873	15037.3	49,38
C.4	219	276	26925	13711.4	20,65
C.5	215	237	37186	17057.45	9,28
D.1	60	7139	30980	20209.95	100,00
D.2	66	85	34318	19794.1	100,00
D.3	72	6659	37343	21069.55	100,00
D.4	62	1027	30087	19829.4	100,00
D.5	61	6877	30954	20350.5	100,00
NRE.1	29	9853	40607	26890.05	99,71
NRE.2	30	11160	46796	25200.7	99,73
NRE.3	27	13791	40337	27570.2	99,80
NRE.4	28	5252	41928	22925.05	99,47
NRE.5	28	3688	42035	24994.8	99,24
NRF.1	14	12296	36131	25069.1	99,89
NRF.2	15	8952	36915	23235.7	99,83
NRF.3	14	10705	46025	26136.35	99,87
NRF.4	14	7911	46071	21260.25	99,82
NRF.5	13	4561	43988	25917.05	99,71
NRG.1	176	4040	71816	47465.65	95,64
NRG.2	154	4084	64492	42305.9	96,23
NRG.3	166	28702	84681	56414.75	99,42
NRG.4	168	21450	96794	48236.2	99,22
NRG.5	168	350	84489	44865.9	52,00
NRH.1	63	22119	86963	50496.25	99,72
NRH.2	63	18910	92579	45425.2	99,67
NRH.3	59	24800	81322	45584.2	99,76
NRH.4	58	586	92852	50199.05	90,10
NRH.5	55	10041	84844	47148.8	99,45

Tabla 16: Standard S1.

Instance	Opt.	Min.	Man.	Avg.	RPD
4.1	429	439	448	445,75	2,28
4.2	512	536	544	542	4,48
4.3	516	528	536	534	2,27
4.4	494	513	522	519,75	3,70
4.5	512	528	633	606,75	3,03
4.6	560	588	733	696,75	4,76
4.7	430	442	468	461,5	2,71
4.8	492	502	621	591,25	1,99
4.9	641	674	774	749	4,90
4.10	514	553	641	619	7,05
5.1	253	280	15529	11716,75	9,64
5.2	302	319	14754	11145,25	5,33
5.3	226	249	15053	11352	9,24
5.4	242	253	13302	10039,75	4,35
5.5	211	227	20004	15059,75	7,05
5.6	213	247	15828	11932,75	13,77
5.7	293	315	18492	13947,75	6,98
5.8	288	317	1841	1460	9,15
5.9	279	309	17603	13279,5	9,71
5.10	265	282	15160	11440,5	6,03
6.1	138	154	8138	6142	10,39
6.2	146	156	7987	6029,25	6,41
6.3	145	170	7779	5876,75	14,71
6.4	131	142	8265	6234,25	7,75
6.5	161	183	8058	6089,25	12,02
A.1	253	263	30025	22584,5	3,80
A.2	252	291	29836	22449,75	13,40
A.3	232	253	20696	15585,25	8,30
A.4	234	352	27523	20730,25	33,52
A.5	236	248	24957	18779,75	4,84
B.1	69	320	21599	16279,25	78,44
B.2	76	236	26767	20134,25	67,80
B.3	80	8859	23711	19998	99,10
B.4	79	218	24565	18478,25	63,76
B.5	72	126	22943	17238,75	42,86

Tabla 17: The Best S1.

Instance	Opt.	Min.	Man.	Avg.	RPD
C.1	227	238	30029	22581,25	4,62
C.2	219	589	34755	26213,5	62,82
C.3	243	482	31883	24032,75	49,59
C.4	219	278	26935	20270,75	21,22
C.5	215	239	37196	27956,75	10,04
D.1	60	7141	30990	25027,75	100,00
D.2	66	87	34328	25767,75	100,00
D.3	72	6661	37353	29680	100,00
D.4	62	1029	30097	22830	100,00
D.5	61	6879	30964	24942,75	100,00
NRE.1	29	9855	40617	32926,5	99,71
NRE.2	30	11162	46806	37895	99,73
NRE.3	27	13793	40347	33708,5	99,80
NRE.4	28	5254	41938	32767	99,47
NRE.5	28	3690	42045	32456,25	99,24
NRF.1	14	12298	36141	30180,25	99,89
NRF.2	15	8954	36925	29932,25	99,83
NRF.3	14	10707	46035	37203	99,87
NRF.4	14	7913	46081	36539	99,82
NRF.5	13	4563	43998	34139,25	99,72
NRG.1	176	4042	71826	54880	95,65
NRG.2	154	4086	64502	49398	96,23
NRG.3	166	28704	84691	70694,25	99,42
NRG.4	168	21452	96804	77966	99,22
NRG.5	168	352	84499	63462,25	52,27
NRH.1	63	22121	86973	70760	99,72
NRH.2	63	18912	92589	74169,75	99,67
NRH.3	59	24802	81332	67199,5	99,76
NRH.4	58	588	92862	69793,5	90,14
NRH.5	55	10043	84854	66151,25	99,45

Tabla 18: The Best S1.

Instance	Opt.	Min.	Man.	Avg.	RPD
4.1	429	451	590	555,25	4,88
4.2	512	547	694	657,25	6,40
4.3	516	529	613	592	2,46
4.4	494	521	563	552,5	5,18
4.5	512	521	573	560	1,73
4.6	560	596	682	660,5	6,04
4.7	430	440	521	500,75	2,27
4.8	492	504	710	658,5	2,38
4.9	641	693	766	747,75	7,50
4.10	514	561	634	615,75	8,38
5.1	253	277	15583	11756,5	8,66
5.2	302	317	21018	15842,75	4,73
5.3	226	251	14950	11275,25	9,96
5.4	242	254	17222	12980	4,72
5.5	211	228	19699	14831,25	7,46
5.6	213	238	19084	14372,5	10,50
5.7	293	318	13426	10149	7,86
5.8	288	319	12157	9197,5	9,72
5.9	279	291	16549	12484,5	4,12
5.10	265	280	19530	14717,5	5,36
6.1	138	157	9234	6964,75	12,10
6.2	146	161	9011	6798,5	9,32
6.3	145	160	7629	5761,75	9,38
6.4	131	143	8908	6716,75	8,39
6.5	161	183	9771	7374	12,02
A.1	253	281	22742	17126,75	9,96
A.2	252	276	20894	15739,5	8,70
A.3	232	284	23382	17607,5	18,31
A.4	234	254	24342	18320	7,87
A.5	236	287	27394	20617,25	17,77
B.1	69	6718	23282	19141	98,97
B.2	76	1351	24611	18796	94,37
B.3	80	4888	23641	18952,75	98,36
B.4	79	690	25983	19659,75	88,55
B.5	72	7811	30962	25174,25	99,08

Tabla 19: The Best S2.

Instance	Opt.	Min.	Man.	Avg.	RPD
C.1	227	239	33328	25055,75	5,02
C.2	219	240	30847	23195,25	8,75
C.3	243	396	39730	29896,5	38,64
C.4	219	274	35268	26519,5	20,07
C.5	215	225	28058	21099,75	4,44
D.1	60	7142	30990	25028	100,00
D.2	66	88	34328	25768	100,00
D.3	72	6662	37353	29680,25	100,00
D.4	62	1030	30097	22830,25	100,00
D.5	61	6880	30964	24943	100,00
NRE.1	29	5714	44113	34513,25	99,49
NRE.2	30	8932	43428	34804	99,66
NRE.3	27	8364	39034	31366,5	99,68
NRE.4	28	5650	47125	36756,25	99,50
NRE.5	28	8657	39516	31801,25	99,68
NRF.1	14	6986	48590	38189	99,80
NRF.2	15	8140	38558	30953,5	99,82
NRF.3	14	14125	35691	30299,5	99,90
NRF.4	14	4121	48862	37676,75	99,66
NRF.5	13	5303	38408	30131,75	99,75
NRG.1	176	3232	98484	74671	94,55
NRG.2	154	23473	83878	68776,75	99,34
NRG.3	166	24890	75513	62857,25	99,33
NRG.4	168	612	83599	62852,25	72,55
NRG.5	168	3479	111104	84197,75	95,17
NRH.1	63	20575	90596	73090,75	99,69
NRH.2	63	12978	100456	78586,5	99,51
NRH.3	59	8942	106897	82408,25	99,34
NRH.4	58	17027	102881	81417,5	99,66
NRH.5	55	12841	83093	65530	99,57

Tabla 20: The Best S2.

Instance	Opt.	Min.	Man.	Avg.	RPD
4.1	429	468	711	650,25	8,33
4.2	512	550	816	749,5	6,91
4.3	516	587	616	608,75	12,10
4.4	494	524	566	555,5	5,73
4.5	512	524	576	563	2,29
4.6	560	592	803	750,25	5,41
4.7	430	446	524	504,5	3,59
4.8	492	506	713	661,25	2,77
4.9	641	678	888	835,5	5,46
4.10	514	557	637	617	7,72
5.1	253	340	15586	11774,5	25,59
5.2	302	323	21021	15846,5	6,50
5.3	226	254	14953	11278,25	11,02
5.4	242	257	17225	12983	5,84
5.5	211	231	19702	14834,25	8,66
5.6	213	296	19087	14389,25	28,04
5.7	293	321	13547	10240,5	8,72
5.8	288	322	12160	9200,5	10,56
5.9	279	294	16552	12487,5	5,10
5.10	265	283	19533	14720,5	6,36
6.1	138	158	9237	6967,25	12,66
6.2	146	166	9014	6802	12,05
6.3	145	222	7632	5779,5	34,68
6.4	131	146	8911	6719,75	10,27
6.5	161	192	9774	7378,5	16,15
A.1	253	267	22865	17215,5	5,24
A.2	252	283	20897	15743,5	10,95
A.3	232	258	23385	17603,25	10,08
A.4	234	256	24345	18322,75	8,59
A.5	236	252	27397	20610,75	6,35
B.1	69	324	23285	17544,75	78,70
B.2	76	240	24614	18520,5	68,33
B.3	80	8920	23644	19963	99,10
B.4	79	222	25986	19545	64,41
B.5	72	130	30965	23256,25	44,62

Tabla 21: The Best S3.

Instance	Opt.	Min.	Man.	Avg.	RPD
C.1	227	242	33331	25058,75	6,20
C.2	219	652	30973	23392,75	66,41
C.3	243	486	39733	29921,25	50,00
C.4	219	282	35271	26523,75	22,34
C.5	215	228	28184	21195	5,70
D.1	60	7145	30993	25031	100,00
D.2	66	145	34331	25784,5	100,00
D.3	72	6665	37356	29683,25	100,00
D.4	62	1089	30100	22847,25	100,00
D.5	61	6883	30967	24946	100,00
NRE.1	29	5717	44234	34604,75	99,49
NRE.2	30	8991	43431	34821	99,67
NRE.3	27	8367	39037	31369,5	99,68
NRE.4	28	5653	47246	36847,75	99,50
NRE.5	28	8660	39519	31804,25	99,68
NRF.1	14	6989	48593	38192	99,80
NRF.2	15	8143	38561	30956,5	99,82
NRF.3	14	14128	35814	30392,5	99,90
NRF.4	14	4180	48865	37693,75	99,67
NRF.5	13	5306	38411	30134,75	99,75
NRG.1	176	3235	98487	74674	94,56
NRG.2	154	23476	83881	68779,75	99,34
NRG.3	166	24893	75516	62860,25	99,33
NRG.4	168	674	83602	62870	75,07
NRG.5	168	3538	111107	84214,75	95,25
NRH.1	63	20578	91928	74090,5	99,69
NRH.2	63	13036	100577	78691,75	99,52
NRH.3	59	8945	107024	82504,25	99,34
NRH.4	58	17086	103003	81523,75	99,66
NRH.5	55	12899	83215	65636	99,57

Tabla 22: The Best S3.

Instance	Opt.	Min.	Man.	Avg.	RPD
4.1	429	452	602	564,5	5,09
4.2	512	548	706	666,5	6,57
4.3	516	530	625	601,25	2,64
4.4	494	559	575	571	11,63
4.5	512	522	585	569,25	1,92
4.6	560	590	694	668	5,08
4.7	430	444	533	510,75	3,15
4.8	492	504	722	667,5	2,38
4.9	641	715	778	762,25	10,35
4.10	514	555	646	623,25	7,39
5.1	253	282	15595	11766,75	10,28
5.2	302	321	21030	15852,75	5,92
5.3	226	252	14962	11284,5	10,32
5.4	242	255	17234	12989,25	5,10
5.5	211	229	19711	14840,5	7,86
5.6	213	239	19096	14381,75	10,88
5.7	293	319	13438	10158,25	8,15
5.8	288	320	12169	9206,75	10,00
5.9	279	292	16561	12493,75	4,45
5.10	265	281	19542	14726,75	5,69
6.1	138	158	9246	6974	12,66
6.2	146	162	9023	6807,75	9,88
6.3	145	161	7641	5771	9,94
6.4	131	182	8920	6735,5	28,02
6.5	161	184	9783	7383,25	12,50
A.1	253	320	22754	17145,5	20,94
A.2	252	277	20906	15748,75	9,03
A.3	232	285	23394	17616,75	18,60
A.4	234	354	24354	18354	33,90
A.5	236	283	27406	20625,25	16,61
B.1	69	4358	23294	18560	98,42
B.2	76	150	24623	18504,75	49,33
B.3	80	8402	23653	19840,25	99,05
B.4	79	5522	25995	20876,75	98,57
B.5	72	6516	30974	24859,5	98,90

Tabla 23: The Best S4.

