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A Greedy Randomized Adaptive Search Procedures for Multi-Period Inventory Routing in Perishable Goods Supply Chains

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Abstract

This thesis addresses the multi-period inventory routing problem (PIRP) under uncertainty, a critical challenge in perishable goods supply chains. Efficiently managing inventory and routing decisions is essential to minimize costs and maintain service levels while accounting for perishability and dynamic customer demands.

The research focuses on evaluating the Greedy Randomized Adaptive Search Procedure (GRASP) metaheuristic as a solution methodology for PIRPs. GRASP's performance is compared to an exact solver across various datasets, highlighting its potential to balance solution quality, runtime efficiency, and scalability. Due to the unavailability of real-world data, simulated datasets were used, spanning multiple planning periods, customer demands, and operational constraints.

The findings reveal that GRASP consistently delivers high-quality solutions, achieving up to 90% of the exact solver's optimal objective value for smaller datasets and maintaining acceptable performance levels (50% to 90%) for larger, more complex instances. GRASP significantly outperforms the exact solver in terms of computational efficiency, solving large-scale problems within a fraction of the time required by the exact solver. This efficiency positions GRASP as a practical tool for time-sensitive and large-scale decision-making in supply chains.

Despite its strengths, the study acknowledges limitations such as reliance on simulated data and the challenges of fully capturing real-world complexities. Future research could explore the application of GRASP on real-world datasets and investigate its integration with complementary methods to further enhance its performance.

Overall, this thesis contributes to advancing heuristic-based approaches for PIRPs, providing actionable insights for supply chain managers. GRASP's scalability and adaptability underscore its practicality for industries dealing with perishable goods, offering a valuable decision-making tool for optimizing supply chain operations under uncertainty.

I dedicate this thesis to my family. Their unwavering support throughout my academic journey has made this achievement possible.

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Chapter 1

Introduction

In the perishable goods supply chain, routing and inventory management play a critical role in ensuring the freshness and quality of goods from the point of origin to the consumer. These processes are essential for food safety, waste reduction, and sustainability (Kumar et al., 2022). Perishable goods, unlike non-perishables, require more sophisticated and dynamic supply chain strategies due to their limited shelf life and varying quality over time (Song & Wu, 2023).

Perishable goods, such as fresh produce, dairy products, and meats, are vital for maintaining the balance between supply and demand. However, their susceptibility to spoilage and inadequate stock can lead to unmet customer demand, underscoring the importance of proper management (Onggo et al., 2019).

The primary objective of this research is to develop an advanced heuristic, namely a Greedy Randomized Adaptive Search Procedure (GRASP), to optimize key performance indicators, including cost and time, for stochastic multi-period inventory routing problems in the perishable goods supply chain. In this context, uncertain demand is a new challenge, making the problem stochastic. The focus of this work is on addressing this challenge within the Perishable Inventory Routing Problem (PIRP), which aims to align inventory replenishment with uncertain demand across the supply chain. This research leverages the Optimized Priority (OP) policy, which dynamically decides which products to deliver based on age and profitability, thus minimizing waste while maximizing profit. Supporting the foundation for this integrated approach, studies like Hrabec et al.

(2022) provide evidence that an integrated approach to production, inventory, and routing decisions can result in significant cost savings and waste reduction. This potential is particularly compelling in perishable goods supply chains, where operational efficiency and product freshness are critical.

A typical perishable goods supply chain includes several key nodes: farms or producers, processing centers, distribution centers (DCs), and retail outlets. Each of these nodes is linked by transportation routes that are vital for the timely and safe delivery of perishable items (Onggo et al., 2019). The configuration of this supply chain is significantly influenced by the perishability of the products, requiring strategic placement of DCs to minimize transit times and optimize inventory levels at various points in the supply chain (Shaabani, 2022). Additionally, the uncertain demand for perishable goods introduces further complexity in planning, as real-time adjustments in routing and inventory are essential to maintaining product freshness. This characteristic impacts inventory levels, routing decisions, and overall supply chain efficiency, with direct consequences for waste reduction, sustainability, and customer satisfaction (Onggo et al., 2019).

The perishable goods supply chain is characterized by its need for rapid responses and adaptive strategies to handle the inherent unpredictability and variability of product life cycles (Aghighi et al., 2021). The added complexity of stochastic demand, where future demand is uncertain, further intensifies the need for adaptive decision-making. Traditional optimization methods often fall short in this dynamic environment due to the extensive computational resources and time they require, which may not be feasible in real-world scenarios where decisions need to be made swiftly to maintain the freshness of goods. Heuristic approaches, therefore, emerge as a powerful tool, bridging the gap between theoretical optimality and the practical necessity for timely, efficient decision-making (Hiassat et al., 2017).

Heuristic algorithms are designed to exploit specific characteristics of the perishable goods supply chain. For instance, heuristic methods, such as the GRASP, can quickly generate feasible routing plans that minimize the time perishable goods spend in transit, thereby reducing spoilage risk without necessitating exhaustive searches through all possible routes (Shaabani, 2022). Moreover, the development of heuristics tailored to larger instances of the problem showcases the scalability of these approaches. As supply chains grow in size and complexity, incorporating more products, locations, and variables, heuristics can adapt to ensure that the computational effort remains within reasonable bounds (Rohmer et al., 2019). This adaptability is crucial for maintaining the relevance and applicability of supply chain models in diverse settings, from local distribution networks to global logistics operations.

While managing a perishable goods supply chain is inherently complex due to the perishability of products and the need for timely deliveries, this complexity increases when the demand is uncertain. Decisions regarding inventory and routing must be made dynamically to prevent spoilage and ensure customer satisfaction. This research addresses these challenges within the framework of the PIRP by developing both an exact algorithm and a GRASP heuristic, leveraging the Optimized Priority (OP) policy. In the following section, we provide a detailed description of the PIRP, outlining the specific problem characteristics and constraints that make it a critical issue in modern supply chains.

1.1 Problem Description

The Inventory-Routing Problem (IRP) in the context of perishable goods represents a unique set of operational challenges within supply chain management (Shaabani, 2022). Traditional mathematical models are often limited to optimizing smaller instances and struggle to capture the full scope of complexities found in larger, more realistic settings. This gap can lead to significant inefficiencies, particularly in the perishable goods industry, where the consequences of suboptimal inventory routing often result in increased spoilage and higher associated costs (Hiassat et al., 2017). The PIRP extends the IRP by accounting for the perishability of goods, requiring the combined optimization of delivery routes and inventory control. The objective is to ensure that products are delivered while they are still fresh, minimizing spoilage and maximizing customer satisfaction (Onggo et al., 2019).

A significant gap in the existing literature is the lack of comprehensive studies on integrated solutions for IRPs that specifically address perishable goods (Hrabec et al., 2022). These problems are more complex because of issues that only affect perishable items, such as variable shelf lives and strict quality requirements, which require adaptable and responsive supply chain strategies (Mirzaei & Seifi, 2015). Adding to these challenges is the significant computational effort needed to solve integrated IRPs, especially for large-scale networks typical in real-world supply chains. This requires the development of heuristic approaches, such as the GRASP heuristic, which can deliver practical solutions within reasonable computational times, ensuring scalability and applicability to diverse supply chain configurations (Hiassat et al., 2017).

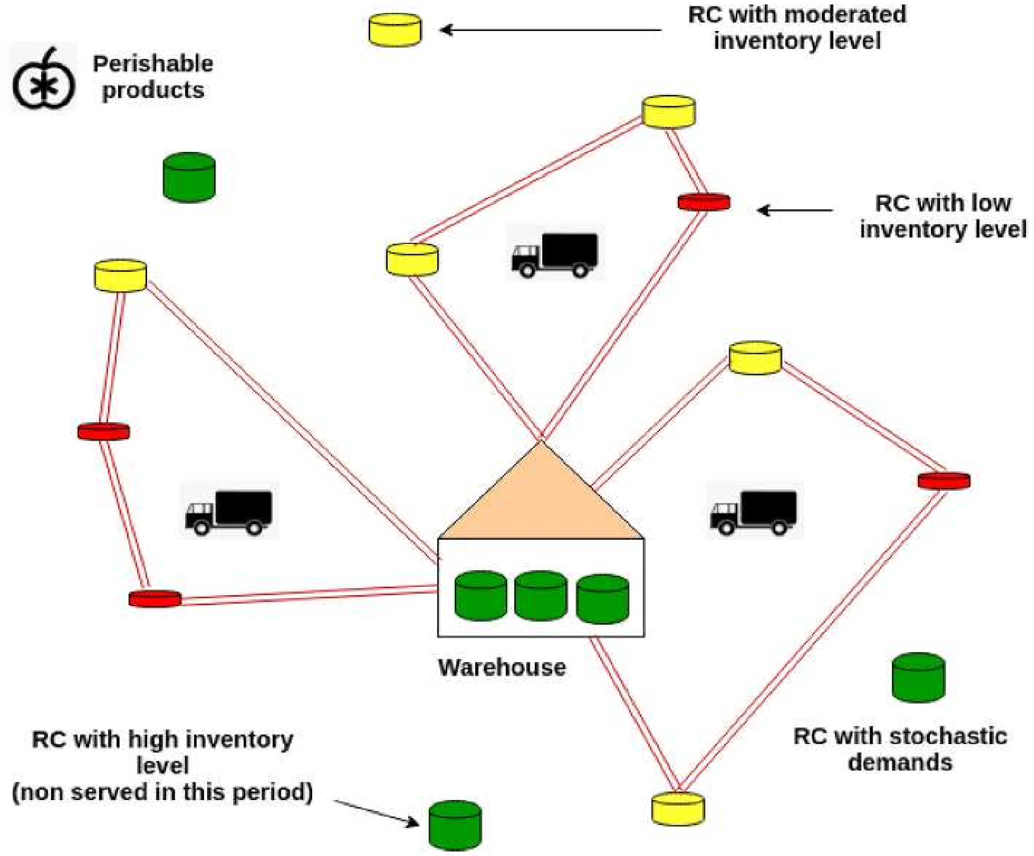

Figure 1.1: Inventory routing problem with perishable products (Onggo et al., 2019).

Figure 1 shows the supply chain flow for perishable goods from a central warehouse to various retail centers (RCs), each facing different inventory challenges. The supply chain consists of two echelons: a central warehouse, where goods are aggregated and prepared for distribution, and retail centers, where the goods are ultimately delivered. The freshness of perishable products is a top priority, necessitating swift transit from the warehouse to RCs to avoid spoilage. The RCs are differentiated by their inventory levels: some have adequate stock (moderated inventory level), while others may experience shortages (low inventory level) or may not require immediate resupply due to high inventory levels. Each echelon faces its own set of decisions and uncertainties—managing inventory levels at the

RCs and determining routing decisions for delivery trucks.

Perishable products can be classified into two main categories based on how they decay over time. The first type includes products whose value remains constant until a specific expiry date, after which their utility drops to zero. This is typical of goods such as yogurt, bottled milk, and certain pharmaceuticals, which become unfit for consumption past their expiration date. The second type consists of products that gradually lose value over time, such as fruits, vegetables, and flowers. For these products, their perceived quality diminishes as they age, even before reaching their final spoilage point. Both types of perishability require precise timing in inventory management and routing to minimize losses and ensure customer satisfaction. In the context of this research, both types of perishability are considered, requiring an adaptive approach to inventory routing that balances freshness, transportation times, and demand uncertainty (Nahmias, 1982).

The age of perishable products directly affects both their inventory holding costs and their revenue potential. As products age, their holding costs tend to increase due to higher risks of spoilage and reduced market value. Similarly, the revenue from these items decreases as consumers place a higher value on fresher products. This dynamic necessitates inventory policies that prioritize the sale of fresher items while minimizing the financial burden of holding aging stock. In this research, this relationship is incorporated into the inventory routing model to optimize both costs and revenue, ensuring that products are distributed efficiently before their value diminishes (Coelho & Laporte, 2014).

In the management of perishable inventory, it is crucial to prioritize which items to sell or deliver based on their age and market value. In this study, the Optimized Priority (OP) policy was implemented, which dynamically determines which items to sell at any given time period to maximize profit. This flexible policy allows the model to decide whether to prioritize fresher items for higher revenue or allow certain items to spoil if the trade-off results in greater overall profitability. Unlike traditional policies such as First-In, First-Out (FIFO) or Last-In, First-Out (LIFO), the OP policy adapts to various parameters, ensuring that decisions align with the objective of maximizing profit under different conditions (Coelho & Laporte, 2014).