Instance	Opt.	Min.	Man.	Avg.	RPD
C.1	227	430	33340	25112,5	47,21
C.2	219	253	30859	23207,5	13,44
C.3	243	484	39742	29927,5	49,79
C.4	219	280	35280	26530	21,79
C.5	215	226	28070	21109	4,87
D.1	60	7143	31002	25037,25	100,00
D.2	66	89	34340	25777,25	100,00
D.3	72	6663	37365	29689,5	100,00
D.4	62	1031	30109	22839,5	100,00
D.5	61	6881	30976	24952,25	100,00
NRE.1	29	5715	44125	34522,5	99,49
NRE.2	30	8933	43440	34813,25	99,66
NRE.3	27	8365	39046	31375,75	99,68
NRE.4	28	5651	47137	36765,5	99,50
NRE.5	28	9097	39528	31920,25	99,69
NRF.1	14	6987	48602	38198,25	99,80
NRF.2	15	8141	38570	30962,75	99,82
NRF.3	14	14163	35703	30318	99,90
NRF.4	14	4122	48874	37686	99,66
NRF.5	13	5742	38420	30250,5	99,77
NRG.1	176	3233	98496	74680,25	94,56
NRG.2	154	23474	83890	68786	99,34
NRG.3	166	24891	75525	62866,5	99,33
NRG.4	168	654	83611	62871,75	74,31
NRG.5	168	3480	111116	84207	95,17
NRH.1	63	20576	90608	73100	99,69
NRH.2	63	12981	100468	78596,25	99,51
NRH.3	59	8943	106909	82417,5	99,34
NRH.4	58	17038	102893	81429,25	99,66
NRH.5	55	12883	83105	65549,5	99,57

Tabla 24: The Best S4.

Instance	Opt.	Min.	Man.	Avg.	RPD
4.1	429	437	449	446.15	1,83
4.2	512	547	559	556.85	6,40
4.3	516	528	537	534.6	2,27
4.4	494	508	532	526.4	2,76
4.5	512	523	527	526.7	2,10
4.6	560	577	607	600.55	2,95
4.7	430	437	447	446.1	1,60
4.8	492	499	509	507.5	1,40
4.9	641	679	697	691.85	5,60
4.10	514	548	572	565.35	6,20
5.1	253	274	280	279.7	7,66
5.2	302	317	317	317	4,73
5.3	226	247	247	247	8,50
5.4	242	251	251	251	3,59
5.5	211	225	225	225	6,22
5.6	213	247	247	247	13,77
5.7	293	315	315	315	6,98
5.8	288	316	316	316	8,86
5.9	279	315	315	315	11,43
5.10	265	280	280	280	5,36
6.1	138	152	152	152	9,21
6.2	146	154	160	159.7	5,19
6.3	145	160	160	160	9,38
6.4	131	140	140	140	6,43
6.5	161	176	186	185.5	8,52
A.1	253	261	261	261	3,07
A.2	252	277	277		9,03
A.3	232	252	252	252	7,94
A.4	234	250	250	250	6,40
A.5	236	241	241	241	2,07
B.1	69	86	86	86	19,77
B.2	76	88	88	88	13,64
B.3	80	85	85	85	5,88
B.4	79	84	84	84	5,95
B.5	72	78	78	78	7,69

Tabla 25: The Best V1.

Instance	Opt.	Min.	Man.	Avg.	RPD
C.1	227	235	235	235	3,40
C.2	219	236	236	236	7,20
C.3	243	270	270	270	10,00
C.4	219	246	246	246	10,98
C.5	215	221	223	222.9	2,71
D.1	60	62	62	62	3,23
D.2	66	74	74	74	10,81
D.3	72	79	79	79	8,86
D.4	62	68	68	68	8,82
D.5	61	66	66	66	7,58
NRE.1	29	30	30	30	3,33
NRE.2	30	35	35	35	14,29
NRE.3	27	34	34	34	20,59
NRE.4	28	33	33	33	15,15
NRE.5	28	30	30	30	6,67
NRF.1	14	17	17	17	17,65
NRF.2	15	18	18	18	16,67
NRF.3	14	17	17	17	17,65
NRF.4	14	18	18	18	22,22
NRF.5	13	16	16	16	18,75
NRG.1	176	196	196	196	10,20
NRG.2	154	168	168	168	8,33
NRG.3	166	180	180	180	7,78
NRG.4	168	184	184	184	8,70
NRG.5	168	187	187	187	10,16
NRH.1	63	73	73	73	13,70
NRH.2	63	67	67	67	5,97
NRH.3	59	69	69	69	14,49
NRH.4	58	68	68	68	14,71
NRH.5	55	61	61	61	9,84

Tabla 26: The Best V1.

Instance	Opt.	Min.	Man.	Avg.	RPD
4.1	429	437	449	447.1	1,83
4.2	512	540	559	551.95	5,19
4.3	516	527	537	535.25	2,09
4.4	494	508	532	526.75	2,76
4.5	512	517	527	525.7	0,97
4.6	560	564	607	598.55	0,71
4.7	430	434	447	444.2	0,92
4.8	492	499	509	507.3	1,40
4.9	641	676	697	692.3	5,18
4.10	514	548	572	565.35	6,20
5.1	253	280	280	280	9,64
5.2	302	314	317	316.85	3,82
5.3	226	247	247	247	8,50
5.4	242	249	251	250.9	2,81
5.5	211	225	225	225	6,22
5.6	213	247	247	247	13,77
5.7	293	315	315	315	6,98
5.8	288	316	316	316	8,86
5.9	279	315	315	315	11,43
5.10	265	280	280	280	5,36
6.1	138	152	152	152	9,21
6.2	146	154	160	159.7	5,19
6.3	145	160	160	160	9,38
6.4	131	140	140	140	6,43
6.5	161	186	186	186	13,44
A.1	253	261	261	261	3,07
A.2	252	277	277	277	9,03
A.3	232	252	252	252	7,94
A.4	234	250	250	250	6,40
A.5	236	241	241	241	2,07
B.1	69	86	86	86	19,77
B.2	76	88	88	88	13,64
B.3	80	85	85	85	5,88
B.4	79	84	84	84	5,95
B.5	72	78	78	78	7,69

Tabla 27: The Best V2.

Instance	Opt.	Min.	Man.	Avg.	RPD
C.1	227	235	235	235	3,40
C.2	219	236	236	236	7,20
C.3	243	270	270	270	10,00
C.4	219	246	246	246	10,98
C.5	215	223	223	223	3,59
D.1	60	62	62	62	3,23
D.2	66	74	74	74	10,81
D.3	72	79	79	79	8,86
D.4	62	68	68	68	8,82
D.5	61	66	66	66	7,58
NRE.1	29	30	30	30	3,33
NRE.2	30	35	35	35	14,29
NRE.3	27	34	34	34	20,59
NRE.4	28	33	33	33	15,15
NRE.5	28	30	30	30	6,67
NRF.1	14	17	17	17	17,65
NRF.2	15	18	18	18	16,67
NRF.3	14	17	17	17	17,65
NRF.4	14	18	18	18	22,22
NRF.5	13	16	16	16	18,75
NRG.1	176	196	196	196	10,20
NRG.2	154	168	168	168	8,33
NRG.3	166	180	180	180	7,78
NRG.4	168	184	184	184	8,70
NRG.5	168	187	187	187	10,16
NRH.1	63	73	73	73	13,70
NRH.2	63	67	67	67	5,97
NRH.3	59	69	69	69	14,49
NRH.4	58	68	68	68	14,71
NRH.5	55	61	61	61	9,84

Tabla 28: The Best V2.

Instance	Opt.	Min.	Man.	Avg.	RPD
4.1	429	443	449	447.65	3,16
4.2	512	527	559	550.9	2,85
4.3	516	528	537	533.75	2,27
4.4	494	505	532	523.85	2,18
4.5	512	517	527	525.85	0,97
4.6	560	579	607	599.95	3,28
4.7	430	440	447	446.3	2,27
4.8	492	499	509	508.1	1,40
4.9	641	670	697	691.9	4,33
4.10	514	538	572	560.85	4,46
5.1	253	280	280	280	9,64
5.2	302	317	317	317	4,73
5.3	226	247	247	247	8,50
5.4	242	251	251	251	3,59
5.5	211	225	225	225	6,22
5.6	213	241	247	246.7	11,62
5.7	293	315	315	315	6,98
5.8	288	316	316	316	8,86
5.9	279	315	315	315	11,43
5.10	265	280	280	280	5,36
6.1	138	147	152	151.75	6,12
6.2	146	160	160	160	8,75
6.3	145	160	160	160	9,38
6.4	131	140	140	140	6,43
6.5	161	181	186	185.75	11,05
A.1	253	261	261	261	3,07
A.2	252	277	277	277	9,03
A.3	232	252	252	252	7,94
A.4	234	250	250	250	6,40
A.5	236	241	241	241	2,07
B.1	69	86	86	86	19,77
B.2	76	88	88	88	13,64
B.3	80	85	85	85	5,88
B.4	79	84	84	84	5,95
B.5	72	78	78	78	7,69

Tabla 29: The Best V3.

Instance	Opt.	Min.	Man.	Avg.	RPD
C.1	227	235	235	235	3,40
C.2	219	236	236	236	7,20
C.3	243	270	270	270	10,00
C.4	219	246	246	246	10,98
C.5	215	223	223	223	3,59
D.1	60	62	62	62	3,23
D.2	66	74	74	74	10,81
D.3	72	79	79	79	8,86
D.4	62	68	68	68	8,82
D.5	61	66	66	66	7,58
NRE.1	29	30	30	30	3,33
NRE.2	30	35	35	35	14,29
NRE.3	27	34	34	34	20,59
NRE.4	28	33	33	33	15,15
NRE.5	28	30	30	30	6,67
NRF.1	14	17	17	17	17,65
NRF.2	15	18	18	18	16,67
NRF.3	14	17	17	17	17,65
NRF.4	14	18	18	18	22,22
NRF.5	13	16	16	16	18,75
NRG.1	176	196	196	196	10,20
NRG.2	154	168	168	168	8,33
NRG.3	166	180	180	180	7,78
NRG.4	168	184	184	184	8,70
NRG.5	168	187	187	187	10,16
NRH.1	63	73	73	73	13,70
NRH.2	63	67	67	67	5,97
NRH.3	59	69	69	69	14,49
NRH.4	58	68	68	68	14,71
NRH.5	55	61	61	61	9,84

Tabla 30: The Best V3.

Instance	Opt.	Min.	Man.	Avg.	RPD
4.1	429	439	449	446,5	2,28
4.2	512	557	559	558,5	8,08
4.3	516	528	537	534,75	2,27
4.4	494	508	532	526	2,76
4.5	512	517	527	524,5	0,97
4.6	560	564	607	596,25	0,71
4.7	430	434	447	443,75	0,92
4.8	492	499	509	506,5	1,40
4.9	641	676	697	691,75	5,18
4.10	514	548	572	566	6,20
5.1	253	274	280	278,5	7,66
5.2	302	317	317	317	4,73
5.3	226	247	247	247	8,50
5.4	242	251	251	251	3,59
5.5	211	225	225	225	6,22
5.6	213	247	247	247	13,77
5.7	293	315	315	315	6,98
5.8	288	316	316	316	8,86
5.9	279	315	315	315	11,43
5.10	265	280	280	280	5,36
6.1	138	152	152	152	9,21
6.2	146	154	160	158,5	5,19
6.3	145	160	160	160	9,38
6.4	131	140	140	140	6,43
6.5	161	176	186	183,5	8,52
A.1	253	261	261	261	3,07
A.2	252	277	277	277	9,03
A.3	232	252	252	252	7,94
A.4	234	250	250	250	6,40
A.5	236	241	241	241	2,07
B.1	69	86	86	86	19,77
B.2	76	88	88	88	13,64
B.3	80	85	85	85	5,88
B.4	79	84	84	84	5,95
B.5	72	78	78	78	7,69

Tabla 31: The Best V4.

Instance	Opt.	Min.	Man.	Avg.	RPD
C.1	227	235	235	235	3,40
C.2	219	236	236	236	7,20
C.3	243	270	270	270	10,00
C.4	219	246	246	246	10,98
C.5	215	221	223	222,5	2,71
D.1	60	62	62	62	3,23
D.2	66	74	74	74	10,81
D.3	72	79	79	79	8,86
D.4	62	68	68	68	8,82
D.5	61	66	66	66	7,58
NRE.1	29	30	30	30	3,33
NRE.2	30	35	35	35	14,29
NRE.3	27	34	34	34	20,59
NRE.4	28	33	33	33	15,15
NRE.5	28	30	30	30	6,67
NRF.1	14	17	17	17	17,65
NRF.2	15	18	18	18	16,67
NRF.3	14	17	17	17	17,65
NRF.4	14	18	18	18	22,22
NRF.5	13	16	16	16	18,75
NRG.1	176	196	196	196	10,20
NRG.2	154	168	168	168	8,33
NRG.3	166	180	180	180	7,78
NRG.4	168	184	184	184	8,70
NRG.5	168	187	187	187	10,16
NRH.1	63	73	73	73	13,70
NRH.2	63	67	67	67	5,97
NRH.3	59	69	69	69	14,49
NRH.4	58	68	68	68	14,71
NRH.5	55	61	61	61	9,84

Tabla 32: The Best V4.

Instance	Opt.	Min.	Man.	Avg.	RPD
4.1	429	437	437	437	1,83
4.2	512	534	536	534.07	4,12
4.3	516	526	526	526	1,90
4.4	494	517	561	535.45	4,45
4.5	512	526	623	543.1	2,66
4.6	560	586	723	620.35	4,44
4.7	430	440	458	448.2	2,27
4.8	492	500	611	523.65	1,60
4.9	641	672	764	701.95	4,61
4.10	514	551	631	580.55	6,72
5.1	253	278	15519	1718.85	8,99
5.2	302	317	14744	1206.9	4,73
5.3	226	247	15043	1275.15	8,50
5.4	242	251	13292	1103.6	3,59
5.5	211	225	19994	2949.85	6,22
5.6	213	245	15818	2566.85	13,06
5.7	293	313	18482	3328.85	6,39
5.8	288	315	1831	488.15	8,57
5.9	279	307	17593	1901.85	9,12
5.10	265	280	15150	1236.95	5,36
6.1	138	152	8128	2601.65	9,21
6.2	146	154	7977	1941.7	5,19
6.3	145	168	7769	1627.85	13,69
6.4	131	140	8255	2136.1	6,43
6.5	161	181	8048	1779.9	11,05
A.1	253	261	30015	8254.65	3,07
A.2	252	289	29826	10438.15	12,80
A.3	232	251	20686	5809.45	7,57
A.4	234	350	27513	8206.65	33,14
A.5	236	246	24947	7447.3	4,07
B.1	69	318	21589	13275.1	78,30
B.2	76	234	26757	13889.3	67,52
B.3	80	8857	23701	17757.2	99,10
B.4	79	216	24555	14306.45	63,43
B.5	72	124	22933	14657.55	41,94

Tabla 33: Standard S2.