The complexities involved in managing perishable inventory and routing decisions, particularly under stochastic demand, present significant challenges that require advanced optimization techniques. The combination of perishability, dynamic demand, and cost considerations calls for a flexible approach like the Optimized Priority (OP) policy, which ensures that decisions are made to maximize profitability. In the next chapter, the specific objectives of this research are outlined, detailing how the development of a GRASP heuristic and the comparison with an exact algorithm will address these challenges, providing an effective solution for managing multi-period perishable inventory routing problems.

1.2 Aims and Objectives

This research aims to evaluate the efficacy of a heuristic approach, specifically the GRASP heuristic, in solving multi-period inventory routing problems for perishable products under stochastic demand. The performance of the heuristic will be benchmarked against solutions obtained from an exact solver. This comparison will be conducted through a two-step process: first, a mathematical model will be formulated and solved using an exact solver to establish benchmark solutions for the heuristics. Subsequently, the GRASP heuristic will be developed, and its solutions will be compared to the best-known solutions obtained from the exact solver.

This research seeks to answer the following question, which forms the basis of the study's direction:

> *How can a heuristic be designed to effectively solve multi-period inventory routing problems under uncertainty in perishable goods supply chains, and how does this heuristic compare to an exact solver in terms of solution quality and runtime efficiency?*

To achieve this aim, the following specific objectives have been set:

- To develop a mathematical model for the PIRP that integrates inventory management and routing decisions within a single framework.
- To design and implement a GRASP heuristic that effectively solves large instances of the PIRP, particularly under uncertainty in demand.
- To compare the performance of the GRASP heuristic with that of an exact solver,

focusing on both solution quality and runtime efficiency.

- To identify conditions under which the GRASP heuristic offers superior computational efficiency and performance for PIRP compared to exact methods.

1.3 Research Contributions

This research makes several key contributions to the study of inventory routing in perishable goods supply chains:

- **Novel Heuristic Approach:** This thesis develops a customized heuristic designed to effectively solve multi-period inventory routing problems under uncertainty, tailored specifically for perishable goods. The heuristic balances solution quality with computational efficiency, providing an alternative to exact methods in complex scenarios.
- **Performance Comparison with exact solvers:** A comprehensive analysis is conducted comparing the heuristic to an exact solver, highlighting strengths and trade-offs in solution quality and runtime efficiency. This comparison offers valuable insights into when a heuristic approach is most suitable.
- **Scalability and Practicality:** The research demonstrates the scalability of the heuristic approach, showing its capability to handle large datasets where exact solvers become computationally prohibitive. This contribution underscores the heuristic's potential for practical applications in supply chain management.

1.4 Outline of the Thesis

This thesis is structured to provide an in-depth analysis of the perishable goods supply chain, with a focus on the IRP and the application of a GRASP heuristic to address the challenges of multi-period inventory management under uncertainty.

- **Chapter 2: Literature Review**
  This chapter presents a comprehensive review of the existing literature on the IRP, focusing specifically on perishable goods and heuristic methods in supply chain optimization. It also identifies gaps in the current research landscape that this thesis

aims to address.

- **Chapter 3: Research Methodology**
  This chapter outlines the development of both the mathematical model and the GRASP heuristic for solving multi-period perishable inventory routing problems. It also explains the methodology for comparing the GRASP heuristic to an exact solver.

- **Chapter 4: Data Analysis and Results Discussion**
  The results of the heuristic and exact solver will be analyzed in this chapter. This section will discuss the performance of the GRASP heuristic in terms of solution quality, computational efficiency, and its effectiveness in solving large-scale instances of the PIRP under uncertainty.

- **Chapter 5: Conclusion**
  The final chapter summarizes the key findings of the research, with a focus on the effectiveness and scalability of the GRASP heuristic in comparison to the exact solver.

Chapter 2

Literature Review

This section provides an overview of seminal works in the field, highlighting the developments and gaps in the literature on the perishable goods supply chain, with a focus on the Inventory Routing Problem (IRP), the perishability of goods, and the application of heuristics methodologies. Through a systematic exploration of recent studies, this section intends to outline the research scope, establishing a basis for addressing recognized shortcomings.

2.1 IRP Problem and Perishability

Zhang et al. (2024) tackled the complexity of managing perishable food supply chains through an innovative closed-loop inventory routing problem, emphasizing the critical role of multi-type returnable transport items (RTIs) selection. Their approach, formulated as an integer linear program, seeks to maximize the supply chain's total profit by carefully balancing revenue from perishable foods—affected by their shelf life and the RTIs used—and associated costs. With the novel application of a kernel search heuristic for solving, the study presents a real-world case involving fresh strawberries, demonstrating the model's effectiveness in enhancing supply chain profitability and providing valuable insights into optimal RTI selection and supply chain management strategies.

Aghighi et al. (2023) proposed an approach to the location-routing-inventory problem for perishable goods, focusing on the critical aspects of customer reneging and balking. By developing a two-phase hybrid model and employing an improved genetic algorithm, they present a solution that adeptly reduces logistics costs and enhances efficiency.

Liang et al. (2023) presented a study on optimizing vehicle routing for perishable goods delivery, focusing on the dual objectives of reducing transportation costs and enhancing customer satisfaction. By incorporating time windows and perishable freshness into a bi-objective Vehicle Routing Problem (VRP) model, and applying a VNS and SA meta-heuristic algorithm, their research offers valuable insights into managing the delivery of perishables. The findings demonstrate the critical balance between logistical efficiency and meeting consumer expectations for fresh goods, providing a blueprint for improving supply chain operations in the perishables sector.

Song and Wu (2023) focused on the optimization of location-inventory and location-inventory-routing problems for perishable goods, seeking cost-reduction strategies in supply chains. It pioneers an approach with mixed integer programming models, addressing supply chain uncertainties. The goal is to cut total supply chain costs, including inventory and transport losses, by considering direct shipments to retailers. Utilizing an exact solution approach with CPLEX and a Simulated Annealing-based heuristic, the paper tackles the problem's complexity. An illustrative case study on YH's fresh milk supply chain in Beijing confirms the models' potential for cost-saving and efficiency gains through direct supplier-to-retailer shipments.

Hrabec et al. (2022) addressed the impact of integrated planning on production, inventory, and routing decisions through a meta-analysis, revealing an 11.08% average cost savings compared to sequential approaches. This work establishes the integrated method's superiority in enhancing operational efficiency and identifies key factors that influence its effectiveness. The analysis serves as a compelling argument for the adoption of integrated planning models in complex supply chain management scenarios.

Shaabani's (2022) literature review on the perishable IRP identified critical research gaps and categorized studies by product types, demand models, and solution strategies. It highlights the predominant focus on deterministic demand and single-objective formulations, suggesting future research should explore non-deterministic demand and multi-objective problems. The review calls for more comprehensive case studies to enhance understanding and application in real-world scenarios, emphasizing the need for innovation in supply chain management for perishables.

Qiu et al. (2019) addressed the complexities of managing perishable goods in supply chains through an innovative production-inventory-routing model. By developing a comprehensive MILP formulation and an exact branch-and-cut algorithm, the research tackles the intertwined decisions of production, inventory management, and delivery scheduling. The introduction of new valid inequalities for the model underscores its contribution to enhancing solution efficiency for PRPs involving perishable items. Computational results validate the model's efficacy, highlighting the importance of perishability in supply chain optimization efforts.

Rohmer et al. (2019) presented an approach to the two-echelon inventory routing problem for perishables, blending perishability with multiple delivery patterns to optimize last-mile distribution. Their methodology employs a MILP and an ALNS metaheuristic, revealing key strategies for minimizing costs and preserving product quality. Distinctively, this paper diverges from the mainstream focus of the existing literature by centering its analysis on inventory management at the depot level rather than at the end customer level, as many other studies tend to do. Their findings highlight the model's adaptability and effectiveness in improving perishable goods' supply chain efficiency, emphasizing the vital role of perishability considerations.

Grillo et al. (2017) presented a mixed integer programming model to optimize the fruit supply chain order process, balancing profit with product freshness. Real-world data underline the model's efficacy, showing that longer shelf life improves both profitability and freshness.

2.2 Heuristics in IRP Problems

Ji et al. (2020) presented a robust optimization approach to the IRP for perishable products, highlighting a model that adapts to demand uncertainties. The analysis, rooted in China's fresh market logistics, reveals that these models, particularly the ellipsoid, not only offer cost-effective solutions but also significantly boost supply chain robustness and service quality in the face of variable demand.

Onggo et al. (2019) delved into the agri-food supply chain's complexities by focusing on the perishable inventory routing problem with stochastic demands. They propose a cutting-edge simheuristic algorithm, blending Monte Carlo simulation with iterated local search, to manage the uncertainties of perishable product supply and customer demand. Their goal is to streamline inventory management and routing to reduce costs related to inventory, transportation, wastage, and shortages.

Hiassat et al. (2017) developed a genetic algorithm to optimize the supply chain for perishable products by integrating location, inventory, and routing decisions. Their innovative methodology addresses the complex challenges of perishability and supply chain costs, demonstrating substantial efficiency improvements and cost reductions. The study validates the approach with numerical experiments, offering a valuable model for strategic supply chain management that significantly benefits from integrated decision-making.

Mirzaei and Seifi (2015) addressed the complexity of inventory routing problems for perishable goods by developing a mathematical model that uniquely accounts for lost sales due to inventory age, an aspect that directly impacts customer demand. By integrating linear and exponential functions to quantify lost sales, alongside traditional transportation and holding costs, the model seeks an optimal balance in supply chain management. The innovative approach is complemented by a meta-heuristic algorithm that synergizes Simulated Annealing and Tabu Search, offering a robust solution to otherwise intractable larger problem instances. Computational experiments validate the model's effectiveness, showcasing its potential to significantly mitigate total costs, including those arising from lost sales, across various supply chain scenarios.

2.3 Sustainability and Perishable Goods Supply Chain Management

Sun et al. (2023) explored the dual objectives of minimizing costs and carbon emissions in the perishable products supply chain, revealing the nuanced trade-offs between economic and environmental goals. Through innovative modeling and Particle Swarm Optimization, they demonstrate strategic adjustments in production, inventory, and routing can significantly affect overall performance. Their findings emphasize the importance of integrating shelf-life dynamics to align supply chain practices with sustainability goals, marking a significant step forward in environmentally responsible supply chain management.

Wang et al. (2023) addressed the complexities of delivering perishable goods using electric vehicles equipped with multi-compartment features for temperature and humidity control. Their ALNS/TS algorithm efficiently solves the MCEVRP-th, balancing cost, quality, and environmental considerations. Computational experiments demonstrate the algorithm's efficacy, particularly in managing electric vehicle recharges and compartment settings, showcasing a path toward more sustainable and efficient perishable product logistics.

Wu and Dong (2023) introduced a mixed-integer linear programming approach to the eco-routing problem, specifically for perishable product delivery. Their work optimizes vehicle routing by factoring in both fuel consumption and product deterioration, demonstrating a bi-objective framework. Through a case study with a Shanghai food company, their findings underscore the efficiency and practicality of incorporating vehicle speed into routing decisions, marking a significant step forward in sustainable supply chain management.

Leithner and Fikar (2022) explored a novel approach to managing perishable goods' supply chains by integrating quality data to inform logistics decisions, focusing on Austria's organic strawberry supply chain. Their simulation-based system evaluates how different logistics scenarios affect food quality and waste, demonstrating significant efficiency gains and waste reduction by applying real-time data on product shelf life.

Liu et al. (2021) addressed the challenges of sustainable supply chain management for perishable products in emerging markets by introducing an integrated location-inventory-routing model. Their innovative approach analyses economic costs, carbon emissions, and product freshness to develop a multi-objective planning model that seeks to minimize costs and emissions while maximizing freshness. Employing the YALMIP toolbox, they solve this complex model, with a case study demonstrating significant enhancements in supply chain management efficiency and the influence of vehicle speed on cost and emissions.

Kumar et al. (2022) examined green inventory routing for Returnable Transport Items and perishables, confronting uncertain demand and pickup challenges. The study presents a chance-constrained programming model aimed at minimizing waste, routing, and emission costs in supply chains. It employs exact solutions using CPLEX and Differential

Evolutionary algorithms for solution finding, with computational experiments confirming the benefits in cost and CO2 reduction with heterogeneous fleets, underscored by sensitivity analysis.

Shirzadi et al. (2021) introduced an inventory-routing model for agri-food logistics that melds environmental sustainability with the challenges of managing perishable goods' freshness and ripeness. Utilizing fuzzy logic to address uncertainties, the model strategically navigates between economic efficiency, environmental protection, and consumer satisfaction. The analyses reveal that eco-friendly logistics and improved plant delivery methods are crucial for sustainable supply chain success, offering a comprehensive framework for future green supply chain initiatives.

Berner et al. (2019) explored enhancing the local food supply in Graz, Austria, through a multi-stakeholder roadmapping approach, focusing on sustainability in urban food systems. They utilize technology roadmapping, integrating stakeholder insights and data analysis to identify strategies for increasing local food self-sufficiency. The methodology includes interviews, textual analysis, and workshops, leading to actionable strategies like fostering stakeholder cooperation, leveraging smart technologies, and forming policy councils. The findings suggest these strategies can significantly scale up local food supply, advocating for policies that support local food dialogues and market baskets to promote sustainability.

Fikar (2018) presented a decision support system for e-grocery deliveries, focusing on reducing food waste through dynamic logistics optimization. By integrating agent-based simulation for perishable products, the system effectively manages the complexities of inventory and delivery routing to enhance sustainability. A case study in Vienna illustrates the system's capacity to optimize supply chain efficiency, revealing pivotal inventory strategy implications for minimizing food waste and ensuring product freshness.

In summary, the existing literature on the PIRP and related areas highlights significant advancements in optimizing supply chains for perishable goods, using both exact methods and heuristic approaches. Studies have emphasized the importance of integrating inventory management with routing decisions while accounting for perishability and customer demand uncertainty. However, there remains a gap in research concerning the application of advanced heuristics like GRASP in multi-period, perishable inventory routing problems, particularly in the context of stochastic demand. This thesis aims to address these gaps by developing and comparing an exact MILP solver with a GRASP-based heuristic for solving the PIRP under uncertainty. The work presented here builds upon the foundational studies and aims to offer novel insights into the application of GRASP metaheuristics for optimizing complex supply chain problems.

2.4 Research Gaps in Existing Literature

Table 2.1: Summary of Research Gaps in Perishable Goods Supply Chain Optimization

ID	Authors	Research Gap
1	Zhang et al. (2024)	Research gaps identified include addressing uncertainties in retailer demand, extending the model to a multi-objective optimization problem that incorporates environmental and social impacts, and considering food waste and the return flow of spoiled food within the supply chain model. Additionally, there's potential for enhancing the kernel search matheuristic by hybridizing it with other heuristics, such as local search, to improve performance. These directions aim to make the model more reflective of real-world complexities and to broaden its scope to include sustainability considerations.

ID	Authors	Research Gap
2	Aghighi et al. (2023)	Research gaps include expanding inventory control studies to retail centers with queue systems and variable reorder points for optimizing inventory costs. Addressing the perishability of products during distribution could enhance the model's practical application, despite the complexity it introduces. Further, integrating continuous-review policies that consider supplier capabilities and readiness for order fulfillment could improve efficiencies. Exploring scenarios where customer orders vary in quantity rather than assuming single-unit orders could also provide more realistic insights. Additionally, developing and comparing uncertainty techniques such as robust optimization and fuzzy programming to the study's stochastic model offers a direction for future research. Implementing and comparing other meta-heuristic algorithms like Differential Evolutionary (DE) and Tabu Search (TS) against the proposed IGA could reveal more efficient solution methods.
3	Liang et al. (2023)	Research gaps include integrating real-time traffic conditions into the mathematical model to optimize travel times for perishable goods delivery. Exploring the vehicle routing problem with the possibility of split deliveries among customers represents a significant area for future investigation, as it could lead to enhanced efficiency and customer satisfaction. Additionally, there's a need for developing more effective solution approaches to tackle the complexity of bi-objective multiperiod vehicle routing problems for perishable goods. These future directions aim to improve logistical operations by balancing transportation costs, customer satisfaction, and the dynamic nature of delivery environments.

ID	Authors	Research Gap
4	Song and Wu (2023)	Research gaps identified include incorporating service levels into the model to go beyond minimizing supply chain costs, investigating dynamic demand for perishable products within the LIR-PWDS model, and expanding the current three-echelon supply chain model to a four-echelon network. These areas are essential for deepening the analysis, adapting to variable market demands, and enhancing the model's complexity to reflect more intricate supply chain structures.
5	Sun et al. (2023)	Research gaps include developing efficient algorithms to address uncertainties in customer demand, vehicle speeds, and transportation costs, especially in the context of road congestion for the supply chain of perishable products. Additionally, exploring methods to extend the lifetime of perishable products through innovations in production technology, processes, and packaging methods represents a crucial area for future research. These efforts aim to balance economic and environmental sustainability within supply chain management, particularly by optimizing transportation strategies to minimize total costs and reduce carbon emissions.
6	Wang et al. (2023)	Research gaps include incorporating real-time traffic information and stochastic elements like demand variability into the model for multi-compartment electric vehicle routing problems with perishable goods (MCEVRP-th). Additionally, considering the capacity of charging stations and specific charging functions could render the model more aligned with actual operational conditions. Developing exact algorithms for solving the MCEVRP-th represents another avenue for research, aiming to enhance solution precision and operational efficiency in the context of sustainable and technology-driven logistics for perishable product delivery.

ID	Authors	Research Gap
7	Wu and Dong (2023)	Research gaps include improving the accuracy of fuel consumption and travel time estimations in the time-constrained ERP for perishable deliveries by incorporating vehicle acceleration and deceleration. Additionally, addressing the impact of uncertain traffic speeds and time-dependent speed limits on delivery routes can enhance the model's realism and applicability. Investigating the use of decomposition-based algorithms, such as Benders decomposition and Lagrangian relaxation, for solving the ERP and Bi-ERP models on large-scale networks presents a promising direction for future research. These approaches aim to optimize routing decision-making and speed optimization more efficiently, considering the dynamic nature of traffic conditions and their effects on perishable product deliveries.
8	Hrabec et al. (2022)	Research gaps include conducting more studies with real-world data to confirm the benefits of integrated over sequential planning in managing production, inventory, and routing. Further investigation is needed to understand how problem attributes like the number of products and customers, planning duration, and various costs influence integration's value. Emphasizing real-data studies will enhance the reliability of expected cost savings from integrated planning and offer clearer insights into when and why it outperforms sequential planning.

ID	Authors	Research Gap
9	Kumar et al. (2022)	Research gaps include refining the inventory routing model to incorporate CO2 emissions within inventory holding costs, and addressing the specific requirements of perishable products by considering emissions from specialized delivery vehicles, such as refrigerated vans. Additionally, there's a need for developing heuristics to solve the model more efficiently, especially for larger instances where traditional methods become less feasible due to the exponential increase in constraints with the number of nodes. This extension is vital for adapting the model to handle the complexities of "many to many" distribution structures more effectively, ensuring it reflects the nuanced dynamics of closed-loop supply chains with heterogeneous fleets and perishable goods.
10	Leithner and Fikar (2022)	Research gaps include the implementation of various product types with differing deterioration characteristics into the supply chain system, necessitating decisions on optimal storage conditions to navigate complex trade-offs among product classes. The challenge lies in jointly storing different products while maintaining high quality and minimizing food losses. Tailored Decision Support Systems (DSSs) are required for organic food supply chains, where shipping volumes are typically lower than those of conventionally produced goods, to effectively manage joint storage and transport settings in this emerging industry.

ID	Authors	Research Gap
11	Shaabani (2022)	Research gaps include exploring the PIRP with multiple products and uncertain demands, addressing the problem from a multi-objective perspective, and incorporating social issues, digital technology, sustainable consumption, and energy transition into the models. Developing exact solution approaches, novel matheuristics, and considering non-linear deterioration rates are recommended. Analysis of multi-depot systems, pricing dynamics alongside inventory and transportation, and the impact of supply chain disruptions on the PIRP require further research. Additionally, focusing on crucial perishable products like pharmaceuticals and blood, revisiting assumptions for real-world applicability, and investigating specific inventory management policies for perishables such as FEFO (first expires first out) and LQFO (lowest quality first out) are crucial future directions.
12	Liu et al. (2021)	Research gaps include the exploration of the integration period and the incorporation of cold chain logistics into the model for perishable products. The model could be extended to address the specific challenges of transporting perishable goods through cold chain logistics, considering both the reduction in product deterioration and the associated high equipment costs. This extension would provide a more comprehensive understanding of how to optimize supply chain management for perishables, balancing freshness with economic and environmental sustainability. Additionally, investigating the optimal integration period can offer insights into the timing and sequence of supply chain operations, further enhancing decision-making for sustainable supply chain management in emerging markets.

ID	Authors	Research Gap
13	Shirzadi et al. (2021)	Research gaps include applying meta-heuristic approaches for solving large-sized problems and conducting numerical analysis, investigating the impact of additional social factors like employment, healthcare, and accidents, and incorporating pricing decisions into the model for a more comprehensive analysis. Further, the development of the distribution network through the inclusion of temporary warehouses or other components could offer deeper insights into sustainable logistics. Additionally, employing efficient solution methods, such as Bender's decomposition approach, presents an avenue for enhancing model solvability and practical applicability in managing the supply chain of fresh agricultural products sustainably.
14	Ji et al. (2020)	Research gaps include the need for exploring robust optimization theory further in the context of the perishable product supply chain with multiple uncertain parameters like transportation cost, time, and facility interruptions. Developing models that incorporate these uncertainties comprehensively to align more closely with real-world situations represents a critical area for future investigation. This approach aims to enhance decision-making under uncertainty, ensuring supply chain configurations for perishable products are both economically viable and robust against a variety of risk factors.

ID	Authors	Research Gap
15	Berner et al. (2019)	Research gaps include the development and implementation of innovative cooperation models among agri-food stakeholders to optimize local farming and food supply systems. Exploring incentives for new market entrants and young farmers to enhance innovation and economic robustness in farming is crucial. Additionally, establishing data-driven food distribution and transportation systems for more sustainable and efficient food flow management represents an area for future investigation. The creation and utilization of a market basket for local food as a monitoring scheme can support the management of food resources and promote sustainable and healthy dietary patterns. Finally, the use of roadmapping as a visual tool to engage stakeholders and guide sustainable transitions in agri-food systems offers a promising approach to address sustainability challenges in agriculture.
16	Onggo et al. (2019)	Research gaps include expanding the model to accommodate multiple perishable products and product substitutions, which are prevalent in agri-food supply chains. Further, there's a need to integrate harvesting, processing, and distribution processes more comprehensively within the supply chain model. Another extension involves refining the model to account for seasonal and correlated demands across retail centers, moving beyond the assumption of independent demands. Lastly, enhancing the proposed simheuristic algorithm by incorporating various heuristics and iterating more effectively between the local search and refinement stages represents an area for future development. These extensions are crucial for creating more robust and versatile models for managing perishable products in agri-food and potentially other supply chains.

ID	Authors	Research Gap
17	Qiu et al. (2019)	Research gaps include incorporating carbon emissions into the vehicle routing of production routing problems with perishable inventory (PRPPIs), extending the model to address multi-level production and routing problems with time windows for perishable inventory, and enhancing the branch-and-cut algorithm with column generation techniques to improve efficiency for scenarios involving a larger number of vehicles. These extensions aim to deepen the model's environmental considerations, broaden its applicability to more complex supply chain structures, and increase computational efficiency.
18	Rohmer et al. (2019)	Research gaps include developing a more refined model for the two-echelon inventory routing problem for perishable products that captures the complexity of product perishability more accurately. This involves moving beyond the assumption of linear deterioration to account for the varied rates at which different products deteriorate. Additionally, incorporating stochastic elements into the model to reflect the inherent uncertainty in perishability and demand could significantly enhance its realism and applicability to real-world operations.
19	Fikar (2018)	Research gaps include incorporating reordering and safety stock policies, along with various pricing, picking, and assortment decisions, to comprehensively study e-grocery operations. Further investigation into consolidation strategies for shipping items between stores and automatically including order forecasts based on historical demand data and seasonality could significantly enhance decision support systems. These extensions aim to improve the efficiency and sustainability of e-grocery deliveries by optimizing food quality, reducing waste, and considering the dynamic nature of demand.

ID	Authors	Research Gap
20	Grillo et al. (2017)	Research gaps include exploring alternative solution techniques, such as metaheuristics, to address the exponential growth in model size due to the inclusion of uncertainties, increasing orders, products, and time periods. Additionally, employing more sophisticated multiobjective optimization techniques, like the epsilon-constrained method, could provide optimal Pareto solutions. Future research should also focus on addressing the uncertainties associated with the perishable nature of products. Developing a Model-Driven Decision Support System based on the proposed model is recommended to facilitate analyses and meet the real-world needs of industries.
21	Hiassat et al. (2017)	Research gaps include exploring the incorporation of multiple products and varying product shelf lives based on seasonal or temperature changes, as well as accounting for carbon emissions costs in the supply chain model. Future work could also focus on enhancing the genetic algorithm used for solving medium to large instances by experimenting with different initialization procedures, crossover and mutation operators and rates, and local search heuristics. Additionally, the potential of other search heuristics, like Ant Colony Optimization and Particle Swarm Optimization, could be investigated for their effectiveness in solving highly constrained models like the one developed in this study.
22	Mirzaei and Seifi (2015)	Research gaps include developing tighter lower bounds or approximating solution methods for large instances of IRP involving perishable goods. Additionally, incorporating uncertainty in end customers' demand into the mathematical models represents a area for future investigation.