Instance	Opt.	Min.	Man.	Avg.	RPD
C.1	227	236	30019	11643.45	3,81
C.2	219	587	34745	17578.9	62,69
C.3	243	480	31873	15037.3	49,38
C.4	219	276	26925	13711.4	20,65
C.5	215	237	37186	17057.45	9,28
D.1	60	7139	30980	20209.95	100,00
D.2	66	85	34318	19794.1	100,00
D.3	72	6659	37343	21069.55	100,00
D.4	62	1027	30087	19829.4	100,00
D.5	61	6877	30954	20350.5	100,00
NRE.1	29	9853	40607	26890.05	99,71
NRE.2	30	11160	46796	25200.7	99,73
NRE.3	27	13791	40337	27570.2	99,80
NRE.4	28	5252	41928	22925.05	99,47
NRE.5	28	3688	42035	24994.8	99,24
NRF.1	14	12296	36131	25069.1	99,89
NRF.2	15	8952	36915	23235.7	99,83
NRF.3	14	10705	46025	26136.35	99,87
NRF.4	14	7911	46071	21260.25	99,82
NRF.5	13	4561	43988	25917.05	99,71
NRG.1	176	4040	71816	47465.65	95,64
NRG.2	154	4084	64492	42305.9	96,23
NRG.3	166	28702	84681	56414.75	99,42
NRG.4	168	21450	96794	48236.2	99,22
NRG.5	168	350	84489	44865.9	52,00
NRH.1	63	22119	86963	50496.25	99,72
NRH.2	63	18910	92579	45425.2	99,67
NRH.3	59	24800	81322	45584.2	99,76
NRH.4	58	586	92852	50199.05	90,10
NRH.5	55	10041	84844	47148.8	99,45

Tabla 34: Standard S2.

Instance	Opt.	Min.	Man.	Avg.	RPD
4.1	429	437	437	437	1,83
4.2	512	533	536	534.6	3,94
4.3	516	526	526	526	1,90
4.4	494	517	561	535.45	4,45
4.5	512	526	623	543.1	2,66
4.6	560	586	723	620.35	4,44
4.7	430	440	458	448.2	2,27
4.8	492	500	611	523.65	1,60
4.9	641	672	764	701.95	4,61
4.10	514	551	631	580.55	6,72
5.1	253	278	15519	1718.85	8,99
5.2	302	317	14744	1206.9	4,73
5.3	226	247	15043	1275.15	8,50
5.4	242	251	13292	1103.6	3,59
5.5	211	225	19994	2949.85	6,22
5.6	213	245	15818	2566.85	13,06
5.7	293	313	18482	3328.85	6,39
5.8	288	315	1831	488.15	8,57
5.9	279	307	17593	1901.85	9,12
5.10	265	280	15150	1236.95	5,36
6.1	138	152	8128	2601.65	9,21
6.2	146	154	7977	1941.7	5,19
6.3	145	168	7769	1627.85	13,69
6.4	131	140	8255	2136.1	6,43
6.5	161	181	8048	1779.9	11,05
A.1	253	261	30015	8254.65	3,07
A.2	252	289	29826	10438.15	12,80
A.3	232	251	20686	5809.45	7,57
A.4	234	350	27513	8206.65	33,14
A.5	236	246	24947	7447.3	4,07
B.1	69	318	21589	13275.1	78,30
B.2	76	234	26757	13889.3	67,52
B.3	80	8857	23701	17757.2	99,10
B.4	79	216	24555	14306.45	63,43
B.5	72	124	22933	14657.55	41,94

Tabla 35: Standard S3.

Instance	Opt.	Min.	Man.	Avg.	RPD
C.1	227	236	30019	11643.45	3,81
C.2	219	587	34745	17578.9	62,69
C.3	243	480	31873	15037.3	49,38
C.4	219	276	26925	13711.4	20,65
C.5	215	237	37186	17057.45	9,28
D.1	60	7139	30980	20209.95	100,00
D.2	66	85	34318	19794.1	100,00
D.3	72	6659	37343	21069.55	100,00
D.4	62	1027	30087	19829.4	100,00
D.5	61	6877	30954	20350.5	100,00
NRE.1	29	9853	40607	26890.05	99,71
NRE.2	30	11160	46796	25200.7	99,73
NRE.3	27	13791	40337	27570.2	99,80
NRE.4	28	5252	41928	22925.05	99,47
NRE.5	28	3688	42035	24994.8	99,24
NRF.1	14	12296	36131	25069.1	99,89
NRF.2	15	8952	36915	23235.7	99,83
NRF.3	14	10705	46025	26136.35	99,87
NRF.4	14	7911	46071	21260.25	99,82
NRF.5	13	4561	43988	25917.05	99,71
NRG.1	176	4040	71816	47465.65	95,64
NRG.2	154	4084	64492	42305.9	96,23
NRG.3	166	28702	84681	56414.75	99,42
NRG.4	168	21450	96794	48236.2	99,22
NRG.5	168	350	84489	44865.9	52,00
NRH.1	63	22119	86963	50496.25	99,72
NRH.2	63	18910	92579	45425.2	99,67
NRH.3	59	24800	81322	45584.2	99,76
NRH.4	58	586	92852	50199.05	90,10
NRH.5	55	10041	84844	47148.8	99,45

Tabla 36: Standard S3.

Instance	Opt.	Min.	Man.	Avg.	RPD
4.1	429	437	438	437.07	1,83
4.2	512	534	534	534	4,12
4.3	516	526	526	526	1,90
4.4	494	511	512	511.4	3,33
4.5	512	526	623	543.1	2,66
4.6	560	586	723	620.35	4,44
4.7	430	440	458	448.2	2,27
4.8	492	500	611	523.65	1,60
4.9	641	672	764	701.95	4,61
4.10	514	551	631	580.55	6,72
5.1	253	278	15519	1718.85	8,99
5.2	302	317	14744	1206.9	4,73
5.3	226	247	15043	1275.15	8,50
5.4	242	251	13292	1103.6	3,59
5.5	211	225	19994	2949.85	6,22
5.6	213	245	15818	2566.85	13,06
5.7	293	313	18482	3328.85	6,39
5.8	288	315	1831	488.15	8,57
5.9	279	307	17593	1901.85	9,12
5.10	265	280	15150	1236.95	5,36
6.1	138	152	8128	2601.65	9,21
6.2	146	154	7977	1941.7	5,19
6.3	145	168	7769	1627.85	13,69
6.4	131	140	8255	2136.1	6,43
6.5	161	181	8048	1779.9	11,05
A.1	253	261	30015	8254.65	3,07
A.2	252	289	29826	10438.15	12,80
A.3	232	251	20686	5809.45	7,57
A.4	234	350	27513	8206.65	33,14
A.5	236	246	24947	7447.3	4,07
B.1	69	318	21589	13275.1	78,30
B.2	76	234	26757	13889.3	67,52
B.3	80	8857	23701	17757.2	99,10
B.4	79	216	24555	14306.45	63,43
B.5	72	124	22933	14657.55	41,94

Tabla 37: Standard S4.

Instance	Opt.	Min.	Man.	Avg.	RPD
C.1	227	236	30019	11643.45	3,81
C.2	219	587	34745	17578.9	62,69
C.3	243	480	31873	15037.3	49,38
C.4	219	276	26925	13711.4	20,65
C.5	215	237	37186	17057.45	9,28
D.1	60	7139	30980	20209.95	100,00
D.2	66	85	34318	19794.1	100,00
D.3	72	6659	37343	21069.55	100,00
D.4	62	1027	30087	19829.4	100,00
D.5	61	6877	30954	20350.5	100,00
NRE.1	29	9853	40607	26890.05	99,71
NRE.2	30	11160	46796	25200.7	99,73
NRE.3	27	13791	40337	27570.2	99,80
NRE.4	28	5252	41928	22925.05	99,47
NRE.5	28	3688	42035	24994.8	99,24
NRF.1	14	12296	36131	25069.1	99,89
NRF.2	15	8952	36915	23235.7	99,83
NRF.3	14	10705	46025	26136.35	99,87
NRF.4	14	7911	46071	21260.25	99,82
NRF.5	13	4561	43988	25917.05	99,71
NRG.1	176	4040	71816	47465.65	95,64
NRG.2	154	4084	64492	42305.9	96,23
NRG.3	166	28702	84681	56414.75	99,42
NRG.4	168	21450	96794	48236.2	99,22
NRG.5	168	350	84489	44865.9	52,00
NRH.1	63	22119	86963	50496.25	99,72
NRH.2	63	18910	92579	45425.2	99,67
NRH.3	59	24800	81322	45584.2	99,76
NRH.4	58	586	92852	50199.05	90,10
NRH.5	55	10041	84844	47148.8	99,45

Tabla 38: Standard S4.

Instance	Opt.	Min.	Man.	Avg.	RPD
4.1	429	449	449	449	4,45
4.2	512	559	559	559	8,41
4.3	516	537	537	537	3,91
4.4	494	532	532	532	7,14
4.5	512	527	527	527	2,85
4.6	560	607	607	607	7,74
4.7	430	447	447	447	3,80
4.8	492	509	509	509	3,34
4.9	641	697	697	697	8,03
4.10	514	572	572	572	10,14
5.1	253	280	280	280	9,64
5.2	302	317	317	317	4,73
5.3	226	247	247	247	8,50
5.4	242	251	251	251	3,59
5.5	211	225	225	225	6,22
5.6	213	247	247	247	13,77
5.7	293	315	315	315	6,98
5.8	288	316	316	316	8,86
5.9	279	315	315	315	11,43
5.10	265	280	280	280	5,36
6.1	138	152	152	152	9,21
6.2	146	160	160	160	8,75
6.3	145	160	160	160	9,38
6.4	131	140	140	140	6,43
6.5	161	186	186	186	13,44
A.1	253	261	261	261	3,07
A.2	252	277	277	277	9,03
A.3	232	252	252	252	7,94
A.4	234	250	250	250	6,40
A.5	236	241	241	241	2,07
B.1	69	86	86	86	19,77
B.2	76	88	88	88	13,64
B.3	80	85	85	85	5,88
B.4	79	84	84	84	5,95
B.5	72	78	78	78	7,69

Tabla 39: Complement V1.

Instance	Opt.	Min.	Man.	Avg.	RPD
C.1	227	235	235	235	3,40
C.2	219	236	236	236	7,20
C.3	243	270	270	270	10,00
C.4	219	246	246	246	10,98
C.5	215	223	223	223	3,59
D.1	60	62	62	62	3,23
D.2	66	74	74	74	10,81
D.3	72	79	79	79	8,86
D.4	62	68	68	68	8,82
D.5	61	66	66	66	7,58
NRE.1	29	30	30	30	3,33
NRE.2	30	35	35	35	14,29
NRE.3	27	34	34	34	20,59
NRE.4	28	33	33	33	15,15
NRE.5	28	30	30	30	6,67
NRF.1	14	17	17	17	17,65
NRF.2	15	18	18	18	16,67
NRF.3	14	17	17	17	17,65
NRF.4	14	18	18	18	22,22
NRF.5	13	16	16	16	18,75
NRG.1	176	196	196	196	10,20
NRG.2	154	168	168	168	8,33
NRG.3	166	180	180	180	7,78
NRG.4	168	184	184	184	8,70
NRG.5	168	189	189	189	11,11
NRH.1	63	73	73	73	13,70
NRH.2	63	67	67	67	5,97
NRH.3	59	69	69	69	14,49
NRH.4	58	68	68	68	14,71
NRH.5	55	61	61	61	9,84

Tabla 40: Complement V1.

Instance	Opt.	Min.	Man.	Avg.	RPD
4.1	429	449	449	449	4,45
4.2	512	559	559	559	8,41
4.3	516	526	537	537	1,90
4.4	494	518	532	532	4,63
4.5	512	518	527	527	1,16
4.6	560	593	607	607	5,56
4.7	430	437	447	447	1,60
4.8	492	501	509	509,2	1,80
4.9	641	697	697	697	8,03
4.10	514	572	572	572	10,14
5.1	253	280	280	280	9,64
5.2	302	317	317	317	4,73
5.3	226	247	247	247	8,50
5.4	242	251	251	251	3,59
5.5	211	225	225	225	6,22
5.6	213	247	247	247	13,77
5.7	293	315	315	315	6,98
5.8	288	316	316	316	8,86
5.9	279	315	315	315	11,43
5.10	265	280	280	280	5,36
6.1	138	152	152	152	9,21
6.2	146	160	160	160	8,75
6.3	145	160	160	160	9,38
6.4	131	140	140	140	6,43
6.5	161	186	186	186	13,44
A.1	253	261	261	261	3,07
A.2	252	277	277	277	9,03
A.3	232	252	252	252	7,94
A.4	234	250	250	250	6,40
A.5	236	241	241	241	2,07
B.1	69	86	86	86	19,77
B.2	76	88	88	88	13,64
B.3	80	85	85	85	5,88
B.4	79	84	84	84	5,95
B.5	72	78	78	78	7,69

Tabla 41: Complement V2.