2.5 Addressing the Identified Research Gaps

The review of current literature has highlighted several areas within the field of perishable goods supply chain management that necessitate further investigation. Key gaps include the need for efficient heuristics tailored to IRP that consider the complexities of perishability, multi-period planning, and stochastic demand. This study seeks to address these gaps by developing both a mathematical model and a heuristic method designed specifically for perishable goods logistics.

By implementing a GRASP heuristic for multi-period, stochastic-demand scenarios, this work explores how heuristics can be optimized to handle the uncertainties and time-sensitive nature of perishable inventory. Additionally, this study includes a comparative analysis with an exact solver, providing insights into the performance of the heuristic approach in terms of both solution quality and computational efficiency, particularly for complex problem instances where traditional methods struggle.

The identified research gaps highlight the need for such explorations, emphasizing the importance of developing methodologies that address real-world supply chain challenges while remaining computationally feasible. By advancing heuristic design and extending the analysis to multi-period, uncertain demand scenarios, this study contributes to both the theoretical and practical domains of perishable goods logistics, offering insights that can be built upon in future research.

Chapter 3

Methodology

3.1 Introduction to the Methodology

This chapter presents the methodologies applied to address the multi-period PIRP under stochastic demand conditions. The PIRP integrates both inventory management and routing optimization, with the added complexity of perishable goods that degrade over time. This chapter outlines the mathematical formulation of the problem and the two approaches used to solve it: an exact solver and a heuristic method.

To handle the PIRP, a Mixed Integer Linear Programming (MILP) model has been formulated to rigorously define the decision-making process. The exact solver is employed to find optimal solutions for small- and medium-sized problem instances, serving as a benchmark for solution quality. For larger instances, where the exact solver becomes computationally infeasible, a GRASP heuristic is developed to find high-quality solutions efficiently within a reasonable timeframe.

The methodologies presented in this chapter provide the foundation for tackling the challenges posed by PIRP, offering both optimal and near-optimal solutions depending on the problem size and computational constraints.

3.2 Mathematical Formulation

This chapter presents the mathematical formulation of the PIRP, which combines two critical components: inventory management and routing decisions, both of which must be optimized simultaneously. In the PIRP, we aim to maximize profit while ensuring that customer demand is fully satisfied. The problem is modeled as a multi-period problem, where each period involves decisions related to delivery schedules and inventory management, taking into account the perishability of products and the uncertainty of customer demand.

The PIRP is formulated as a MILP and includes decision variables for vehicle routing, inventory levels, and product deliveries. In this research, customer demand is treated as stochastic and follows a normal distribution. The PIRP is challenging to solve because of the integration of both inventory management and routing decisions and the NP-hard nature of the problem.

3.2.1 Problem Definition

The PIRP is defined on an undirected graph $G = (V, E)$, where $V = \{0, 1, \ldots, n\}$ is the vertex set, and $E = \{(i, j) : i, j \in V, i < j\}$ represents the set of edges. Vertex 0 represents the supplier, while the remaining vertices $V' = V \setminus \{0\}$ represent the set of n customers. The routing cost for traveling between any two vertices (i, j) is denoted by C_{ij}. The vehicles available for deliveries are denoted by the set $K = \{1, 2, \ldots, k\}$, with each vehicle having a capacity of Q_k.

The products under consideration have a limited shelf life and are categorized by age, represented by the set $S = \{0, 1, \ldots, s\}$. Each product age g has an associated selling revenue u_i^g and an inventory holding cost h_i^g for location $i \in V$. The inventory levels and demand are tracked for each product age.

At each period $t \in T$, the supplier produces or receives a fresh quantity of products denoted by r^t. The supplier's goal is to distribute the products to customers over the planning horizon while minimizing transportation and holding costs. The inventory level for customer i in period t is denoted by I_i^{gt}, representing the quantity of products of age g.

The PIRP aims to maximize the total profit, which is the sales revenue from customers, minus the routing and inventory holding costs. This leads to the following mathematical formulation.

Several key assumptions underlie the PIRP model:

- **Single product:** The model considers a single perishable product whose demand varies over time and across customers.
- **Symmetric routing cost matrix:** The cost of traveling between any two locations is symmetric, meaning the cost is the same in both directions.
- **No split deliveries:** Each customer receives at most one delivery per period, i.e., split deliveries are not allowed.
- **Product perishability:** Products have a limited shelf life, represented by a discrete set of ages. After a certain number of periods, products are no longer fit for consumption and are considered spoiled.
- **Capacity constraints:** Both vehicles and customer locations have limited capacities, which must be respected when determining delivery and inventory decisions.
- **Stochastic demand:** Customer demand varies over time and is modeled as a random variable with a normal distribution. This introduces uncertainty that the model must account for in its optimization process.

Sets and Indices

- **Sets:**
  - V: Set of vertices, including the supplier (0) and customers $\{1, 2, \dots, n\}$.
  - $V' \subset V$: Set of customer nodes, excluding the depot.
  - $E \subseteq V \times V$: Set of edges representing the possible routes between vertices ($E = \{(i, j) : i, j \in V, i < j\}$).
  - K: Set of vehicles.
  - $S = \{0, 1, \dots, s\}$: Set of ages of the products.
  - $T = \{1, 2, \dots, H\}$: Set of periods in the planning horizon.

- **Indices:**
  - $i, j \in V$: Indices for vertices.
  - $i, j \in V'$: Indices for customer nodes.
  - $k \in K$: Index for vehicles.
  - $g \in S$: Index for the age of the product.
  - $t \in T$: Index for periods.
  - $m \in S \subset V'$: An arbitrary reference node within subset S of customer nodes, used to anchor the subtour elimination constraint.

Parameters

- C_{ij}: Cost of traveling from node i to j (routing cost for traveling edge (i, j)).
- d_i^{gt}: Stochastic demand of customer i for products of age g in period t, modeled as a random variable with a normal distribution.
- d_i^t: Stochastic demand of customer i in period t, modeled as a random variable with a normal distribution.
- Q_k: Capacity of vehicle k.
- C_i: Maximum inventory capacity at node i.
- r^t: Quantity of fresh products produced by the supplier in period t.
- u_i^g: Selling revenue of one unit of product of age g at node i.
- h_i^g: Inventory holding cost for one unit of product of age g at node i.
- I_i^{g0}: Initial inventory level of product of age g at customer i.
- I_0^{g0}: Initial inventory level of product of age g at the supplier.

Variables

- x_{ij}^{kt}: Binary variable indicating if vehicle k travels from node i to node j in period t.
- y_i^{kt}: Binary variable indicating if customer i is visited by vehicle k in period t.

- I_i^t: Total inventory level at node i in period t.
- I_i^{gt}: Inventory level of product of age g at node i in period t.
- q_i^{gkt}: Quantity of product of age g delivered to customer i by vehicle k in period t.

Objective Function

$$\text{(PIRP) maximize} \quad \sum_{i\in V}\sum_{g\in S}\sum_{t\in T} u_i^g d_i^{gt} - \sum_{i\in V}\sum_{g\in S}\sum_{t\in T} h_i^g I_i^{gt} - \sum_{(i,j)\in E}\sum_{k\in K}\sum_{t\in T} C_{ij} x_{ij}^{kt}$$

The objective is to maximize the total profit, which is the revenue from sales minus the inventory holding costs and transportation costs.

Explanation

- **Revenue from Sales:**

$$\sum_{i\in V}\sum_{g\in S}\sum_{t\in T} u_i^g d_i^{gt}$$

  Summing the revenue from selling products of different ages g to customers i over all periods t.

- **Inventory Holding Costs:**

$$\sum_{i\in V}\sum_{g\in S}\sum_{t\in T} h_i^g I_i^{gt}$$

  Summing the costs of holding inventory of different ages g at different nodes i over all periods t.

- **Transportation Costs:**

$$\sum_{(i,j)\in E}\sum_{k\in K}\sum_{t\in T} C_{ij} x_{ij}^{kt}$$

  Summing the costs of transportation for each vehicle k traveling from node i to node j over all periods t.

Constraints

1. Inventory Conservation at Supplier

$$I_0^{gt} = I_0^{g-1,t-1} - \sum_{i\in V'}\sum_{k\in K} q_i^{gkt}, \quad g \in S \setminus \{0\}, \quad t \in T$$

Keeps track of the inventory at the supplier, aging the product by one unit in each period.

2. Supplier Production

$$I_0^{0t} = r^t, \quad t \in T$$

Ensures that the supplier always produces or receives top fresh products in each period.

3. Inventory Conservation at Customers

$$I_i^{gt} = I_i^{g-1,t-1} + \sum_{k \in K} q_i^{gkt} - d_i^{gt}, \quad i \in V', \quad g \in S \setminus \{0\}, \quad t \in T$$

Keeps track of inventory at customers, including deliveries and aging.

4. Fresh Inventory Conservation at Customers

$$I_i^{0t} = \sum_{k \in K} q_i^{0kt} - d_i^{0t}, \quad i \in V', \quad t \in T$$

Ensures fresh product deliveries and consumption are balanced.

5. Maximum Inventory Capacity

$$\sum_{g \in S} I_i^{gt} \leq C_i, \quad i \in V', \quad t \in T$$

Ensures customers' inventory does not exceed capacity.

6. Initial Inventory Levels

$$I_i^0 = \sum_{g \in S} I_i^{g0}, \quad i \in V$$

The total initial inventory is the sum of products of all ages at each node.

7. Demand Satisfaction

$$d_i^t = \sum_{g \in S} d_i^{gt}, \quad i \in V', \quad t \in T$$

Ensures demand is met by products of different ages. The constraint states that the demand of each customer in each period is the sum of product quantities of different ages. Note that by design, any product whose age g is higher than s is spoiled, i.e., it no longer appears in the inventory nor can it be used to satisfy the demand.

8. Delivery Quantity Limits

$$\sum_{g \in S} \sum_{k \in K} q_i^{gkt} \leq C_i - \sum_{g \in S} I_i^{g,t-1}, \quad i \in V', \quad t \in T$$

Limits the quantity delivered to customers based on their inventory capacity.

9. Linking Deliveries to Visits

$$q_i^{gkt} \leq C_i y_i^{kt}, \quad i \in V', \quad g \in S, \quad k \in K, \quad t \in T$$

Allows product deliveries only if the vehicle visits the customer. Constraints 8 and 9 link the quantities delivered to the routing variables. In particular, they only allow a vehicle to deliver products to a customer if a vehicle has been assigned to visit that customer.

10. Vehicle Capacity

$$\sum_{i \in V'} \sum_{g \in S} q_i^{gkt} \leq Q_k y_0^{kt}, \quad k \in K, \quad t \in T$$

Ensures vehicle capacities are not exceeded.

11. Degree Constraints

$$\sum_{j \in V, j<i} x_{ij}^{kt} + \sum_{j \in V, j<i} x_{ji}^{kt} = 2y_i^{kt}, \quad i \in V, \quad k \in K, \quad t \in T$$

Ensures vehicles enter and leave each visited node exactly once.

12. Subtour Elimination

$$\sum_{i \in S} \sum_{j \in S, i<j} x_{ij}^{kt} \leq \sum_{i \in S} y_i^{kt} - y_m^{kt}, \quad S \subseteq V', \quad k \in K, \quad t \in T, \quad m \in S$$

Prevents the formation of subtours within the set of customer nodes S.

13. No Split Deliveries

$$\sum_{k \in K} y_i^{kt} \leq 1, \quad i \in V', \quad t \in T$$

Ensures that at most one vehicle visits each customer in each period, thus forbidding split deliveries.

14. Vehicle Start at Depot

$$y_0^{kt} = 1, \quad k \in K, \quad t \in T$$

Each vehicle starts from the depot in every period.

15. Vehicle Departure and Return to Depot

$$\sum_{i \in V'} x_{0i}^{kt} = 2, \quad k \in K, \quad t \in T$$

Each vehicle leaves and returns to the depot in each period.

16. No Trips in Period 0

$$y_i^{k0} = 0, \quad i \in V', \quad k \in K$$

No vehicle visits any customer in period 0.

Variable Domains

1. Non-negative Continuous Variables

$$I_i^{gt}, d_i^{gt}, q_i^{gkt} \geq 0, \quad i \in V', \quad g \in S, \quad k \in K, \quad t \in T$$

Inventory levels, demand quantities, and delivery quantities cannot be negative.

2. Binary and Integer Variables

$$x_{0i}^{kt} \in \{0, 1, 2\}, \quad i \in V', \quad k \in K, \quad t \in T$$

$$x_{ij}^{kt} \in \{0, 1\}, \quad (i, j) \in E, \quad k \in K, \quad t \in T$$

$$y_i^{kt} \in \{0, 1\}, \quad i \in V, \quad k \in K, \quad t \in T$$

Routing variables x_{ij}^{kt} indicate whether an edge is used in a route and y_i^{kt} indicates if a node is visited by a vehicle.

3.2.2 Exact Solver for PIRP

The exact solver for the PIRP aims to provide optimal solutions by exploring all feasible configurations while adhering to the problem's constraints. It systematically maximizes profit by minimizing transportation and inventory holding costs across multiple periods, accounting for product perishability and stochastic customer demand. However, solving the PIRP using an exact algorithm is extremely computationally intensive, especially for larger instances with numerous customers, vehicles, and time periods. As such, the exact solver is most effective for small to medium-sized instances, where it can rigorously evaluate all configurations. For larger problem sizes, the solver's exhaustive approach becomes impractical, as it requires significant computational resources to handle the complexity of inventory conservation, demand satisfaction, and routing constraints.

Algorithm 1 Exact Solver for PIRP

```
Input: Dataset file paths, time limit
Output: Optimal solution, objective value, solution status
Initialize variables to track best solution and objective values
for each dataset file do
    for each run (number of runs) do
        Load Data: Extract number of customers, vehicles, periods, inventory, demand, etc.
        Define decision variables for inventory, routing, demand satisfaction, and vehicle usage
        Initialize the linear programming problem with maximization objective
        Build Objective Function: Maximize revenue and minimize holding and transportation costs
        Add Constraints:
        - Inventory conservation at depot and customers
        - Supplier replenishment constraints
        - Maximum inventory capacity at customers
        - Delivery quantity limits
        - Demand satisfaction for each customer in every period
        - Vehicle routing and capacity constraints
        - Subtour elimination and no split deliveries
        Solve the problem using GLPK or CBC solver with a time limit
        Collect Results: Store the objective value and check solution status (optimal or non-optimal)
    end for
    Calculate average and best objective values over multiple runs
    Save results to a CSV file
end for
```

Algorithm 3.1: Exact Solver for PIRP

Algorithm Explanation: Exact Solver for PIRP

- **Data Input:** The solver begins by loading dataset file paths and problem parameters such as the number of customers, vehicles, time periods, and inventory data.
- **Objective Function:** The objective is to maximize total profit, which includes revenues from satisfying customer demands while minimizing transportation and inventory holding costs.
- **Decision Variables:** Key decision variables are initialized, including those representing vehicle routes, inventory levels, deliveries, and demand fulfillment.
- **Constraints:** The model enforces several key constraints:

  - Inventory conservation at both the depot and customer locations.
  - Replenishment constraints for suppliers.
  - Capacity limitations for customers' inventories.
  - Delivery quantity limits per vehicle and per period.
  - Demand satisfaction constraints for each customer in every time period.
  - Routing constraints, vehicle capacity limits, and no split deliveries.

- **Solver Execution:** The problem is solved using an exact linear programming solver (e.g., GLPK or CBC), applying a time limit to ensure that the solver attempts to find optimal solutions within a reasonable time frame.
- **Result Collection:** After each run, the results, including the objective value (profit), solution status (optimal or non-optimal), and computation time, are logged. For multiple runs, the best and average results are computed.
- **Performance Reporting:** Finally, the solver outputs the optimal solution along with performance metrics, which are saved to a CSV file for later analysis.

3.3 Heuristic Design Using GRASP

The GRASP is a popular metaheuristic, widely used for solving complex combinatorial optimization problems. It was first introduced by Feo and Resende (1995) and has since become a powerful tool for tackling problems that require finding high-quality solutions in a reasonable amount of time, particularly when exact methods are computationally infeasible.

GRASP operates in two distinct phases: the Construction Phase and the Local Search Phase. In the construction phase, an initial feasible solution is iteratively built by making randomized greedy decisions, a balance between greediness (picking the locally best option) and randomness (to explore different regions of the solution space). In the local search phase, this initial solution is refined by exploring the solution's neighborhood in order to improve it further. The search continues until a local optimum is found. The best overall solution is retained.

The multi-period PIRP, with its stochastic demand and complexities involving inventory age and vehicle routing, presents a significant challenge. Finding an exact solution within a reasonable time frame is computationally prohibitive, especially for large instances. Therefore, GRASP is particularly well-suited to this problem, as it provides a framework to generate high-quality solutions by iterating through a series of randomized constructions and local improvements.

Algorithm 2 Pseudo-code of GRASP

$x \leftarrow$ null
while stopping criterion not met **do**
    $x' \leftarrow$ RandomizedConstruction ()
    $x' \leftarrow$ LocalSearch(x')
    if cost(x') < cost(x) **then**
        $x \leftarrow x'$
    end if
end while
return x

Algorithm 3.2: GRASP

Algorithm 1 presents the basic structure of the GRASP metaheuristic. The pseudo-code illustrates the two key components of GRASP: the randomized construction and the local search.

Algorithm Explanation: GRASP

- **Initialization:** The algorithm begins by initializing a solution variable x as *null*, representing the fact that no solution has been generated yet. This allows the algorithm to later compare and store the best solution it finds during the iterations.

- **Main Loop:** The while loop represents the core of GRASP. It runs until a predefined stopping condition is met, such as a fixed number of iterations or when a certain amount of time has passed. The goal is to iteratively construct and improve solutions.

- **Randomized Construction:** Within each iteration, a new solution x' is generated using a *randomized greedy procedure*. This construction phase balances the greediness of selecting the locally best option (e.g., the highest immediate profit) and randomness to ensure diversification, allowing exploration of different parts of the solution space.

- **Local Search:** After constructing a solution, a *local search* procedure is applied to x' to improve the solution further. This phase explores the solution's neighborhood by making small changes, such as swapping routes or reallocating inventory, to find a better local solution.

- **Update Best Solution:** Once the local search completes, the algorithm checks if the new solution x' has a lower cost (or higher profit) than the current best solution x. If x' is better, it becomes the new best solution.

- **Return Best Solution:** After the loop concludes, the best solution found during all iterations is returned as the output of the GRASP algorithm.

The pseudo-code for GRASP is flexible and can be tailored to different types of problems, including the PIRP problem addressed in this work. The strength of the GRASP algorithm lies in its ability to explore multiple regions of the solution space through randomized construction while also exploiting local improvements to refine solutions.

This basic GRASP framework serves as the foundation for tackling PIRP in this thesis. Each of the following subchapters will go into more detail about the key components, such as the construction phase and local search, showing how they have been tailored to the specific requirements of PIRP.

3.3.1 GRASP Construction (Greedy Randomized Phase)

The construction phase in GRASP involves building a feasible solution by iteratively making decisions through a randomized greedy strategy. The primary goal is to construct a near-optimal solution quickly, while allowing for a level of randomization that encourages solution diversity.

In traditional greedy algorithms, the decision-making process is entirely deterministic, meaning that the algorithm always selects the best possible option at each step. This can lead to suboptimal solutions, as it tends to get stuck in local optima. By contrast, GRASP introduces randomized decision-making within a greedy framework to avoid these pitfalls and explore a larger portion of the solution space.

The Greedy Randomized Algorithm starts by calculating the potential benefit or profit of each possible decision. For instance, when assigning vehicle routes in the multi-period PIRP, the algorithm evaluates the cost of using existing inventory at a customer's location versus the cost of transporting new products from the depot. The Restricted Candidate List (RCL) is then constructed by selecting the most promising candidates based on their potential profit.

However, unlike a traditional greedy algorithm, GRASP does not always select the best candidate. Instead, a candidate is chosen at random from the RCL. This introduces controlled randomness into the construction process and ensures that the algorithm is not overly biased toward the most promising solutions. This strategy helps GRASP explore different parts of the solution space and reduces the likelihood of prematurely converging on suboptimal solutions.

Algorithm 3 Greedy Randomized Algorithm

```
Input: Customer nodes, vehicle capacity, transportation cost, holding cost, demand,
  inventory levels
Output: Initial solution with total profit, vehicle routes, inventory usage
Initialize total profit to 0
Initialize depot inventory and customer inventory levels
for each period t in planning horizon do
    Initialize vehicles at depot with full capacity
    Initialize solution with empty routes and zero profit for period t
    while all customer nodes not serviced do
        for each vehicle v do
            For each unvisited customer node i, calculate the profit for:
                    • Using existing inventory at node i
                    • Transporting new inventory to node i
            Select the more profitable option for each node i
            Construct RCL based on the highest profit options
            Select best node i from RCL (randomized)
            if use existing inventory at node i then
                Reduce inventory at node i to meet demand
            else
                if vehicle capacity allows new transport to node i then
                    Move vehicle to node i and reduce its capacity
                    Update depot inventory and vehicle route
                end if
            end if
        end for
    end while
    Age all inventories and discard expired products
    Update holding costs and subtract from total profit
    Replenish depot inventory for next period
end for
return Initial solution with total profit, routes, and inventory usage
```

Algorithm 3.3: Greedy Randomized Algorithm

Algorithm Explanation: Greedy Randomized Algorithm

- **Initialization:** The algorithm begins by initializing the total profit and setting up the depot and customer inventory levels. At this stage, vehicles are initialized at the depot with full capacity.
- **Vehicle Assignment:** Vehicles are assigned to serve customers for each period. The solution for the current period is initialized as empty, and customer nodes must be serviced within the period to meet demand.

- **Profit Calculation:** For each unvisited customer node, the algorithm calculates the potential profit from either using the existing inventory (if the customer has sufficient inventory to meet demand) or transporting new products to the customer. The node with the highest profit is then chosen.
- **Construction of RCL:** The Restricted Candidate List (RCL) is constructed from the nodes with the highest profits, ensuring a set of strong candidates to choose from.
- **Random Selection:** A node is randomly selected from the RCL to continue building the solution. This step introduces randomness in the decision-making process to diversify the search.
- **Inventory Updates:** Depending on the decision, either existing inventory is used to meet customer demand, or new products are transported to the customer. Inventory and vehicle capacities are updated accordingly.
- **Aging and Costs:** At the end of each period, inventories are aged, expired products are discarded, and holding costs are updated, which reduces the overall profit for the period.
- **Replenishment:** Depot inventory is replenished for the next period, allowing vehicles to transport fresh products to customers during subsequent iterations.

This process repeats across all periods in the planning horizon, ultimately yielding an initial solution to be further refined by the local search phase of GRASP.

3.3.2 Local Search Phase (Tabu Search)

The local search phase is a crucial component of many metaheuristic algorithms, including GRASP. Its goal is to explore the neighborhood of a given solution by making small modifications to improve the solution iteratively. Unlike global search techniques, local search focuses on refining a current solution by exploring nearby solutions in the solution space. However, it is prone to getting stuck in local optima—solutions that are better than all neighboring solutions but may not be the globally best solution. Techniques like Tabu Search are often used to overcome this limitation by preventing the algorithm from revisiting recently explored solutions and enabling it to escape local optima.

After constructing an initial solution using the Greedy Randomized phase, the local search phase is applied to refine and improve the solution. In this research, Tabu Search was implemented, using a swap method to explore new configurations of customer nodes within vehicle routes.

Tabu Search is a metaheuristic that guides the search process beyond local optima by maintaining a tabu list—a short-term memory that keeps track of recent moves (swaps) to avoid cycling back to previously visited solutions. The swap method employed in this context exchanges the positions of two randomly selected customer nodes within a single vehicle's route. This allows the search to explore alternative sequences of customer visits, while keeping the vehicle routes and delivery quantities intact.

For each swap, the solution's profit is recalculated by evaluating the transport cost changes. If the new sequence results in a higher profit, the solution is accepted. However, even if the new solution does not immediately improve the profit, it may still be accepted, depending on the tabu list or aspiration criteria. The aspiration criterion allows the algorithm to override the tabu restriction if a move leads to a solution better than the best one found so far.

The tabu list records recent swaps that are temporarily prohibited (tabu) for a number of iterations (the tabu tenure). This prevents the search from revisiting already explored poor solutions. At each iteration, the algorithm generates neighboring solutions by performing new swaps, and the best neighbor is selected based on its profit value.