Instance	Opt.	Min.	Man.	Avg.	RPD
C.1	227	235	235	235	3,40
C.2	219	236	236	236	7,20
C.3	243	270	270	270	10,00
C.4	219	246	246	246	10,98
C.5	215	223	223	223	3,59
D.1	60	62	62	62	3,23
D.2	66	74	74	74	10,81
D.3	72	79	79	79	8,86
D.4	62	68	68	68	8,82
D.5	61	66	66	66	7,58
NRE.1	29	30	30	30	3,33
NRE.2	30	35	35	35	14,29
NRE.3	27	34	34	34	20,59
NRE.4	28	33	33	33	15,15
NRE.5	28	30	30	30	6,67
NRF.1	14	17	17	17	17,65
NRF.2	15	18	18	18	16,67
NRF.3	14	17	17	17	17,65
NRF.4	14	18	18	18	22,22
NRF.5	13	16	16	16	18,75
NRG.1	176	196	196	196	10,20
NRG.2	154	168	168	168	8,33
NRG.3	166	180	180	180	7,78
NRG.4	168	184	184	184	8,70
NRG.5	168	189	189	189	11,11
NRH.1	63	73	73	73	13,70
NRH.2	63	67	67	67	5,97
NRH.3	59	69	69	69	14,49
NRH.4	58	68	68	68	14,71
NRH.5	55	61	61	61	9,84

Tabla 42: Complement V2.

Instance	Opt.	Min.	Man.	Avg.	RPD
4.1	429	449	449	449	4,45
4.2	512	559	559	559	8,41
4.3	516	537	537	537	3,91
4.4	494	532	532	532	7,14
4.5	512	527	527	527	2,85
4.6	560	607	607	607	7,74
4.7	430	447	447	447	3,80
4.8	492	509	509	509	3,34
4.9	641	697	697	697	8,03
4.10	514	572	572	572	10,14
5.1	253	280	280	280	9,64
5.2	302	317	317	317	4,73
5.3	226	247	247	247	8,50
5.4	242	251	251	251	3,59
5.5	211	225	225	225	6,22
5.6	213	247	247	247	13,77
5.7	293	315	315	315	6,98
5.8	288	316	316	316	8,86
5.9	279	315	315	315	11,43
5.10	265	280	280	280	5,36
6.1	138	152	152	152	9,21
6.2	146	160	160	160	8,75
6.3	145	160	160	160	9,38
6.4	131	140	140	140	6,43
6.5	161	186	186	186	13,44
A.1	253	261	261	261	3,07
A.2	252	277	277	277	9,03
A.3	232	252	252	252	7,94
A.4	234	250	250	250	6,40
A.5	236	241	241	241	2,07
B.1	69	86	86	86	19,77
B.2	76	88	88	88	13,64
B.3	80	85	85	85	5,88
B.4	79	84	84	84	5,95
B.5	72	78	78	78	7,69

Tabla 43: Complement V3.

Instance	Opt.	Min.	Man.	Avg.	RPD
C.1	227	235	235	235	3,40
C.2	219	236	236	236	7,20
C.3	243	270	270	270	10,00
C.4	219	246	246	246	10,98
C.5	215	223	223	223	3,59
D.1	60	62	62	62	3,23
D.2	66	74	74	74	10,81
D.3	72	79	79	79	8,86
D.4	62	68	68	68	8,82
D.5	61	66	66	66	7,58
NRE.1	29	30	30	30	3,33
NRE.2	30	35	35	35	14,29
NRE.3	27	34	34	34	20,59
NRE.4	28	33	33	33	15,15
NRE.5	28	30	30	30	6,67
NRF.1	14	17	17	17	17,65
NRF.2	15	18	18	18	16,67
NRF.3	14	17	17	17	17,65
NRF.4	14	18	18	18	22,22
NRF.5	13	16	16	16	18,75
NRG.1	176	196	196	196	10,20
NRG.2	154	168	168	168	8,33
NRG.3	166	180	180	180	7,78
NRG.4	168	184	184	184	8,70
NRG.5	168	189	189	189	11,11
NRH.1	63	73	73	73	13,70
NRH.2	63	67	67	67	5,97
NRH.3	59	69	69	69	14,49
NRH.4	58	68	68	68	14,71
NRH.5	55	61	61	61	9,84

Tabla 44: Complement V3.

Instance	Opt.	Min.	Man.	Avg.	RPD
4.1	429	441	449	446,9	2,72
4.2	512	531	559	557,2	3,58
4.3	516	537	537	537	3,91
4.4	494	532	532	532	7,14
4.5	512	527	527	527	2,85
4.6	560	607	607	607	7,74
4.7	430	447	447	447	3,80
4.8	492	509	509	509	3,34
4.9	641	697	697	697	8,03
4.10	514	572	572	572	10,14
5.1	253	280	280	280	9,64
5.2	302	317	317	317	4,73
5.3	226	247	247	247	8,50
5.4	242	251	251	251	3,59
5.5	211	225	225	225	6,22
5.6	213	247	247	247	13,77
5.7	293	315	315	315	6,98
5.8	288	316	316	316	8,86
5.9	279	315	315	315	11,43
5.10	265	280	280	280	5,36
6.1	138	152	152	152	9,21
6.2	146	160	160	160	8,75
6.3	145	160	160	160	9,38
6.4	131	140	140	140	6,43
6.5	161	186	186	186	13,44
A.1	253	261	261	261	3,07
A.2	252	277	277	277	9,03
A.3	232	252	252	252	7,94
A.4	234	250	250	250	6,40
A.5	236	241	241	241	2,07
B.1	69	86	86	86	19,77
B.2	76	88	88	88	13,64
B.3	80	85	85	85	5,88
B.4	79	84	84	84	5,95
B.5	72	78	78	78	7,69

Tabla 45: Complement V4.

Instance	Opt.	Min.	Man.	Avg.	RPD
C.1	227	235	235	235	3,40
C.2	219	236	236	236	7,20
C.3	243	270	270	270	10,00
C.4	219	246	246	246	10,98
C.5	215	223	223	223	3,59
D.1	60	62	62	62	3,23
D.2	66	74	74	74	10,81
D.3	72	79	79	79	8,86
D.4	62	68	68	68	8,82
D.5	61	66	66	66	7,58
NRE.1	29	30	30	30	3,33
NRE.2	30	35	35	35	14,29
NRE.3	27	34	34	34	20,59
NRE.4	28	33	33	33	15,15
NRE.5	28	30	30	30	6,67
NRF.1	14	17	17	17	17,65
NRF.2	15	18	18	18	16,67
NRF.3	14	17	17	17	17,65
NRF.4	14	18	18	18	22,22
NRF.5	13	16	16	16	18,75
NRG.1	176	196	196	196	10,20
NRG.2	154	168	168	168	8,33
NRG.3	166	180	180	180	7,78
NRG.4	168	184	184	184	8,70
NRG.5	168	189	189	189	11,11
NRH.1	63	73	73	73	13,70
NRH.2	63	67	67	67	5,97
NRH.3	59	69	69	69	14,49
NRH.4	58	68	68	68	14,71
NRH.5	55	61	61	61	9,84

Tabla 46: Complement V4.

Instance	Opt.	Min.	Man.	Avg.	RPD
4.1	429	449	449	449	4,45
4.2	512	559	559	559	8,41
4.3	516	526	537	527	1,90
4.4	494	518	532	525	4,63
4.5	512	518	527	520	1,16
4.6	560	593	607	599	5,56
4.7	430	437	447	445	1,60
4.8	492	501	509	506	1,80
4.9	641	697	697	697	8,03
4.10	514	572	572	572	10,14
5.1	253	280	280	280	9,64
5.2	302	317	317	317	4,73
5.3	226	247	247	247	8,50
5.4	242	251	251	251	3,59
5.5	211	225	225	225	6,22
5.6	213	247	247	247	13,77
5.7	293	315	315	315	6,98
5.8	288	316	316	316	8,86
5.9	279	315	315	315	11,43
5.10	265	280	280	280	5,36
6.1	138	152	152	152	9,21
6.2	146	160	160	160	8,75
6.3	145	160	160	160	9,38
6.4	131	140	140	140	6,43
6.5	161	186	186	186	13,44
A.1	253	261	261	261	3,07
A.2	252	277	277	277	9,03
A.3	232	252	252	252	7,94
A.4	234	250	250	250	6,40
A.5	236	241	241	241	2,07
B.1	69	86	86	86	19,77
B.2	76	88	88	88	13,64
B.3	80	85	85	85	5,88
B.4	79	84	84	84	5,95
B.5	72	78	78	78	7,69

Tabla 47: Complement S1.

Instance	Opt.	Min.	Man.	Avg.	RPD
C.1	227	235	235	235	3,40
C.2	219	236	236	236	7,20
C.3	243	270	270	270	10,00
C.4	219	246	246	246	10,98
C.5	215	223	223	223	3,59
D.1	60	62	62	62	3,23
D.2	66	74	74	74	10,81
D.3	72	79	79	79	8,86
D.4	62	68	68	68	8,82
D.5	61	66	66	66	7,58
NRE.1	29	30	30	30	3,33
NRE.2	30	35	35	35	14,29
NRE.3	27	34	34	34	20,59
NRE.4	28	33	33	33	15,15
NRE.5	28	30	30	30	6,67
NRF.1	14	17	17	17	17,65
NRF.2	15	18	18	18	16,67
NRF.3	14	17	17	17	17,65
NRF.4	14	18	18	18	22,22
NRF.5	13	16	16	16	18,75
NRG.1	176	196	196	196	10,20
NRG.2	154	168	168	168	8,33
NRG.3	166	180	180	180	7,78
NRG.4	168	184	184	184	8,70
NRG.5	168	189	189	189	11,11
NRH.1	63	73	73	73	13,70
NRH.2	63	67	67	67	5,97
NRH.3	59	69	69	69	14,49
NRH.4	58	68	68	68	14,71
NRH.5	55	61	61	61	9,84

Tabla 48: Complement S1.

Instance	Opt.	Min.	Man.	Avg.	RPD
4.1	429	449	449	449	4,45
4.2	512	559	559	559	8,41
4.3	516	537	537	537	3,91
4.4	494	532	532	532	7,14
4.5	512	527	527	527	2,85
4.6	560	607	607	607	7,74
4.7	430	447	447	447	3,80
4.8	492	509	509	509	3,34
4.9	641	697	697	697	8,03
4.10	514	572	572	572	10,14
5.1	253	280	280	280	9,64
5.2	302	317	317	317	4,73
5.3	226	247	247	247	8,50
5.4	242	251	251	251	3,59
5.5	211	225	225	225	6,22
5.6	213	247	247	247	13,77
5.7	293	315	315	315	6,98
5.8	288	316	316	316	8,86
5.9	279	315	315	315	11,43
5.10	265	280	280	280	5,36
6.1	138	152	152	152	9,21
6.2	146	160	160	160	8,75
6.3	145	160	160	160	9,38
6.4	131	140	140	140	6,43
6.5	161	186	186	186	13,44
A.1	253	261	261	261	3,07
A.2	252	277	277	277	9,03
A.3	232	252	252	252	7,94
A.4	234	250	250	250	6,40
A.5	236	241	241	241	2,07
B.1	69	86	86	86	19,77
B.2	76	88	88	88	13,64
B.3	80	85	85	85	5,88
B.4	79	84	84	84	5,95
B.5	72	78	78	78	7,69

Tabla 49: Complement S2.

Instance	Opt.	Min.	Man.	Avg.	RPD
C.1	227	235	235	235	3,40
C.2	219	236	236	236	7,20
C.3	243	270	270	270	10,00
C.4	219	246	246	246	10,98
C.5	215	223	223	223	3,59
D.1	60	62	62	62	3,23
D.2	66	74	74	74	10,81
D.3	72	79	79	79	8,86
D.4	62	68	68	68	8,82
D.5	61	66	66	66	7,58
NRE.1	29	30	30	30	3,33
NRE.2	30	35	35	35	14,29
NRE.3	27	34	34	34	20,59
NRE.4	28	33	33	33	15,15
NRE.5	28	30	30	30	6,67
NRF.1	14	17	17	17	17,65
NRF.2	15	18	18	18	16,67
NRF.3	14	17	17	17	17,65
NRF.4	14	18	18	18	22,22
NRF.5	13	16	16	16	18,75
NRG.1	176	196	196	196	10,20
NRG.2	154	168	168	168	8,33
NRG.3	166	180	180	180	7,78
NRG.4	168	184	184	184	8,70
NRG.5	168	189	189	189	11,11
NRH.1	63	73	73	73	13,70
NRH.2	63	67	67	67	5,97
NRH.3	59	69	69	69	14,49
NRH.4	58	68	68	68	14,71
NRH.5	55	61	61	61	9,84

Tabla 50: Complement S2.

Instance	Opt.	Min.	Man.	Avg.	RPD
4.1	429	449	449	449	4,45
4.2	512	559	559	559	8,41
4.3	516	526	537	537	1,90
4.4	494	518	532	532	4,63
4.5	512	518	527	527	1,16
4.6	560	593	607	607	5,56
4.7	430	437	447	447	1,60
4.8	492	501	509	509	1,80
4.9	641	697	697	697	8,03
4.10	514	572	572	572	10,14
5.1	253	280	280	280	9,64
5.2	302	317	317	317	4,73
5.3	226	247	247	247	8,50
5.4	242	251	251	251	3,59
5.5	211	225	225	225	6,22
5.6	213	247	247	247	13,77
5.7	293	315	315	315	6,98
5.8	288	316	316	316	8,86
5.9	279	315	315	315	11,43
5.10	265	280	280	280	5,36
6.1	138	152	152	152	9,21
6.2	146	160	160	160	8,75
6.3	145	160	160	160	9,38
6.4	131	140	140	140	6,43
6.5	161	186	186	186	13,44
A.1	253	261	261	261	3,07
A.2	252	277	277	277	9,03
A.3	232	252	252	252	7,94
A.4	234	250	250	250	6,40
A.5	236	241	241	241	2,07
B.1	69	86	86	86	19,77
B.2	76	88	88	88	13,64
B.3	80	85	85	85	5,88
B.4	79	84	84	84	5,95
B.5	72	78	78	78	7,69

Tabla 51: Complement S3.

Instance	Opt.	Min.	Man.	Avg.	RPD
C.1	227	235	235	235	3,40
C.2	219	236	236	236	7,20
C.3	243	270	270	270	10,00
C.4	219	246	246	246	10,98
C.5	215	223	223	223	3,59
D.1	60	62	62	62	3,23
D.2	66	74	74	74	10,81
D.3	72	79	79	79	8,86
D.4	62	68	68	68	8,82
D.5	61	66	66	66	7,58
NRE.1	29	30	30	30	3,33
NRE.2	30	35	35	35	14,29
NRE.3	27	34	34	34	20,59
NRE.4	28	33	33	33	15,15
NRE.5	28	30	30	30	6,67
NRF.1	14	17	17	17	17,65
NRF.2	15	18	18	18	16,67
NRF.3	14	17	17	17	17,65
NRF.4	14	18	18	18	22,22
NRF.5	13	16	16	16	18,75
NRG.1	176	196	196	196	10,20
NRG.2	154	168	168	168	8,33
NRG.3	166	180	180	180	7,78
NRG.4	168	184	184	184	8,70
NRG.5	168	189	189	189	11,11
NRH.1	63	73	73	73	13,70
NRH.2	63	67	67	67	5,97
NRH.3	59	69	69	69	14,49
NRH.4	58	68	68	68	14,71
NRH.5	55	61	61	61	9,84

Tabla 52: Complement S3.

Instance	Opt.	Min.	Man.	Avg.	RPD
4.1	429	449	449	449	4,45
4.2	512	559	559	559	8,41
4.3	516	537	537	537	3,91
4.4	494	532	532	532	7,14
4.5	512	527	527	527	2,85
4.6	560	607	607	607	7,74
4.7	430	447	447	447	3,80
4.8	492	509	509	509	3,34
4.9	641	697	697	697	8,03
4.10	514	572	572	572	10,14
5.1	253	280	280	280	9,64
5.2	302	317	317	317	4,73
5.3	226	247	247	247	8,50
5.4	242	251	251	251	3,59
5.5	211	225	225	225	6,22
5.6	213	247	247	247	13,77
5.7	293	315	315	315	6,98
5.8	288	316	316	316	8,86
5.9	279	315	315	315	11,43
5.10	265	280	280	280	5,36
6.1	138	152	152	152	9,21
6.2	146	160	160	160	8,75
6.3	145	160	160	160	9,38
6.4	131	140	140	140	6,43
6.5	161	186	186	186	13,44
A.1	253	261	261	261	3,07
A.2	252	277	277	277	9,03
A.3	232	252	252	252	7,94
A.4	234	250	250	250	6,40
A.5	236	241	241	241	2,07
B.1	69	86	86	86	19,77
B.2	76	88	88	88	13,64
B.3	80	85	85	85	5,88
B.4	79	84	84	84	5,95
B.5	72	78	78	78	7,69

Tabla 53: Complement S4.

Instance	Opt.	Min.	Man.	Avg.	RPD
C.1	227	235	235	235	3,40
C.2	219	236	236	236	7,20
C.3	243	270	270	270	10,00
C.4	219	246	246	246	10,98
C.5	215	223	223	223	3,59
D.1	60	62	62	62	3,23
D.2	66	74	74	74	10,81
D.3	72	79	79	79	8,86
D.4	62	68	68	68	8,82
D.5	61	66	66	66	7,58
NRE.1	29	30	30	30	3,33
NRE.2	30	35	35	35	14,29
NRE.3	27	34	34	34	20,59
NRE.4	28	33	33	33	15,15
NRE.5	28	30	30	30	6,67
NRF.1	14	17	17	17	17,65
NRF.2	15	18	18	18	16,67
NRF.3	14	17	17	17	17,65
NRF.4	14	18	18	18	22,22
NRF.5	13	16	16	16	18,75
NRG.1	176	196	196	196	10,20
NRG.2	154	168	168	168	8,33
NRG.3	166	180	180	180	7,78
NRG.4	168	184	184	184	8,70
NRG.5	168	189	189	189	11,11
NRH.1	63	73	73	73	13,70
NRH.2	63	67	67	67	5,97
NRH.3	59	69	69	69	14,49
NRH.4	58	68	68	68	14,71
NRH.5	55	61	61	61	9,84

Tabla 54: Complement S4.

Instance	Opt.	Min.	Man.	Avg.	RPD
4.1	429	445	495	454.05	3,60
4.2	512	542	568	557.3	5,54
4.3	516	534	579	544.0	3,37
4.4	494	529	558	534.7	6,62
4.5	512	526	576	536.1	2,66
4.6	560	580	635	604.25	3,45
4.7	430	438	484	453.6	1,83
4.8	492	500	555	514.15	1,60
4.9	641	685	722	696.05	6,42
4.10	514	550	618	572.45	6,55
5.1	253	278	2014	466.0	8,99
5.2	302	317	18877	1333.05	4,73
5.3	226	242	18389	1948.75	6,61
5.4	242	251	14826	1019.6	3,59
5.5	211	225	2506	402.75	6,22
5.6	213	245	523	321.2	13,06
5.7	293	315	19111	1360.5	6,98
5.8	288	316	871	393.55	8,86
5.9	279	308	627	385.95	9,42
5.10	265	280	16229	1132.6	5,36
6.1	138	152	7274	1543.75	9,21
6.2	146	156	6179	819.7	6,41
6.3	145	160	6486	950.45	9,38
6.4	131	140	7646	1534.65	6,43
6.5	161	183	7905	1780.25	12,02
A.1	253	278	25429	7308.45	8,99
A.2	252	294	22009	10197.45	14,29
A.3	232	270	21915	4449.4	14,07
A.4	234	254	23029	5889.75	7,87
A.5	236	242	23010	8107.65	2,48
B.1	69	4354	28752	14488.5	98,42
B.2	76	146	22807	11621.3	47,95
B.3	80	8398	24862	15339.65	99,05
B.4	79	5518	21276	13663.3	98,57
B.5	72	6512	20542	15531.1	98,89

Tabla 55: Statics Probability V1.

Instance	Opt.	Min.	Man.	Avg.	RPD
C.1	227	426	32537	15138.7	46,71
C.2	219	249	31352	11957.75	12,05
C.3	243	294	32588	9840.15	17,35
C.4	219	359	30336	14522.85	39,00
C.5	215	265	34845	12064.85	18,87
D.1	60	244	33093	18106.2	75,41
D.2	66	6664	28739	16906.85	99,01
D.3	72	7267	34485	20513.45	99,01
D.4	62	6865	34985	19775.95	99,10
D.5	61	8750	33544	18701.9	99,30
NRE.1	29	1759	41555	23797.4	98,35
NRE.2	30	8573	39823	25771.0	99,65
NRE.3	27	1150	39443	24362.65	97,65
NRE.4	28	9537	39211	23985.15	99,71
NRE.5	28	5117	15081	13404.6	99,45
NRF.1	14	2256	11992	15164.35	99,38
NRF.2	15	6494	7268	69354.4	99,77
NRF.3	14	7174	9022	8245.05	99,80
NRF.4	14	5863	7174	5907.3	99,76
NRF.5	13	2967	4887	2957.95	99,56
NRG.1	176	3423	7132	50042.7	94,86
NRG.2	154	862	1861	1014.35	82,13
NRG.3	166	2180	3348	3102.8	92,39
NRG.4	168	4634	8618	7346.35	96,37
NRG.5	168	7909	8042	8007.85	97,88
NRH.1	63	8912	9174	8977.75	99,29
NRH.2	63	6475	8372	8275.35	99,03
NRH.3	59	4242	9837	1107.5	98,61
NRH.4	58	8556	7047	9699.05	99,32
NRH.5	55	724	6703	4076.15	92,40

Tabla 56: Statics Probability V1.

Instance	Opt.	Min.	Man.	Avg.	RPD
4.1	429	445	490	452.5	3,60
4.2	512	544	724	567.4	5,88
4.3	516	534	571	541.7	3,37
4.4	494	517	561	535.45	4,45
4.5	512	526	623	543.1	2,66
4.6	560	586	723	620.35	4,44
4.7	430	440	458	448.2	2,27
4.8	492	500	611	523.65	1,60
4.9	641	672	764	701.95	4,61
4.10	514	551	631	580.55	6,72
5.1	253	278	15519	1718.85	8,99
5.2	302	317	14744	1206.9	4,73
5.3	226	247	15043	1275.15	8,50
5.4	242	251	13292	1103.6	3,59
5.5	211	225	19994	2949.85	6,22
5.6	213	245	15818	2566.85	13,06
5.7	293	313	18482	3328.85	6,39
5.8	288	315	1831	488.15	8,57
5.9	279	307	17593	1901.85	9,12
5.10	265	280	15150	1236.95	5,36
6.1	138	152	8128	2601.65	9,21
6.2	146	154	7977	1941.7	5,19
6.3	145	168	7769	1627.85	13,69
6.4	131	140	8255	2136.1	6,43
6.5	161	181	8048	1779.9	11,05
A.1	253	261	30015	8254.65	3,07
A.2	252	289	29826	10438.15	12,80
A.3	232	251	20686	5809.45	7,57
A.4	234	350	27513	8206.65	33,14
A.5	236	246	24947	7447.3	4,07
B.1	69	318	21589	13275.1	78,30
B.2	76	234	26757	13889.3	67,52
B.3	80	8857	23701	17757.2	99,10
B.4	79	216	24555	14306.45	63,43
B.5	72	124	22933	14657.55	41,94

Tabla 57: Statics Probability V2.

Instance	Opt.	Min.	Man.	Avg.	RPD
C.1	227	236	30019	11643.45	3,81
C.2	219	587	34745	17578.9	62,69
C.3	243	480	31873	15037.3	49,38
C.4	219	276	26925	13711.4	20,65
C.5	215	237	37186	17057.45	9,28
D.1	60	157	33542	20209.95	61,78
D.2	66	8903	37015	19794.1	99,26
D.3	72	11391	32477	21069.55	99,37
D.4	62	216	33663	19829.4	71,30
D.5	61	273	43213	20350.5	77,66
NRE.1	29	9853	40607	26890.05	99,71
NRE.2	30	11160	46796	25200.7	99,73
NRE.3	27	13791	40337	27570.2	99,80
NRE.4	28	5252	41928	22925.05	99,47
NRE.5	28	3688	42035	24994.8	99,24
NRF.1	14	12296	36131	25069.1	99,89
NRF.2	15	8952	36915	23235.7	99,83
NRF.3	14	10705	46025	26136.35	99,87
NRF.4	14	7911	46071	21260.25	99,82
NRF.5	13	4561	43988	25917.05	99,71
NRG.1	176	4040	71816	47465.65	95,64
NRG.2	154	4084	64492	42305.9	96,23
NRG.3	166	28702	84681	56414.75	99,42
NRG.4	168	21450	96794	48236.2	99,22
NRG.5	168	350	84489	44865.9	52,00
NRH.1	63	22119	86963	50496.25	99,72
NRH.2	63	18910	92579	45425.2	99,67
NRH.3	59	24800	81322	45584.2	99,76
NRH.4	58	586	92852	50199.05	90,10
NRH.5	55	10041	84844	47148.8	99,45

Tabla 58: Statics Probability V2.

Instance	Opt.	Min.	Man.	Avg.	RPD
4.1	429	448	580	463.0	4,24
4.2	512	544	684	566.85	5,88
4.3	516	526	603	543.5	1,90
4.4	494	518	553	531.45	4,63
4.5	512	518	563	535.05	1,16
4.6	560	593	672	611.45	5,56
4.7	430	437	511	450.95	1,60
4.8	492	501	700	529.65	1,80
4.9	641	690	756	708.35	7,10
4.10	514	558	624	574.15	7,89
5.1	253	274	15573	1881.8	7,66
5.2	302	314	21008	3045.95	3,82
5.3	226	248	14940	1334.45	8,87
5.4	242	251	17212	1874.2	3,59
5.5	211	225	19689	2787.9	6,22
5.6	213	235	19074	2029.95	9,36
5.7	293	315	13416	1207.7	6,98
5.8	288	316	12147	1013.65	8,86
5.9	279	288	16539	2701.35	3,13
5.10	265	277	19520	1460.1	4,33
6.1	138	154	9224	2715.6	10,39
6.2	146	158	9001	2521.7	7,59
6.3	145	157	7619	1538.7	7,64
6.4	131	140	8898	1686.4	6,43
6.5	161	180	9761	1331.15	10,56
A.1	253	278	22732	6687.45	8,99
A.2	252	273	20884	3482.6	7,69
A.3	232	281	23372	7943.05	17,44
A.4	234	251	24332	9984.75	6,77
A.5	236	284	27384	9435.05	16,90
B.1	69	6715	23272	16268.55	98,97
B.2	76	1348	24601	16055.35	94,36
B.3	80	4885	23631	15305.15	98,36
B.4	79	687	25973	13104.85	88,50
B.5	72	7808	30952	15088.75	99,08

Tabla 59: Statics Probability V3.

Instance	Opt.	Min.	Man.	Avg.	RPD
C.1	227	236	33318	16085.85	3,81
C.2	219	237	30837	13656.55	7,59
C.3	243	393	39720	13755.35	38,17
C.4	219	271	35258	15192.45	19,19
C.5	215	222	28048	10106.7	3,15
D.1	60	7139	30980	19471.3	99,16
D.2	66	85	34318	18322.5	22,35
D.3	72	6659	37343	20818.0	98,92
D.4	62	1027	30087	16308.75	93,96
D.5	61	6877	30954	20477.85	99,11
NRE.1	29	5711	44103	24558.1	99,49
NRE.2	30	8929	43418	24641.1	99,66
NRE.3	27	8361	39024	23319.45	99,68
NRE.4	28	5647	47115	22887.7	99,50
NRE.5	28	8654	39506	24385.8	99,68
NRF.1	14	6983	48580	26806.55	99,80
NRF.2	15	8137	38548	25134.8	99,82
NRF.3	14	14122	35681	23484.95	99,90
NRF.4	14	4118	48852	25051.9	99,66
NRF.5	13	5300	38398	23496.65	99,75
NRG.1	176	3229	98474	54752.15	94,55
NRG.2	154	23470	83868	52786.9	99,34
NRG.3	166	24887	75503	50252.6	99,33
NRG.4	168	609	83589	48760.75	72,41
NRG.5	168	3476	111094	51247.3	95,17
NRH.1	63	20572	90586	52413.05	99,69
NRH.2	63	12975	100446	48432.15	99,51
NRH.3	59	8939	106887	52592.2	99,34
NRH.4	58	17024	102871	55260.1	99,66
NRH.5	55	12838	83083	42983.1	99,57

Tabla 60: Statics Probability V3.