The Tabu Search continues for a number of iterations, equal to the total number of possible swaps within all vehicle routes. At each iteration, the algorithm selects the best neighbor that is either not in the tabu list or meets the aspiration criteria, and updates the current solution accordingly. Once all possible swaps have been evaluated, the search terminates, and the best solution found during the search is returned.

Algorithm 4 Tabu Search Algorithm for PIRP

Input: Initial solution with vehicle routes and profit, transportation cost matrix c, tabu tenure set to 5
Output: Best solution found in terms of profit
Initialize **current solution** and **best solution** to the initial solution
Initialize an empty **tabu list**
Calculate **total_swaps** as $\sum_{\text{n}\in\text{vehicle\_routes}} \frac{n\times(n-1)}{2}$,, where n is the number of nodes in each route
Aspiration Criterion: Allow tabu move if it yields a profit higher than **best solution**
for iteration up to **total_swaps do**
    Generate **neighbor solutions** by performing a route change (swap) within the vehicle routes of the current solution
    Set **best neighbor** to *None* and **best profit** to $-\infty$
    for each **neighbor** solution generated by route change **do do**
        Calculate **profit** of neighbor by updating route costs by recalculating transportation costs after the swap
        Define the **move** as the specific swap of two nodes within the route
        if move is tabu and does not meet aspiration criterion **then**
            Skip this neighbor
        else if move is not tabu or meets aspiration criterion **then**
            if neighbor's profit is higher than **best profit then**
                Update **best profit** and set **best neighbor**
            end if
        end if
    end for
    if best neighbor found **then**
        Update **current solution** to best neighbor
        Add move (specific swap) to **tabu list**, removing oldest if list exceeds 5 entries
        if best neighbor's profit exceeds **best solution then**
            Update **best solution**
        end if
    end if
end for
return the best solution found

Algorithm 3.4: Tabu Search Algorithm

Algorithm Explanation: Tabu Search Algorithm

- **Initialization:** The search starts with the initial solution generated from the Greedy Randomized phase. In this solution, each vehicle route is defined, and the initial total profit is calculated based on the transportation costs of the chosen routes. The current solution is initially set as the best solution. An empty tabu list is created to record recent swap moves, with a fixed **tabu tenure of 5**, meaning each move stays tabu for 5 iterations.

- **Neighborhood Generation:** The neighborhood is generated by creating alternative solutions using a **swap method** that swaps two randomly selected customer nodes within the same vehicle's route. This swap allows the algorithm to explore different customer visit sequences without changing the vehicle or the quantity delivered. For instance, if a route includes nodes 1, 3, and 5 in sequence, a swap might change this sequence to 1, 5, and 3, thus creating a new potential solution. The total number of possible swaps is calculated as $\sum_{\textbf{route}} \frac{n\times(n-1)}{2}$, where n represents the number of customers in each vehicle's route. This calculation determines the upper bound of iterations in the search, ensuring that all possible swaps are considered.

- **Tabu List and Tenure:** Each swap move is added to the tabu list to avoid revisiting recently explored solutions and prevent cycling. For instance, if a swap involves nodes 2 and 4 in a route, this specific swap is recorded as tabu, preventing it from being immediately reversed in the next few iterations. The **tabu tenure is set to 5**, meaning that a move stays tabu for the next 5 iterations. Once the tabu list exceeds this tenure, the oldest move is removed, maintaining a maximum list size of 5 entries.

- **Evaluating Neighboring Solutions:** For each neighboring solution generated by a swap, the algorithm recalculates the solution's **profit** by updating the transportation costs based on the new route sequence. This involves summing the costs associated with traveling between nodes in the new order. For example, if the original route was $0 \to 1 \to 3 \to 5$, swapping nodes 3 and 5 would change the sequence to $0 \to 1 \to 5 \to 3$, and the new transportation costs are calculated accordingly. The algorithm then selects the solution with the highest profit, provided it is not in the tabu list or meets the aspiration criterion.

- **Aspiration Criterion:** To ensure that the algorithm can explore potentially superior solutions, the aspiration criterion allows a move to override its tabu status if it leads to a solution with a higher profit than the current best solution. This enables the algorithm to accept tabu moves that bring significant improvement, preventing the tabu restrictions from blocking progress towards an optimal solution. For instance, if a tabu move generates a solution with a profit higher than the current best, it is accepted despite being tabu.

- **Termination Criterion:** The search terminates after exploring the defined total number of swaps across all vehicle routes, calculated based on the neighborhood size. By evaluating every possible swap within each route, the algorithm thoroughly explores the solution space. The best solution found during this process is returned as the output of the local search phase. This solution represents the highest profit configuration of vehicle routes and customer sequences, tailored to the specific demands of the perishable goods inventory routing problem.

3.3.3 RCL Constructors Methods

The Restricted Candidate List (RCL) plays a crucial role in the GRASP by controlling the balance between exploration and exploitation in the solution space. During the construction phase of GRASP, decisions are made by selecting nodes or options from a list of candidates. The RCL influences these decisions by providing a list of "promising" candidates, which are determined based on various criteria such as profit or distance. By controlling how the RCL is built, we can adjust the algorithm's behavior to either focus more on immediate high-profit solutions (exploitation) or to explore less obvious solutions (exploration).

In this research, multiple RCL construction methods have been implemented, each designed to manipulate the trade-off between greediness and randomness differently. These methods include fixed-size RCLs, percentage-based RCLs, and more complex probabilistic inclusion strategies. Below, we describe each RCL construction method in detail, accompanied by pseudo-code and explanations.

Top N Constructor

In the *Top N Constructor*, the RCL is built by selecting the top N nodes based on their profitability. This method focuses heavily on exploitation, as it always selects from a fixed set of the most profitable nodes, making the algorithm more predictable and deterministic.

Algorithm 3.5: RCL Constructor: Top N

Algorithm 5 RCL Constructor: Top N

Input: profit_list (a list of nodes with associated profits)
Output: Restricted Candidate List (RCL) containing the top N nodes based on profit
Set **RCL_size** to 3 ▷ Top N=3 nodes
Sort **profit_list** in descending order based on profit
Select the top **RCL_size** nodes from the sorted **profit_list**
Return the selected nodes as **RCL**

Algorithm Explanation: Top N

- **Initialization:** The constructor begins by sorting the list of candidate nodes in descending order of profit.
- **Selecting Top N Nodes:** The top N nodes (in this implementation, N = 3) are selected and added to the RCL. This ensures that only the most profitable nodes are considered for the next steps.
- **Fixed Size:** The size of the RCL remains constant at N, making the algorithm's behavior more deterministic. It reduces the element of randomness compared to other RCL constructors.

Elitist Strategy Constructor

The *Elitist Strategy Constructor* takes a slightly more exploratory approach by selecting nodes whose profits are within a certain percentage of the highest-profit node. This allows for a more diverse selection process, as nodes that may not be the absolute best in terms of profit still have a chance to be included in the RCL.

Algorithm 6 RCL Constructor: Elitist Strategy

```
Input: profit_list (a list of nodes with associated profits)
Output: Restricted Candidate List (RCL) containing nodes whose profits are within 40% of the highest-profit node
Set percentage to 40                                  ▷ Fixed threshold for this model
if profit_list is empty then
    return empty list
end if
Initialize max_profit to zero
for each node in profit_list do
    if node's profit > max_profit then
        Update max_profit to node's profit
    end if
end for                                               ▷ Finds the highest profit among nodes
Calculate threshold_profit = max_profit * (1 - percentage / 100)  ▷ Setting threshold at 40% below max profit
Initialize an empty list RCL
for each node in profit_list do
    if node's profit ≥ threshold_profit then
        Add node to RCL
    end if
end for                         ▷ Include nodes within the 40% threshold of max profit
if RCL is empty then
    Add the highest-profit node to RCL                ▷ Fallback to ensure RCL is not empty
end if
Return RCL
```

Algorithm 3.6: RCL Constructor: Elitist Strategy

Algorithm Explanation: Elitist Strategy

- **Maximum Profit Calculation:** The method begins by calculating the maximum profit from the list of candidate nodes. This maximum profit value serves as a reference point for selecting other nodes in the RCL.
- **Percentage-Based Threshold:** A fixed threshold is set at 40% of the maximum profit value, allowing nodes within at least 60% of the maximum profit to be included in the RCL. Only nodes with profits equal to or greater than this threshold are added, ensuring that the RCL includes nodes within a profitable range close to the best.
- **Building the RCL:** After setting the threshold, the algorithm iterates through the profit list and includes each node with a profit above or equal to the threshold profit

in the RCL. This selection process ensures a focused yet flexible candidate pool.

- **Flexibility and Exploration:** By including nodes within 40% of the maximum profit, this method encourages a slightly exploratory approach. Allowing near-optimal nodes in the RCL enables the algorithm to explore a broader solution space, potentially avoiding local optima and identifying better overall solutions in subsequent steps.

Simulated Annealing-Inspired Constructor

The Simulated Annealing-Inspired Constructor introduces a probabilistic approach to RCL construction. As the number of iterations increases, the threshold for including nodes becomes more relaxed, allowing nodes with lower profits to be included based on probability. This helps balance between exploitation in the early stages and exploration later on, similar to the simulated annealing process.

Algorithm 7 RCL Constructor: Simulated Annealing-Inspired Probabilistic RCL

Input: profit_list (list of nodes with associated profits), t (current iteration), H (total iterations), base_percentage = 20, max_percentage = 60
Output: Restricted Candidate List (RCL) containing selected nodes based on dynamic profit thresholds and probabilistic inclusion
if profit_list is empty **then**
  return empty list
end if
Calculate **current_percentage** as $20 + (60 - 20) \times \frac{t}{H}$ ▷ Progressively relaxes threshold from 20% to 60%
Find **max_profit** as the highest profit value in **profit_list**
Calculate **threshold_profit = max_profit** $\times(1 - \frac{\text{current\_percentage}}{100})$ ▷ Defines profit threshold
Initialize empty **RCL**
for each node in **profit_list do**
  if node's profit $\geq$ threshold_profit **then**
    Add node to **RCL** ▷ Include nodes above threshold directly
  end if
end for
for each node in **profit_list do**
  if node's profit $<$ threshold_profit **then**
    Calculate **distance_from_threshold = threshold_profit** - node's profit
    Calculate **inclusion_probability** = $\max(0, 1 - \frac{\text{distance\_from\_threshold}}{\text{threshold\_profit}})$
    Adjust the inclusion probability: **adjusted_probability** = inclusion_probability $\times \frac{t}{H}$
    if randomly selected value $<$ adjusted_probability **then**
      Add node to **RCL** ▷ Probabilistically include nodes below threshold
    end if
  end if
end for
return RCL

Algorithm 3.7: RCL Constructor: Simulated Annealing-Inspired Probabilistic RCL

Algorithm Explanation: Simulated Annealing-Inspired Probabilistic RCL

- **Dynamic Threshold Calculation:** This method begins by setting a dynamic percentage threshold that gradually increases from a stricter 20% to a more inclusive 60% over the course of the algorithm. This percentage is calculated using the formula $20 + (60 - 20) \times \frac{t}{H}$, where t is the current iteration and H is the maximum number of iterations.

- **Threshold Profit Calculation:** After determining the current percentage, the method calculates the profit threshold by multiplying the maximum profit in the list by

$(1 - \frac{\text{current\_percentage}}{100})$. This threshold is used to distinguish higher-profit nodes for direct inclusion in the RCL.

- **Direct Inclusion of Top Nodes:** Nodes with profits equal to or greater than the calculated threshold are added directly to the RCL. This ensures that the highest-profit nodes have priority in the candidate list, balancing between exploitation of known profitable nodes and exploration of other options.

- **Probabilistic Inclusion for Exploration:** For nodes that do not meet the threshold, the algorithm applies a probabilistic inclusion based on their distance from the threshold. The probability of including a node below the threshold is calculated as $1 - \frac{\text{distance\_from\_threshold}}{\text{threshold\_profit}}$, adjusted by the factor $\frac{t}{H}$ to increase as the iteration count progresses. This probabilistic inclusion adds flexibility to the search by allowing near-optimal nodes to enter the RCL, supporting exploration.

- **Exploration-Exploitation Balance:** Early iterations focus on higher-profit nodes with a tighter threshold, prioritizing exploitation. As iterations increase, the threshold relaxes, and the probabilistic inclusion rate rises, promoting exploration of a wider solution space. This design is particularly suited to perishable goods inventory routing, where maintaining a flexible approach can prevent premature convergence and yield better long-term solutions.

Dynamically Shrinking Adaptive Constructor

The Dynamically Shrinking Adaptive Constructor adjusts the size of the Restricted Candidate List (RCL) throughout the algorithm's iterations. The size of the RCL starts larger in the early stages of the search to allow more exploration, but it gradually shrinks as the algorithm progresses. This shrinking mechanism ensures a balance between exploration and exploitation, with the search becoming more focused on high-profit candidates in the later stages.

Algorithm 8 RCL Constructor: Dynamically Shrinking Adaptive RCL

```
Input: profit_list (list of nodes with associated profits), total_periods, current_period,
    total_iterations, current_iteration
Output: Dynamically sized Restricted Candidate List (RCL)
Set initial_rcl_size_percentage = 0.5        ▷ 50% of nodes at the start of each period
Set rcl_decrease_step = initial_rcl_size_percentage / total_iterations
Calculate current_rcl_percentage = initial_rcl_size_percentage - (rcl_decrease_step
    × (current_iteration - 1))
Clamp current_rcl_percentage to a minimum of 0.1 (10%)
Calculate total_nodes = size of profit_list
Calculate current_rcl_size = max(2, total_nodes × current_rcl_percentage)
Sort profit_list by profit in descending order
Initialize empty RCL
for each node in sorted_profit_list do
    if size of RCL < current_rcl_size then
        Add node to RCL
    end if
end for
return RCL
```

Algorithm 3.8: RCL Constructor: Dynamically Shrinking Adaptive RCL

Algorithm Explanation: Dynamically Shrinking Adaptive Constructor

- **Initial RCL Size Setting:** At the beginning of each period, the RCL size is set to 50% of the total nodes to promote exploration.
- **Gradual RCL Shrinking Mechanism:** The RCL size decreases with each iteration within a period by a small, fixed step based on the total number of iterations. This gradually focuses the selection on higher-profit nodes as the period progresses.
- **Profit-Based Selection and Minimum Thresholds:** Nodes are sorted by profit, and the top nodes up to the current RCL size are chosen. The RCL size is clamped to a minimum of 10% of nodes or at least two nodes, maintaining selection diversity.
- **Periodic Reset:** At the start of each new period, the RCL size resets to 50%, reintroducing exploration to adapt to potential changes in node profitability.

Profit-Weighted Probabilistic Inclusion Constructor

The Profit-Weighted Probabilistic Inclusion Constructor introduces a probabilistic approach to RCL construction, where nodes are selected based on their profit relative to the total profit of all candidates. This method emphasizes exploitation by giving higher-probability selection to high-profit nodes, while still allowing lower-profit nodes a chance to be included, thus maintaining some level of exploration.

Algorithm 9 RCL Constructor: Profit-Weighted Probabilistic Inclusion RCL

Input: profit_list (list of nodes with associated profits), rcl_size
Output: Restricted Candidate List (RCL) with probabilistic inclusion
Set **rcl_size** = 4 ▷ Fixed size of the RCL
if profit_list is empty or rcl_size $\leq$ 0 **then**
    return empty list
end if
Calculate **total_profit** = sum of profits of all nodes in profit_list
if total_profit == 0 **then**
    return random sample of nodes (size = rcl_size)
end if
Copy profit_list to **available_nodes**
Initialize empty **RCL**
while size of RCL $<$ rcl_size and available_nodes not empty **do**
    Recalculate **total_profit** for available_nodes
    if total_profit == 0 **then**
        Select **selected_node** randomly from available_nodes
    else
        Calculate **probabilities** = node's profit / total_profit for each available node
        Select **selected_node** based on probabilistic weights
    end if
    Add **selected_node** to RCL and remove it from available_nodes
end while
return RCL

Algorithm 3.9: RCL Constructor: Profit-Weighted Probabilistic Inclusion RCL

Algorithm Explanation: Profit-Weighted Probabilistic Inclusion Constructor

- **Total Profit Calculation:** The algorithm starts by calculating the total profit of all candidate nodes in the list, ensuring that each node's probability is proportional to its profit.
- **Probability Assignment:** Each node is assigned a probability based on its profit relative to the total profit. Nodes with higher profits have a greater chance of being

included in the RCL.

- **Probabilistic Selection:** Nodes are selected probabilistically for inclusion in the RCL based on their assigned probabilities. Although higher-profit nodes are more likely to be chosen, lower-profit nodes also have a chance, ensuring a balance between exploration and exploitation.
- **Dynamic Recalculation:** After each node is selected for the RCL, the total profit is recalculated, and the selection probabilities are updated to reflect the remaining nodes.

K-Means Constructor

The K-Means Constructor uses a clustering approach to form the Restricted Candidate List (RCL) based on node proximity, rather than profit alone. This method groups nodes into clusters using a distance matrix and selects the most profitable node from each cluster. The K-Means Constructor balances geographical diversity with profitability by ensuring nodes from different clusters are considered for selection.

Algorithm 10 RCL Constructor: K-Means RCL

```
Input: profit_list (list of nodes with profits), distance_matrix (2D matrix of distances between nodes)
Output: Restricted Candidate List (RCL) containing the top node from each cluster
Set k = 3                                  ▷ Number of clusters fixed to 3
Set max_iterations = 1000                  ▷ Maximum iterations fixed to 1000
Extract node IDs from profit_list
if k == 0 then
    return empty list
end if
Randomly initialize centers by selecting k random nodes
for iteration = 1 to max_iterations do
    Initialize empty clusters for each center
    for each node in node IDs do
        Assign node to the nearest center based on distance matrix
    end for
    Recalculate each center as the node with the minimum total distance to all other nodes in the cluster
    if new_centers == previous centers then
        Break loop (convergence reached)
    end if
    Update centers with new centers
end for
Initialize empty RCL
for each cluster do
    Filter profit_list to nodes in the current cluster
    Sort nodes by profit and select the top node in the cluster
    Add the top node to RCL
end for
return RCL
```

Algorithm 3.10: RCL Constructor: K-Means RCL

Algorithm Explanation: K-Means Constructor

- **Clustering Initialization:** The algorithm begins by randomly selecting k=3 initial centers from the list of nodes. These centers represent the starting points for the clusters.
- **Node Assignment:** Each node is assigned to the nearest cluster center based on the distance matrix. This ensures that nodes close together in terms of distance are grouped into the same cluster.
- **Recalculation of Cluster Centers:** After assigning nodes to clusters, the cluster centers are recalculated as the node with the minimum total distance to the other

nodes in the cluster. This step is repeated until the clusters stabilize.

- **Selection of Top Nodes:** Once clustering is complete, the most profitable node from each cluster is selected and added to the RCL. This ensures that the final RCL contains a geographically diverse set of nodes with high profits.

3.3.4 RCL Selection Methods

Once the RCL has been constructed, the next critical step in the GRASP algorithm is selecting a node from this list. The choice of node directly impacts the balance between exploration and exploitation during the search process. Some selection methods prioritize randomness to explore a wider range of solutions, while others focus more on the most promising solutions to exploit higher profits. Below, we discuss the different RCL selection strategies implemented in this research and their roles in guiding the algorithm.

Random Selection

Random selection introduces pure randomness into the decision-making process. It is one of the simplest selection strategies, where a node is chosen randomly from the RCL without regard to profit or any other criteria. This approach is particularly useful for encouraging exploration, as it prevents the algorithm from consistently selecting the highest-profit node, which could lead to premature convergence on suboptimal solutions. By selecting nodes randomly, the algorithm ensures that a wider portion of the solution space is explored.

Algorithm 11 RCL Selection:Random Selection

```
Input: Restricted Candidate List (RCL)
Output: Randomly selected node from the RCL
if RCL is empty then
    return None
end if
Randomly select a node from the RCL
return the selected node
```

Algorithm 3.11: RCL Selection:Random Selection

Algorithm Explanation: Random Selection

- **Selection Process:** The method randomly selects one node from the list of available nodes in the RCL. This ensures that each node in the RCL has an equal probability of being chosen.
- **Exploration Focus:** This method encourages exploration by not favoring any particular node based on profit or other criteria. This helps the algorithm escape local optima and explore a more diverse set of potential solutions.
- **Simplicity:** The random selection method is computationally simple and can be implemented efficiently.

Roulette Wheel Selection

The Roulette Wheel Selection method introduces a profit-based probabilistic mechanism for choosing a node from the RCL. Instead of selecting nodes randomly or greedily, each node is assigned a selection probability proportional to its profit. Nodes with higher profits have a greater chance of being selected, but lower-profit nodes still have a non-zero probability of inclusion, making this method a balance between exploration and exploitation.

Algorithm 12 RCL Selection: Roulette Wheel Selection

```
Input: Restricted Candidate List (RCL) with node profits
Output: Selected node based on roulette wheel selection
if RCL is empty then
    return None
end if
Set epsilon to a small value to avoid division by zero
Calculate total_profit as the sum of absolute node profits in the RCL, adding epsilon
to each
if total_profit == 0 then
    return None
end if
Generate a random pick between 0 and total_profit
Initialize current to 0
for each node in RCL do
    Add the absolute profit of the node to current
    if current exceeds random pick then
        return the selected node
    end if
end for
return the last node in the RCL as a fallback
```

Algorithm 3.12: RCL Selection: Roulette Wheel Selection

Algorithm Explanation: Roulette Wheel Selection

- **Profit-Based Probability Assignment:** Each node in the RCL is assigned a probability of being selected, which is proportional to its profit relative to the total profit of all nodes in the RCL. This ensures that higher-profit nodes are more likely to be selected, while still allowing for the possibility of selecting lower-profit nodes.
- **Selection Process:** The algorithm generates a random value to simulate a "spin" of the roulette wheel, and the node corresponding to the selected probability range is chosen. This probabilistic approach ensures that nodes with higher profits occupy larger segments of the roulette wheel.
- **Exploration-Exploitation Balance:** This method strikes a balance between exploration and exploitation. While it tends to favor more profitable nodes, lower-profit nodes are still considered, allowing for a broader search of the solution space.
- **Diversity in Selection:** By avoiding a purely greedy strategy, the algorithm can avoid being trapped in local optima and increase the diversity of solutions explored

during the search.

Greedy-Biased Stochastic Selection

The Greedy-Biased Stochastic Selection method incorporates a bias toward selecting higher-profit nodes while still maintaining a degree of randomness. It is designed to balance greediness with exploration by assigning higher probabilities to more profitable nodes, but ensuring that all nodes have a chance of being selected. Unlike the Roulette Wheel selection, which distributes probabilities directly proportional to the profit, this method introduces an exponential bias, giving more weight to higher-ranked nodes while still allowing lower-ranked nodes to be selected with decreasing probability. This makes the selection process more focused on the top candidates compared to the evenly distributed probabilities in the Roulette Wheel method.

Algorithm 13 RCL Selection: Greedy-Biased Stochastic Selection

```
Input: Restricted Candidate List (RCL), bias strength for greediness (default: 0.5)
Output: Selected node based on greedy-biased stochastic sampling
if RCL is empty then
    return None
end if
Sort the RCL by node profit in descending order
Initialize an empty list for probabilities
for each node i in the sorted RCL do
    Calculate the probability for node i as P(i) = e^{−bias strength×(rank of i−1)}
    Append the probability to the probabilities list
end for
Calculate total probability as the sum of all probabilities
Normalize the probabilities so that they sum to 1
Perform a weighted random selection based on the normalized probabilities
return the selected node
```

Algorithm 3.13: RCL Selection: Greedy-Biased Stochastic Selection

Algorithm Explanation: Greedy-Biased Stochastic Selection

- **Profit-Based Sorting:** The nodes in the RCL are first sorted in descending order of profit, ensuring that the highest-profit nodes are given priority during selection.
- **Greedy Bias:** The algorithm applies a bias toward selecting the higher-ranked nodes by assigning probabilities that decrease exponentially with rank. This means

that the first few nodes in the sorted list will have significantly higher probabilities of being selected than those ranked lower.

- **Stochastic Selection:** Despite the bias, this method still maintains an element of randomness. All nodes in the RCL have a non-zero probability of being selected, which introduces diversity and allows for exploration.

- **Greedy-Explorative Balance:** The strength of the greedy bias can be adjusted by the "bias strength" parameter. A higher bias strength leads to more exploitation of higher-profit nodes, while a lower bias increases the likelihood of exploring less profitable nodes.

- **Normalization of Probabilities:** After calculating the bias for each node, the probabilities are normalized to ensure they sum to 1, enabling a proper weighted random selection.

3.3.5 RCL Comparison

The methods described in the previous chapters—covering various RCL construction and selection techniques—were compared to evaluate their performance in solving the PIRP. The goal of this comparison is to understand how different strategies impact both solution quality and computational efficiency.

For this comparison, multiple combinations of RCL construction and selection methods were applied across various datasets of different sizes and complexities. The results were assessed based on two primary metrics:

- **Objective Value**: The quality of the solution, typically measured by the profit or cost.