Instance	Opt.	Min.	Man.	Avg.	RPD
4.1	429	448	580	452.5	4,24
4.2	512	544	684	567.4	5,88
4.3	516	526	603	541.7	1,90
4.4	494	517	553	535.45	4,45
4.5	512	526	563	543.1	2,66
4.6	560	586	672	620.35	4,44
4.7	430	440	511	448.2	2,27
4.8	492	500	700	523.65	1,60
4.9	641	672	756	701.95	4,61
4.10	514	551	624	580.55	6,72
5.1	253	278	15573	1718.85	8,99
5.2	302	317	21008	1206.9	4,73
5.3	226	248	14940	1275.15	8,87
5.4	242	251	17212	1103.6	3,59
5.5	211	225	19689	2949.85	6,22
5.6	213	235	19074	2566.85	9,36
5.7	293	315	13416	3328.85	6,98
5.8	288	316	12147	488.15	8,86
5.9	279	288	16539	1901.85	3,13
5.10	265	277	19520	1236.95	4,33
6.1	138	154	9224	2601.65	10,39
6.2	146	158	9001	1941.7	7,59
6.3	145	157	7619	1627.85	7,64
6.4	131	140	8898	2136.1	6,43
6.5	161	180	9761	1779.9	10,56
A.1	253	278	22732	8254.65	8,99
A.2	252	273	20884	10438.15	7,69
A.3	232	281	23372	5809.45	17,44
A.4	234	350	24332	8206.65	33,14
A.5	236	246	27384	7447.3	4,07
B.1	69	318	23272	13275.1	78,30
B.2	76	234	24601	13889.3	67,52
B.3	80	8857	23631	17757.2	99,10
B.4	79	216	25973	14306.45	63,43
B.5	72	124	30952	14657.55	41,94

Tabla 61: Statics Probability V4.

Instance	Opt.	Min.	Man.	Avg.	RPD
C.1	227	236	33318	11643.45	3,81
C.2	219	587	30837	17578.9	62,69
C.3	243	480	39720	15037.3	49,38
C.4	219	276	35258	13711.4	20,65
C.5	215	222	28048	17057.45	3,15
D.1	60	7139	30980	20209.95	99,16
D.2	66	85	34318	19794.1	22,35
D.3	72	6659	37343	21069.55	98,92
D.4	62	1027	30087	19829.4	93,96
D.5	61	6877	30954	20350.5	99,11
NRE.1	29	5711	44103	26890.05	99,49
NRE.2	30	8929	43418	25200.7	99,66
NRE.3	27	8361	39024	27570.2	99,68
NRE.4	28	5647	47115	22925.05	99,50
NRE.5	28	8654	39506	24994.8	99,68
NRF.1	14	6983	48580	25069.1	99,80
NRF.2	15	8137	38548	23235.7	99,82
NRF.3	14	14122	35681	26136.35	99,90
NRF.4	14	4118	48852	21260.25	99,66
NRF.5	13	5300	38398	25917.05	99,75
NRG.1	176	3229	98474	47465.65	94,55
NRG.2	154	23470	83868	42305.9	99,34
NRG.3	166	24887	75503	56414.75	99,33
NRG.4	168	609	83589	48236.2	72,41
NRG.5	168	3476	111094	44865.9	95,17
NRH.1	63	20572	90586	50496.25	99,69
NRH.2	63	12975	100446	45425.2	99,51
NRH.3	59	8939	106887	45584.2	99,34
NRH.4	58	17024	102871	50199.05	99,66
NRH.5	55	12838	83083	47148.8	99,57

Tabla 62: Statics Probability V4.

Instance	Opt.	Min.	Man.	Avg.	RPD
4.1	429	448	580	452.5	4,24
4.2	512	544	684	567.4	5,88
4.3	516	526	603	541.7	1,90
4.4	494	517	553	535.45	4,45
4.5	512	526	563	543.1	2,66
4.6	560	586	672	620.35	4,44
4.7	430	440	511	448.2	2,27
4.8	492	500	700	523.65	1,60
4.9	641	672	756	701.95	4,61
4.10	514	551	624	580.55	6,72
5.1	253	278	15573	1718.85	8,99
5.2	302	317	21008	1206.9	4,73
5.3	226	248	14940	1275.15	8,87
5.4	242	251	17212	1103.6	3,59
5.5	211	225	19689	2949.85	6,22
5.6	213	235	19074	2566.85	9,36
5.7	293	315	13416	3328.85	6,98
5.8	288	316	12147	488.15	8,86
5.9	279	288	16539	1901.85	3,13
5.10	265	277	19520	1236.95	4,33
6.1	138	154	9224	2601.65	10,39
6.2	146	158	9001	1941.7	7,59
6.3	145	157	7619	1627.85	7,64
6.4	131	140	8898	2136.1	6,43
6.5	161	180	9761	1779.9	10,56
A.1	253	278	22732	8254.65	8,99
A.2	252	273	20884	10438.15	7,69
A.3	232	281	23372	5809.45	17,44
A.4	234	350	24332	8206.65	33,14
A.5	236	246	27384	7447.3	4,07
B.1	69	318	23272	13275.1	78,30
B.2	76	234	24601	13889.3	67,52
B.3	80	8857	23631	17757.2	99,10
B.4	79	216	25973	14306.45	63,43
B.5	72	124	30952	14657.55	41,94

Tabla 63: Statics Probability S1.

Instance	Opt.	Min.	Man.	Avg.	RPD
C.1	227	236	33318	11643.45	3,81
C.2	219	587	30837	17578.9	62,69
C.3	243	480	39720	15037.3	49,38
C.4	219	276	35258	13711.4	20,65
C.5	215	222	28048	17057.45	3,15
D.1	60	7139	30980	20209.95	99,16
D.2	66	85	34318	19794.1	22,35
D.3	72	6659	37343	21069.55	98,92
D.4	62	1027	30087	19829.4	93,96
D.5	61	6877	30954	20350.5	99,11
NRE.1	29	5711	44103	26890.05	99,49
NRE.2	30	8929	43418	25200.7	99,66
NRE.3	27	8361	39024	27570.2	99,68
NRE.4	28	5647	47115	22925.05	99,50
NRE.5	28	8654	39506	24994.8	99,68
NRF.1	14	6983	48580	25069.1	99,80
NRF.2	15	8137	38548	23235.7	99,82
NRF.3	14	14122	35681	26136.35	99,90
NRF.4	14	4118	48852	21260.25	99,66
NRF.5	13	5300	38398	25917.05	99,75
NRG.1	176	3229	98474	47465.65	94,55
NRG.2	154	23470	83868	42305.9	99,34
NRG.3	166	24887	75503	56414.75	99,33
NRG.4	168	609	83589	48236.2	72,41
NRG.5	168	3476	111094	44865.9	95,17
NRH.1	63	20572	90586	50496.25	99,69
NRH.2	63	12975	100446	45425.2	99,51
NRH.3	59	8939	106887	45584.2	99,34
NRH.4	58	17024	102871	50199.05	99,66
NRH.5	55	12838	83083	47148.8	99,57

Tabla 64: Statics Probability S1.

Instance	Opt.	Min.	Man.	Avg.	RPD
4.1	429	448	580	452.5	4,24
4.2	512	544	684	567.4	5,88
4.3	516	526	603	541.7	1,90
4.4	494	517	553	535.45	4,45
4.5	512	526	563	543.1	2,66
4.6	560	586	672	620.35	4,44
4.7	430	440	511	448.2	2,27
4.8	492	501	700	523.65	1,80
4.9	641	690	756	701.95	7,10
4.10	514	558	624	580.55	7,89
5.1	253	274	15573	1718.85	7,66
5.2	302	314	21008	1206.9	3,82
5.3	226	248	14940	1275.15	8,87
5.4	242	251	17212	1103.6	3,59
5.5	211	225	19689	2949.85	6,22
5.6	213	235	19074	2566.85	9,36
5.7	293	315	13416	3328.85	6,98
5.8	288	316	12147	488.15	8,86
5.9	279	288	16539	1901.85	3,13
5.10	265	277	19520	1236.95	4,33
6.1	138	154	9224	2601.65	10,39
6.2	146	158	9001	1941.7	7,59
6.3	145	157	7619	1627.85	7,64
6.4	131	140	8898	2136.1	6,43
6.5	161	180	9761	1779.9	10,56
A.1	253	278	22732	8254.65	8,99
A.2	252	273	20884	10438.15	7,69
A.3	232	281	23372	5809.45	17,44
A.4	234	350	24332	8206.65	33,14
A.5	236	242	27384	7447.3	2,48
B.1	69	4354	23272	13275.1	98,42
B.2	76	146	24601	13889.3	47,95
B.3	80	8398	23631	17757.2	99,05
B.4	79	5518	25973	14306.45	98,57
B.5	72	6512	30952	14657.55	98,89

Tabla 65: Statics Probability S2.

Instance	Opt.	Min.	Man.	Avg.	RPD
C.1	227	426	33318	11643.45	46,71
C.2	219	249	30837	17578.9	12,05
C.3	243	480	39720	15037.3	49,38
C.4	219	276	35258	13711.4	20,65
C.5	215	222	28048	17057.45	3,15
D.1	60	7139	30980	20209.95	99,16
D.2	66	85	34318	19794.1	22,35
D.3	72	6659	37343	21069.55	98,92
D.4	62	1027	30087	19829.4	93,96
D.5	61	6877	30954	20350.5	99,11
NRE.1	29	5711	44103	26890.05	99,49
NRE.2	30	8929	43418	25200.7	99,66
NRE.3	27	8361	39024	27570.2	99,68
NRE.4	28	5647	47115	22925.05	99,50
NRE.5	28	8654	39506	24994.8	99,68
NRF.1	14	6983	48580	25069.1	99,80
NRF.2	15	8137	38548	23235.7	99,82
NRF.3	14	14122	35681	26136.35	99,90
NRF.4	14	4118	48852	21260.25	99,66
NRF.5	13	5300	38398	25917.05	99,75
NRG.1	176	3229	98474	47465.65	94,55
NRG.2	154	23470	83868	42305.9	99,34
NRG.3	166	24887	75503	56414.75	99,33
NRG.4	168	609	83589	48236.2	72,41
NRG.5	168	3476	111094	44865.9	95,17
NRH.1	63	20572	90586	50496.25	99,69
NRH.2	63	12975	100446	45425.2	99,51
NRH.3	59	8939	106887	45584.2	99,34
NRH.4	58	17024	102871	50199.05	99,66
NRH.5	55	12838	83083	47148.8	99,57

Tabla 66: Statics Probability S2.

Instance	Opt.	Min.	Man.	Avg.	RPD
4.1	429	448	580	452.5	4,24
4.2	512	544	684	567.4	5,88
4.3	516	526	603	541.7	1,90
4.4	494	518	553	535.45	4,63
4.5	512	518	563	543.1	1,16
4.6	560	586	672	620.35	4,44
4.7	430	440	511	448.2	2,27
4.8	492	500	700	523.65	1,60
4.9	641	672	756	701.95	4,61
4.10	514	551	624	580.55	6,72
5.1	253	278	15573	1718.85	8,99
5.2	302	317	21008	1206.9	4,73
5.3	226	248	14940	1275.15	8,87
5.4	242	251	17212	1103.6	3,59
5.5	211	225	19689	2949.85	6,22
5.6	213	235	19074	2566.85	9,36
5.7	293	315	13416	3328.85	6,98
5.8	288	316	12147	488.15	8,86
5.9	279	288	16539	1901.85	3,13
5.10	265	277	19520	1236.95	4,33
6.1	138	152	9224	2601.65	9,21
6.2	146	160	9001	1941.7	8,75
6.3	145	160	7619	1627.85	9,38
6.4	131	140	8898	2136.1	6,43
6.5	161	186	9761	1779.9	13,44
A.1	253	261	22732	8254.65	3,07
A.2	252	277	20884	10438.15	9,03
A.3	232	252	23372	5809.45	7,94
A.4	234	250	24332	8206.65	6,40
A.5	236	246	27384	7447.3	4,07
B.1	69	318	23272	13275.1	78,30
B.2	76	234	24601	13889.3	67,52
B.3	80	8857	23631	17757.2	99,10
B.4	79	216	25973	14306.45	63,43
B.5	72	124	30952	14657.55	41,94

Tabla 67: Statics Probability S3.

Instance	Opt.	Min.	Man.	Avg.	RPD
C.1	227	236	33318	11643.45	3,81
C.2	219	587	30837	17578.9	62,69
C.3	243	480	39720	15037.3	49,38
C.4	219	276	35258	13711.4	20,65
C.5	215	222	28048	17057.45	3,15
D.1	60	7139	30980	20209.95	99,16
D.2	66	85	34318	19794.1	22,35
D.3	72	6659	37343	21069.55	98,92
D.4	62	1027	30087	19829.4	93,96
D.5	61	6877	30954	20350.5	99,11
NRE.1	29	5711	44103	26890.05	99,49
NRE.2	30	8929	43418	25200.7	99,66
NRE.3	27	8361	39024	27570.2	99,68
NRE.4	28	5647	47115	22925.05	99,50
NRE.5	28	8654	39506	24994.8	99,68
NRF.1	14	6983	48580	25069.1	99,80
NRF.2	15	8137	38548	23235.7	99,82
NRF.3	14	14122	35681	26136.35	99,90
NRF.4	14	4118	48852	21260.25	99,66
NRF.5	13	5300	38398	25917.05	99,75
NRG.1	176	3229	98474	47465.65	94,55
NRG.2	154	23470	83868	42305.9	99,34
NRG.3	166	24887	75503	56414.75	99,33
NRG.4	168	609	83589	48236.2	72,41
NRG.5	168	3476	111094	44865.9	95,17
NRH.1	63	20572	90586	50496.25	99,69
NRH.2	63	12975	100446	45425.2	99,51
NRH.3	59	8939	106887	45584.2	99,34
NRH.4	58	17024	102871	50199.05	99,66
NRH.5	55	12838	83083	47148.8	99,57

Tabla 68: Statics Probability S3.

Instance	Opt.	Min.	Man.	Avg.	RPD
4.1	429	448	580	452.5	4,24
4.2	512	544	684	567.4	5,88
4.3	516	526	603	541.7	1,90
4.4	494	518	553	535.45	4,63
4.5	512	518	563	543.1	1,16
4.6	560	586	672	620.35	4,44
4.7	430	440	511	448.2	2,27
4.8	492	500	700	523.65	1,60
4.9	641	672	756	701.95	4,61
4.10	514	551	624	580.55	6,72
5.1	253	278	15573	1718.85	8,99
5.2	302	317	21008	1206.9	4,73
5.3	226	248	14940	1275.15	8,87
5.4	242	251	17212	1103.6	3,59
5.5	211	225	19689	2949.85	6,22
5.6	213	235	19074	2566.85	9,36
5.7	293	315	13416	3328.85	6,98
5.8	288	316	12147	488.15	8,86
5.9	279	288	16539	1901.85	3,13
5.10	265	277	19520	1236.95	4,33
6.1	138	154	9224	2601.65	10,39
6.2	146	158	9001	1941.7	7,59
6.3	145	157	7619	1627.85	7,64
6.4	131	140	8898	2136.1	6,43
6.5	161	180	9761	1779.9	10,56
A.1	253	278	22732	8254.65	8,99
A.2	252	273	20884	10438.15	7,69
A.3	232	281	23372	5809.45	17,44
A.4	234	350	24332	8206.65	33,14
A.5	236	242	27384	7447.3	2,48
B.1	69	4354	23272	13275.1	98,42
B.2	76	146	24601	13889.3	47,95
B.3	80	8398	23631	17757.2	99,05
B.4	79	5518	25973	14306.45	98,57
B.5	72	6512	30952	14657.55	98,89

Tabla 69: Statics Probability S4.

Instance	Opt.	Min.	Man.	Avg.	RPD
C.1	227	426	33318	11643.45	46,71
C.2	219	249	30837	17578.9	12,05
C.3	243	480	39720	15037.3	49,38
C.4	219	276	35258	13711.4	20,65
C.5	215	222	28048	17057.45	3,15
D.1	60	7139	30980	20209.95	99,16
D.2	66	85	34318	19794.1	22,35
D.3	72	6659	37343	21069.55	98,92
D.4	62	1027	30087	19829.4	93,96
D.5	61	6877	30954	20350.5	99,11
NRE.1	29	5711	44103	26890.05	99,49
NRE.2	30	8929	43418	25200.7	99,66
NRE.3	27	8361	39024	27570.2	99,68
NRE.4	28	5647	47115	22925.05	99,50
NRE.5	28	8654	39506	24994.8	99,68
NRF.1	14	6983	48580	25069.1	99,80
NRF.2	15	8137	38548	23235.7	99,82
NRF.3	14	14122	35681	26136.35	99,90
NRF.4	14	4118	48852	21260.25	99,66
NRF.5	13	5300	38398	25917.05	99,75
NRG.1	176	3229	98474	47465.65	94,55
NRG.2	154	23470	83868	42305.9	99,34
NRG.3	166	24887	75503	56414.75	99,33
NRG.4	168	609	83589	48236.2	72,41
NRG.5	168	3476	111094	44865.9	95,17
NRH.1	63	20572	90586	50496.25	99,69
NRH.2	63	12975	100446	45425.2	99,51
NRH.3	59	8939	106887	45584.2	99,34
NRH.4	58	17024	102871	50199.05	99,66
NRH.5	55	12838	83083	47148.8	99,57

Tabla 70: Statics Probability S4.

Instance	Opt.	Min.	Man.	Avg.	RPD
4.1	429	439	449	448.45	2,28
4.2	512	549	559	557.8	6,74
4.3	516	532	537	536.35	3,01
4.4	494	527	532	530.35	6,26
4.5	512	526	527	526.95	2,66
4.6	560	597	607	604.05	6,20
4.7	430	437	447	446.1	1,60
4.8	492	509	509	509	3,34
4.9	641	678	697	693.35	5,46
4.10	514	556	572	570.0	7,55
5.1	253	275	280	279.5	8,00
5.2	302	315	317	316.85	4,13
5.3	226	241	247	245.55	6,22
5.4	242	249	251	250.85	2,81
5.5	211	221	225	224.8	4,52
5.6	213	236	247	244.2	9,75
5.7	293	312	315	314.7	6,09
5.8	288	312	316	314.5	7,69
5.9	279	304	315	314.1	8,22
5.10	265	275	280	279.05	3,64
6.1	138	148	152	151.55	6,76
6.2	146	154	160	157.95	5,19
6.3	145	152	160	159.0	4,61
6.4	131	134	140	139.5	2,24
6.5	161	177	184	181.9	9,04
A.1	253	261	261	261.0	3,07
A.2	252	275	354	280.75	8,36
A.3	232	249	252	251.85	6,83
A.4	234	244	250	249.5	4,10
A.5	236	240	241	240.65	1,67
B.1	69	85	86	85.95	18,82
B.2	76	88	99	88.55	13,64
B.3	80	84	100	85.8	4,76
B.4	79	84	152	88.6	5,95
B.5	72	76	98	78.9	5,26

Tabla 71: Roulette S1.

Instance	Opt.	Min.	Man.	Avg.	RPD
C.1	227	235	270	236.75	3,40
C.2	219	235	236	235.95	6,81
C.3	243	270	324	273.25	10,00
C.4	219	245	279	249.35	10,61
C.5	215	222	244	223.4	3,15
D.1	60	61	92	63.95	1,64
D.2	66	73	74	73.4	9,59
D.3	72	79	146	80.2	8,86
D.4	62	66	146	72.25	6,06
D.5	61	65	136	69.9	6,15
NRE.1	29	30	112	36.5	3,33
NRE.2	30	35	118	45.9	14,29
NRE.3	27	32	75	37.2	15,63
NRE.4	28	33	70	34.85	15,15
NRE.5	28	30	86	33.75	6,67
NRF.1	14	16	342	45.25	12,50
NRF.2	15	18	103	33.5	16,67
NRF.3	14	17	180	33.45	17,65
NRF.4	14	16	18	17.75	12,50
NRF.5	13	16	16	16	18,75
NRG.1	176	195	195	195	9,74
NRG.2	154	168	168	168	8,33
NRG.3	166	179	180	179.95	7,26
NRG.4	168	181	184	183.65	7,18
NRG.5	168	186	189	188.2	9,68
NRH.1	63	72	73	73	12,50
NRH.2	63	67	67	67	5,97
NRH.3	59	69	69	69	14,49
NRH.4	58	68	68	68	14,71
NRH.5	55	61	61	61	9,84

Tabla 72: Roulette S1.

Instance	Opt.	Min.	Man.	Avg.	RPD
4.1	429	443	452	448.1	3,16
4.2	512	544	596	559.0	5,88
4.3	516	532	537	536.6	3,01
4.4	494	520	556	532.35	5,00
4.5	512	527	577	529.5	2,85
4.6	560	586	607	605.45	4,44
4.7	430	444	458	448.1	3,15
4.8	492	501	510	508.35	1,80
4.9	641	673	727	697.5	4,75
4.10	514	556	572	570.0	7,55
5.1	253	277	397	291.75	8,66
5.2	302	317	345	319.25	4,73
5.3	226	237	314	252.15	4,64
5.4	242	248	283	254.35	2,42
5.5	211	225	225	225	6,22
5.6	213	245	268	247.85	13,06
5.7	293	313	351	318.3	6,39
5.8	288	312	352	321.5	7,69
5.9	279	311	346	317.3	10,29
5.10	265	275	280	279.05	3,64
6.1	138	147	152	151.45	6,12
6.2	146	154	183	160.1	5,19
6.3	145	151	175	159.35	3,97
6.4	131	134	142	139.5	2,24
6.5	161	180	186	183.3	10,56
A.1	253	261	469	291.35	3,07
A.2	252	275	432	286.7	8,36
A.3	232	249	252	251.85	6,83
A.4	234	242	294	259.5	3,31
A.5	236	240	508	272.5	1,67
B.1	69	86	445	164.05	19,77
B.2	76	88	395	146.8	13,64
B.3	80	84	100	85.8	4,76
B.4	79	84	152	88.6	5,95
B.5	72	78	298	114.85	7,69

Tabla 73: Roulette S2.

Instance	Opt.	Min.	Man.	Avg.	RPD
C.1	227	235	270	236.75	3,40
C.2	219	236	545	308.95	7,20
C.3	243	270	324	273.25	10,00
C.4	219	246	765	329.55	10,98
C.5	215	222	244	223.4	3,15
D.1	60	61	92	63.95	1,64
D.2	66	73	74	73.4	9,59
D.3	72	79	146	80.2	8,86
D.4	62	66	146	72.25	6,06
D.5	61	65	136	69.9	6,15
NRE.1	29	30	112	36.5	3,33
NRE.2	30	35	118	45.9	14,29
NRE.3	27	32	75	37.2	15,63
NRE.4	28	33	70	34.85	15,15
NRE.5	28	30	86	33.75	6,67
NRF.1	14	16	342	45.25	12,50
NRF.2	15	18	103	33.5	16,67
NRF.3	14	17	180	33.45	17,65
NRF.4	14	18	18	17.7	22,22
NRF.5	13	18	16	16	27,78
NRG.1	176	196	196	196	10,20
NRG.2	154	164	168	167.75	6,10
NRG.3	166	179	180	179.95	7,26
NRG.4	168	182	208	183.65	7,69
NRG.5	168	187	189	188.4	10,16
NRH.1	63	73	73	73	13,70
NRH.2	63	67	67	67	5,97
NRH.3	59	66	69	68.85	10,61
NRH.4	58	66	68	67.8	12,12
NRH.5	55	61	61	61	9,84

Tabla 74: Roulette S2.

Instance	Opt.	Min.	Man.	Avg.	RPD
4.1	429	439	449	446,5	2,28
4.2	512	549	559	556,5	6,74
4.3	516	532	537	535,75	3,01
4.4	494	527	532	530,75	6,26
4.5	512	526	527	526,75	2,66
4.6	560	597	607	604,5	6,20
4.7	430	437	447	444,5	1,60
4.8	492	509	509	509	3,34
4.9	641	678	697	692,25	5,46
4.10	514	556	572	568	7,55
5.1	253	275	280	278,75	8,00
5.2	302	315	317	316,5	4,13
5.3	226	241	247	245,5	6,22
5.4	242	249	251	250,5	2,81
5.5	211	221	225	224	4,52
5.6	213	236	247	244,25	9,75
5.7	293	312	315	314,25	6,09
5.8	288	312	316	315	7,69
5.9	279	304	315	312,25	8,22
5.10	265	275	280	278,75	3,64
6.1	138	148	152	151	6,76
6.2	146	154	160	158,5	5,19
6.3	145	152	160	158	4,61
6.4	131	134	140	138,5	2,24
6.5	161	177	184	182,25	9,04
A.1	253	261	261	261	3,07
A.2	252	275	354	334,25	8,36
A.3	232	249	252	251,25	6,83
A.4	234	244	250	248,5	4,10
A.5	236	240	241	240,75	1,67
B.1	69	85	86	85,75	18,82
B.2	76	88	99	96,25	13,64
B.3	80	84	100	96	4,76
B.4	79	84	152	135	5,95
B.5	72	76	98	92,5	5,26

Tabla 75: Roulette S3.

Instance	Opt.	Min.	Man.	Avg.	RPD
C.1	227	235	270	261,25	3,40
C.2	219	235	236	235,75	6,81
C.3	243	270	324	310,5	10,00
C.4	219	245	279	270,5	10,61
C.5	215	222	244	238,5	3,15
D.1	60	61	92	84,25	1,64
D.2	66	73	74	73,75	9,59
D.3	72	79	146	129,25	8,86
D.4	62	66	146	126	6,06
D.5	61	65	136	118,25	6,15
NRE.1	29	30	112	91,5	3,33
NRE.2	30	35	118	97,25	14,29
NRE.3	27	32	75	64,25	15,63
NRE.4	28	33	70	60,75	15,15
NRE.5	28	30	86	72	6,67
NRF.1	14	16	342	260,5	12,50
NRF.2	15	18	103	81,75	16,67
NRF.3	14	17	180	139,25	17,65
NRF.4	14	16	18	17,5	12,50
NRF.5	13	16	16	16	18,75
NRG.1	176	195	195	195	9,74
NRG.2	154	168	168	168	8,33
NRG.3	166	179	180	179,75	7,26
NRG.4	168	181	184	183,25	7,18
NRG.5	168	186	189	188,25	9,68
NRH.1	63	72	73	72,75	12,50
NRH.2	63	67	67	67	5,97
NRH.3	59	69	69	69	14,49
NRH.4	58	68	68	68	14,71
NRH.5	55	61	61	61	9,84

Tabla 76: Roulette S3.

Instance	Opt.	Min.	Man.	Avg.	RPD
4.1	429	443	452	449,75	3,16
4.2	512	544	596	583	5,88
4.3	516	532	537	535,75	3,01
4.4	494	520	556	547	5,00
4.5	512	527	577	564,5	2,85
4.6	560	586	607	601,75	4,44
4.7	430	444	458	454,5	3,15
4.8	492	501	510	507,75	1,80
4.9	641	673	727	713,5	4,75
4.10	514	556	572	568	7,55
5.1	253	277	397	367	8,66
5.2	302	317	345	338	4,73
5.3	226	237	314	294,75	4,64
5.4	242	248	283	274,25	2,42
5.5	211	225	225	225	6,22
5.6	213	245	268	262,25	13,06
5.7	293	313	351	341,5	6,39
5.8	288	312	352	342	7,69
5.9	279	311	346	337,25	10,29
5.10	265	275	280	278,75	3,64
6.1	138	147	152	150,75	6,12
6.2	146	154	183	175,75	5,19
6.3	145	151	175	169	3,97
6.4	131	134	142	140	2,24
6.5	161	180	186	184,5	10,56
A.1	253	261	469	417	3,07
A.2	252	275	432	392,75	8,36
A.3	232	249	252	251,25	6,83
A.4	234	242	294	281	3,31
A.5	236	240	508	441	1,67
B.1	69	86	445	355,25	19,77
B.2	76	88	395	318,25	13,64
B.3	80	84	100	96	4,76
B.4	79	84	152	135	5,95
B.5	72	78	298	243	7,69

Tabla 77: Roulette S4.

Instance	Opt.	Min.	Man.	Avg.	RPD
C.1	227	235	270	261,25	3,40
C.2	219	236	545	467,75	7,20
C.3	243	270	324	310,5	10,00
C.4	219	246	765	635,25	10,98
C.5	215	222	244	238,5	3,15
D.1	60	61	92	84,25	1,64
D.2	66	73	74	73,75	9,59
D.3	72	79	146	129,25	8,86
D.4	62	66	146	126	6,06
D.5	61	65	136	118,25	6,15
NRE.1	29	30	112	91,5	3,33
NRE.2	30	35	118	97,25	14,29
NRE.3	27	32	75	64,25	15,63
NRE.4	28	33	70	60,75	15,15
NRE.5	28	30	86	72	6,67
NRF.1	14	16	342	260,5	12,50
NRF.2	15	18	103	81,75	16,67
NRF.3	14	17	180	139,25	17,65
NRF.4	14	18	18	18	22,22
NRF.5	13	18	16	16,5	27,78
NRG.1	176	196	196	196	10,20
NRG.2	154	164	168	167	6,10
NRG.3	166	179	180	179,75	7,26
NRG.4	168	182	208	201,5	7,69
NRG.5	168	187	189	188,5	10,16
NRH.1	63	73	73	73	13,70
NRH.2	63	67	67	67	5,97
NRH.3	59	66	69	68,25	10,61
NRH.4	58	66	68	67,5	12,12
NRH.5	55	61	61	61	9,84

Tabla 78: Roulette S4.

Instance	Opt.	Min.	Man.	Avg.	RPD
4.1	429	443	449	448.35	3,16
4.2	512	546	559	557.35	6,23
4.3	516	528	537	536.35	2,27
4.4	494	528	532	531.1	6,44
4.5	512	526	527	526.95	2,66
4.6	560	598	607	605.7	6,35
4.7	430	437	447	446.35	1,60
4.8	492	509	509	509	3,34
4.9	641	684	697	695.45	6,29
4.10	514	561	572	569.0	8,38
5.1	253	274	280	279.25	7,66
5.2	302	314	317	316.7	3,82
5.3	226	246	247	246.85	8,13
5.4	242	251	251	251	3,59
5.5	211	225	225	225	6,22
5.6	213	244	247	246.75	12,70
5.7	293	315	315	315	6,98
5.8	288	302	316	314.8	4,64
5.9	279	292	315	312.65	4,45
5.10	265	276	280	279.65	3,99
6.1	138	152	152	152	9,21
6.2	146	153	160	156.75	4,58
6.3	145	152	160	159.05	4,61
6.4	131	134	140	139.7	2,24
6.5	161	179	186	183.85	10,06
A.1	253	261	261	261	3,07
A.2	252	271	277	276.7	7,01
A.3	232	250	252	251.85	7,20
A.4	234	242	250	247.9	3,31
A.5	236	240	241	240.7	1,67
B.1	69	82	86	85.55	15,85
B.2	76	88	88	88	13,64
B.3	80	84	85	84.95	4,76
B.4	79	83	84	83.95	4,82
B.5	72	72	78	77.7	0,00

Tabla 79: Roulette V1.

Instance	Opt.	Min.	Man.	Avg.	RPD
C.1	227	235	235	235	3,40
C.2	219	234	236	235.75	6,41
C.3	243	270	270	270	10,00
C.4	219	243	246	245.8	9,88
C.5	215	222	223	222.65	3,15
D.1	60	61	62	61.45	1,64
D.2	66	72	74	73.45	8,33
D.3	72	79	79	79	8,86
D.4	62	66	68	67.5	6,06
D.5	61	65	66	65.75	6,15
NRE.1	29	30	30	30	3,33
NRE.2	30	34	35	34.8	11,76
NRE.3	27	32	34	33.7	15,63
NRE.4	28	33	33	33	15,15
NRE.5	28	30	30	30	6,67
NRF.1	14	17	17	17	17,65
NRF.2	15	18	18	18	16,67
NRF.3	14	17	17	17	17,65
NRF.4	14	16	18	17.7	12,50
NRF.5	13	16	16	16	18,75
NRG.1	176	196	195	196	10,20
NRG.2	154	164	168	167.75	6,10
NRG.3	166	179	180	179.95	7,26
NRG.4	168	182	184	183.65	7,69
NRG.5	168	187	189	188.4	10,16
NRH.1	63	73	73	73	13,70
NRH.2	63	67	67	67	5,97
NRH.3	59	66	69	68.85	10,61
NRH.4	58	66	68	67.8	12,12
NRH.5	55	61	61	61	9,84

Tabla 80: Roulette V1.

Instance	Opt.	Min.	Man.	Avg.	RPD
4.1	429	446	449	448.6	3,81
4.2	512	553	559	558.3	7,41
4.3	516	534	537	536.85	3,37
4.4	494	527	532	530.6	6,26
4.5	512	520	527	526.65	1,54
4.6	560	598	607	605.9	6,35
4.7	430	445	447	446.9	3,37
4.8	492	509	509	509	3,34
4.9	641	682	697	694.25	6,01
4.10	514	559	572	569.4	8,05
5.1	253	276	280	279.65	8,33
5.2	302	317	317	317	4,73
5.3	226	242	247	246.2	6,61
5.4	242	250	251	250.95	3,20
5.5	211	219	225	224.7	3,65
5.6	213	236	247	246.1	9,75
5.7	293	311	315	314.7	5,79
5.8	288	312	316	315.45	7,69
5.9	279	303	315	314.0	7,92
5.10	265	275	280	279.55	3,64
6.1	138	147	152	151.6	6,12
6.2	146	154	160	158.1	5,19
6.3	145	151	160	159.25	3,97
6.4	131	136	140	139.8	3,68
6.5	161	181	186	183.55	11,05
A.1	253	260	261	260.95	2,69
A.2	252	275	277	276.75	8,36
A.3	232	250	252	251.8	7,20
A.4	234	246	250	249.2	4,88
A.5	236	240	241	240.8	1,67
B.1	69	83	86	85.55	16,87
B.2	76	86	88	87.9	11,63
B.3	80	84	86	85	4,76
B.4	79	84	84	84	5,95
B.5	72	77	78	77.95	6,49

Tabla 81: Roulette V2.

Instance	Opt.	Min.	Man.	Avg.	RPD
C.1	227	235	235	235	3,40
C.2	219	234	236	235.75	6,41
C.3	243	269	270	269.95	9,67
C.4	219	246	246	246	10,98
C.5	215	222	223	222.7	3,15
D.1	60	61	62	61.8	1,64
D.2	66	73	74	73.75	9,59
D.3	72	78	79	78.9	7,69
D.4	62	66	68	67.8	6,06
D.5	61	64	66	65.55	4,69
NRE.1	29	30	30	30	3,33
NRE.2	30	34	35	34.95	11,76
NRE.3	27	32	34	33.6	15,63
NRE.4	28	33	33	33	15,15
NRE.5	28	30	30	30	6,67
NRF.1	14	17	17	17	17,65
NRF.2	15	18	18	18	16,67
NRF.3	14	17	17	17	17,65
NRF.4	14	16	18	17.75	12,50
NRF.5	13	16	16	16	18,75
NRG.1	176	195	195	195	9,74
NRG.2	154	168	168	168	8,33
NRG.3	166	179	180	179.95	7,26
NRG.4	168	181	184	183.65	7,18
NRG.5	168	186	189	188.2	9,68
NRH.1	63	72	73	72.9	12,50
NRH.2	63	67	67	67	5,97
NRH.3	59	68	69	68.95	13,24
NRH.4	58	67	68	67.85	13,43
NRH.5	55	61	61	61	9,84

Tabla 82: Roulette V2.

Instance	Opt.	Min.	Man.	Avg.	RPD
4.1	429	446	449	448.55	3,81
4.2	512	553	559	555.35	7,41
4.3	516	534	537	535.35	3,37
4.4	494	527	532	529.1	6,26
4.5	512	520	527	526.95	1,54
4.6	560	598	607	604.75	6,35
4.7	430	445	447	447	3,37
4.8	492	509	509	508.6	3,34
4.9	641	682	697	695.9	6,01
4.10	514	559	572	569.4	8,05
5.1	253	274	280	279.65	7,66
5.2	302	317	317	317	4,73
5.3	226	246	247	246.2	8,13
5.4	242	251	251	251	3,59
5.5	211	225	225	225	6,22
5.6	213	242	247	246.75	11,98
5.7	293	313	315	314.9	6,39
5.8	288	316	316	316	8,86
5.9	279	304	315	314.0	8,22
5.10	265	275	280	279.55	3,64
6.1	138	147	152	151.5	6,12
6.2	146	154	160	158.1	5,19
6.3	145	151	160	159.65	3,97
6.4	131	136	140	139.7	3,68
6.5	161	181	186	183.55	11,05
A.1	253	261	261	261	3,07
A.2	252	276	277	276.9	8,70
A.3	232	252	252	252	7,94
A.4	234	248	250	249.85	5,65
A.5	236	240	241	240.8	1,67
B.1	69	83	86	85.45	16,87
B.2	76	86	88	87.9	11,63
B.3	80	84	85	85	4,76
B.4	79	84	84	84	5,95
B.5	72	77	78	77.9	6,49

Tabla 83: Roulette V3.

Instance	Opt.	Min.	Man.	Avg.	RPD
C.1	227	235	235	235	3,40
C.2	219	234	236	235.75	6,41
C.3	243	269	270	269.95	9,67
C.4	219	246	246	246	10,98
C.5	215	222	223	222.7	3,15
D.1	60	30	62	62	-100,00
D.2	66	34	74	73.75	-94,12
D.3	72	32	79	78.9	-125,00
D.4	62	33	68	67.8	-87,88
D.5	61	30	66	65.55	-103,33
NRE.1	29	17	30	30	-70,59
NRE.2	30	34	35	34.95	11,76
NRE.3	27	32	34	33.6	15,63
NRE.4	28	33	33	33	15,15
NRE.5	28	30	30	30	6,67
NRF.1	14	17	17	17	17,65
NRF.2	15	18	18	18	16,67
NRF.3	14	17	17	17	17,65
NRF.4	14	16	18	17.75	12,50
NRF.5	13	16	16	16	18,75
NRG.1	176	195	195	195	9,74
NRG.2	154	168	168	168	8,33
NRG.3	166	179	180	179.95	7,26
NRG.4	168	181	184	183.65	7,18
NRG.5	168	186	189	188.2	9,68
NRH.1	63	72	73	72.95	12,50
NRH.2	63	67	67	67	5,97
NRH.3	59	69	69	69	14,49
NRH.4	58	68	68	68	14,71
NRH.5	55	61	61	61	9,84

Tabla 84: Roulette V3.

Instance	Opt.	Min.	Man.	Avg.	RPD
4.1	429	442	449	448.4	2,94
4.2	512	553	559	558.15	7,41
4.3	516	528	537	536.2	2,27
4.4	494	530	532	531.9	6,79
4.5	512	526	527	526.95	2,66
4.6	560	581	607	604.75	3,61
4.7	430	447	447	447	3,80
4.8	492	501	509	508.6	1,80
4.9	641	683	697	695.9	6,15
4.10	514	556	572	569.4	7,55
5.1	253	274	280	279.65	7,66
5.2	302	317	317	317	4,73
5.3	226	246	247	246.2	8,13
5.4	242	251	251	251	3,59
5.5	211	225	225	225	6,22
5.6	213	242	247	246.75	11,98
5.7	293	313	315	314.9	6,39
5.8	288	316	316	316	8,86
5.9	279	304	315	314.0	8,22
5.10	265	275	280	279.55	3,64
6.1	138	147	152	151.5	6,12
6.2	146	154	160	158.1	5,19
6.3	145	156	160	159.65	7,05
6.4	131	136	140	139.7	3,68
6.5	161	181	186	183.55	11,05
A.1	253	261	261	261	3,07
A.2	252	276	277	276.9	8,70
A.3	232	252	252	252	7,94
A.4	234	248	250	249.85	5,65
A.5	236	240	241	240.8	1,67
B.1	69	81	86	85.65	14,81
B.2	76	88	88	88	13,64
B.3	80	85	85	85	5,88
B.4	79	84	84	84	5,95
B.5	72	78	78	78	7,69

Tabla 85: Roulette V4.

Instance	Opt.	Min.	Man.	Avg.	RPD
C.1	227	235	235	235	3,40
C.2	219	234	236	235.75	6,41
C.3	243	269	270	269.95	9,67
C.4	219	246	246	246	10,98
C.5	215	222	223	222.7	3,15
D.1	60	62	62	62	3,23
D.2	66	73	74	73.75	9,59
D.3	72	78	79	78.9	7,69
D.4	62	66	68	67.8	6,06
D.5	61	64	66	65.55	4,69
NRE.1	29	30	30	30	3,33
NRE.2	30	34	35	34.95	11,76
NRE.3	27	32	34	33.6	15,63
NRE.4	28	33	33	33	15,15
NRE.5	28	30	30	30	6,67
NRF.1	14	17	17	17	17,65
NRF.2	15	18	18	18	16,67
NRF.3	14	17	17	17	17,65
NRF.4	14	16	18	17.75	12,50
NRF.5	13	16	16	16	18,75
NRG.1	176	195	195	195	9,74
NRG.2	154	168	168	168	8,33
NRG.3	166	179	180	179.95	7,26
NRG.4	168	181	184	183.65	7,18
NRG.5	168	186	189	188.2	9,68
NRH.1	63	72	73	72.95	12,50
NRH.2	63	67	67	67	5,97
NRH.3	59	69	69	69	14,49
NRH.4	58	68	68	68	14,71
NRH.5	55	61	61	61	9,84

Tabla 86: Roulette V4.