- **Computation Time**: The time taken to complete the search and return a solution.

The purpose of this evaluation is to determine which combinations of RCL methods provide the best trade-off between high-quality solutions and reduced computation times, especially when applied to different instances of the PIRP problem.

RCL Construction and Selection Method Comparison

To evaluate the performance of different RCL construction and selection methods, we implemented a systematic comparison procedure. The algorithm executes the GRASP metaheuristic multiple times, applying different combinations of RCL strategies for both construction and selection phases. The goal of this comparison is to identify which combinations of RCL strategies yield the best balance between solution quality (objective value) and computational efficiency (time taken).

Algorithm 14 RCL Construction and Selection Method Comparison

```
Input: List of RCL construction methods, List of RCL selection methods, simulation parameters, number of runs
Output: Best-performing RCL combination, ranked by profit and time
Initialize best solution as −∞
Set number of runs to 100            ▷ Number of iterations for each RCL combination
Initialize inventory for comparison
for each RCL construction method do
    for each RCL selection method do
        for each iteration i from 1 to number_of_runs do
            Reinitialize inventory for the iteration
            Run Greedy Randomized Algorithm for current RCL construction and selection method
            Save results: total profit and time taken for the iteration
            if current total profit is greater than best solution then
                Update best solution with current profit
            end if
        end for
    end for
end for
Normalize both Objective Value (Profit) and Time Taken to scale between 0 and 1   ▷ Ensures comparability
Combine normalized profit and time using a weighted score   ▷ Higher profit and lower time preferred
Rank RCL combinations by performance (weighted score)
Return the best-performing combination
```

Algorithm 3.14: RCL Construction and Selection Method Comparison

Algorithm Explanation: RCL Construction and Selection Method Comparison

- **Initialization:** The algorithm starts by initializing the dataset, loading the required problem instance for the PIRP, and setting up variables for vehicle routes, delivery quantities, and perishable item constraints.

- **Run GRASP with Different RCL Methods:** The GRASP metaheuristic is executed multiple times, each with a different combination of RCL construction and selection methods.
- **Performance Evaluation:** After each GRASP execution, the algorithm evaluates the total profit achieved and the time taken to run the algorithm.
- **Store Results:** The results from each iteration, including the total profit and computation time, are saved, along with the specific RCL method combination used.
- **Comparison and Ranking:** Once all RCL method combinations have been executed, the results are normalized for comparability, ranked based on a weighted score that combines profit and time, and the best-performing combination is identified.

3.3.6 GRASP-Based Optimization Process

The GRASP is a multi-start metaheuristic designed to solve combinatorial optimization problems like the PIRP. GRASP works by generating multiple independent solutions, each built in two phases: construction and local search. In this work, GRASP has been adapted to explore different RCL construction and selection strategies for improving solution quality.

GRASP Phases:

- **Construction Phase:** In this phase, a feasible solution is iteratively built by selecting elements from a RCL. The construction method can vary—examples include Top N or Elitist Strategy—affecting the diversity and quality of the solutions generated. Randomized selection from the RCL introduces an element of exploration to balance with greediness.
- **Local Search Phase:** After constructing an initial solution, the local search phase refines it by exploring its neighborhood. This improves the solution quality by adjusting the vehicle routes, delivery quantities, or inventory levels. Through multiple iterations, the search explores the local area around the solution in order to escape local optima and find more profitable configurations.

The GRASP algorithm executes multiple iterations (multi-start) to avoid getting stuck in local optima. Each run builds a new solution and improves it with local search, and the best solution found across all iterations is returned as the final result.

Algorithm 15 GRASP-Based Optimization Process

```
Input: List of datasets, simulation parameters, number of GRASP iterations
Output: Best solutions and performance reports (profits, time)
Initialize the list of datasets
Set the number of GRASP iterations to 1000
for each dataset do
    Read dataset and extract problem parameters
    Initialize a CSV file to store performance reports
    Initialize tracking for profits and best solutions
    Start a timer to track execution time
    for each iteration from 1 to number_of_iterations_to_run_GRASP do
        Initialize total profit for the iteration
        Initialize the best solution for each period
        for each period t in the dataset do
            Reinitialize inventory for the period
            Run the Greedy Randomized Algorithm to generate the initial solution
            Improve the solution using Tabu Search
            Store the best solution for the period
            Accumulate the total profit for the iteration
        end for
        if the current total profit is greater than the best solution found so far then
            Update the best overall solution
        end if
    end for
    Compute the average profit, best profit, and total execution time
    Optionally save final reports for the dataset
end for
```

Algorithm 3.15: GRASP-Based Optimization Process

Algorithm Explanation: GRASP-Based Optimization Process

- **Initialization:** The algorithm starts by setting up the datasets and problem parameters for the PIRP. It also initializes variables for storing profits, solutions, and computation times.

- **Multi-Run Process:** GRASP runs iteratively, using a set number of iterations (in this case, 1000) to explore various solutions. For each iteration, the algorithm generates and evaluates new solutions, helping it avoid local optima.

- **Greedy Randomized Algorithm:** In each iteration, the algorithm applies the Greedy Randomized Algorithm to build an initial solution.
- **Tabu Search Improvement:** After generating the initial solution, the algorithm uses Tabu Search to refine it further by exploring neighboring solutions, aiming to find a higher-quality solution.
- **Tracking and Storing Solutions:** Throughout each iteration, the algorithm tracks the total profit and stores the best solution found so far. If a new iteration yields a better solution, the best solution is updated.
- **Final Performance Evaluation:** After all iterations are complete, the algorithm computes the average profit, best profit, and total computation time for each dataset. These metrics are used to determine the effectiveness of the GRASP method on each dataset.

Conclusion

The GRASP algorithm, through its iterative nature and balance of exploration and exploitation, offers a structured approach for addressing the PIRP. By running the algorithm across multiple datasets and testing various RCL construction and selection methods, a wide range of potential solutions were efficiently explored. The flexibility of GRASP, particularly its ability to incorporate different RCL strategies, makes it a suitable approach for addressing complex optimization problems like the PIRP.

3.4 Summary

This chapter explored two key methodologies used to tackle the PIRP: the exact solver and the GRASP metaheuristic. Both methods were formulated to address the objective of maximizing the revenue, while adhering to the constraints posed by product perishability and stochastic customer demand.

The chapter began by presenting the mathematical formulation of the PIRP as a MILP. The exact solver was discussed as a method for providing optimal solutions for smaller problem instances by systematically exploring all feasible configurations, although its computational intensity limits its scalability to larger instances. The GRASP metaheuristic was then introduced, detailing the RCL construction and selection strategies, as well as how GRASP provides a balance between exploration and exploitation in its search for near-optimal solutions.

In the comparison of the exact solver and the GRASP heuristic, it became evident that while the exact solver guarantees optimal solutions, its high computational demands make it impractical for larger problems. In contrast, GRASP offers a more flexible and scalable approach, capable of providing high-quality solutions in a much shorter time.

The next chapter presents the results of the computational experiments. The performance of both the exact solver and the GRASP algorithm will be analyzed across multiple datasets, comparing their efficiency, solution quality, and computational times. These experiments will highlight the trade-offs between exact and heuristic methods for solving the PIRP and will identify the most effective strategies for the datasets used in this study.

Chapter 4

Data Analysis and Results Discussion

This chapter presents a comprehensive analysis of the results obtained from the comparison of the GRASP metaheuristic and the exact solver in solving the PIRP. The aim is to evaluate the performance of both methods in terms of solution quality (objective value) and computational efficiency (runtime), highlighting GRASP's effectiveness, particularly on larger instances where the exact solver struggles.

The chapter begins with an outline of the computational setup and dataset generation, ensuring a clear understanding of the conditions under which both algorithms were tested. This is followed by a detailed comparison between the GRASP and exact solver, supported by visualizations that highlight their performance in terms of objective value and runtime. Since the exact solver faces challenges in handling larger datasets due to computational constraints, the scalability of GRASP is further explored by estimating its performance on these larger datasets, providing insights into how well GRASP generalizes across more complex instances.

4.1 Computational Setup and Dataset Generation

This section provides an overview of the computational environment used for running both the GRASP heuristic and the exact algorithm, followed by a detailed explanation of the dataset generation process.

4.1.1 Computational Setup

All computations were performed using Python on a MacBook Pro equipped with an Apple M1 chip, 16 GB of RAM, and running macOS Sonoma 14.2.1. The exact solver used in this study is the CBC (Coin-or Branch and Cut) solver, which is well-suited for solving MILP models. The GRASP heuristic was implemented using Python's standard libraries. Both the GRASP heuristic and the exact algorithm were designed and executed within the same environment to ensure consistency in performance evaluation. Both runtime and objective values were logged and stored for subsequent analysis and comparison.

4.1.2 Dataset Generation

To evaluate the performance of both the GRASP heuristic and the exact algorithm, a set of randomly generated instances was used. The structure of these datasets was largely inspired by the work of Coelho and Laporte in their paper *"Optimal joint replenishment, delivery and inventory management policies for perishable products."* However, modifications were made to better align the dataset with specific requirements, particularly in handling stochastic demand.

The dataset includes various instances that differ in the number of customers, periods, vehicles, and the maximum age of the products. These parameters were varied to test the performance of the algorithms across a broad range of scenarios, from small to large-scale problems. Each dataset instance is denoted as `pirp-n-s-K-H-instance`, where:

- `n` represents the number of customers,
- `s` denotes the maximum age of the products,
- `K` indicates the number of vehicles,
- `H` is the number of periods in the planning horizon,
- and `instance` refers to different iterations of the same dataset type (1 through 5).

In total, 105 datasets were created to ensure comprehensive testing across different scenarios.

The following key parameters were used in generating the datasets:

- **Number of customers** (n): 10, 12, 15, 20, 30, 40, 50.
- **Number of periods** (H): 3, 6, 10.
- **Number of vehicles** (K): 1 for $n = 15$; 2 for $n = 20$ and $n = 30$; 3 for $n = 40$ and $n = 50$.
- **Maximum age of products** (s): 2 for $H = 3$; 3 for $H = 6$; 5 for $H = 10$.
- **Demand** (d_i^t): Initially, a baseline demand is randomly assigned to each customer i in each period t from the interval [30, 210]. To incorporate realistic variations, a stochastic adjustment is applied using a normal distribution, where the mean is set to the pre-generated demand value and the standard deviation is set to 25% of the mean. This ensures that demand fluctuates in a controlled manner rather than being entirely random across periods.
- **Position** (x_i, y_i) of the supplier and customers: randomly selected from the interval [0, 1000].
- **Customers' inventory capacity** (C_i): $R \times \max\{d_i\}$, where R is randomly selected from the set $\{2, 3\}$.
- **Initial inventory** (I_i^0): equal to $C_i - d_i^1$.
- **Revenue** (u_i^g): equal to $R_1 - (R_1 - R_2)g/s$, where R_1 and R_2 are randomly selected from the intervals [10, 20] and [4, 7], respectively.
- **Inventory holding cost** (h_i^g): equal to $\left(\frac{R_1+gR_2}{1+g}\right)/100$, where R_1 and R_2 are randomly selected from the intervals [0, 100] and [0, 70], respectively.
- **Vehicle capacities** (Q_k): equal to $\left\lfloor 1.25 \times \sum_{i \in V'} \sum_{t \in T} d_i^t / (H \times K) \right\rfloor$.

4.2 Comparative Performance Analysis of RCL Methods

This section presents a comparative performance analysis of different RCL construction and selection methods that can be used in the GRASP heuristic. The analysis aims to evaluate how various RCL approaches influence both solution quality and computational efficiency. Given the stochastic nature of demand, the model performs multiple simulations for each dataset to accurately capture variability, ensuring a fair comparison across all RCL methods.

4.2.1 Evaluation Metrics and Scoring Method

To systematically evaluate and rank the performance of each RCL construction and selection method combination, two primary metrics were considered:

- **Objective Value**: This metric assesses the quality of each solution measured by the profit.
- **Computation Time**: This metric indicates the time required to complete the search and return a solution, providing insight into the computational efficiency of each RCL method.

To create a unified performance score for each RCL method combination, a scoring system was developed based on these metrics. This system assigns an overall score to each combination by balancing solution quality and computational efficiency, allowing for identification of the most effective methods.

The score for each RCL method combination is calculated using the following formula:

$$\text{Score} = \alpha \cdot \text{Normalized Objective Value} - (1 - \alpha) \cdot \text{Normalized Time Taken} \tag{4.1}$$

where:

- α is a weighting factor set to 0.5, giving equal importance to the objective value and computation time.
- Normalized Objective Value: The objective value is normalized to a scale of 0 to 1 using the following formula:

$$\text{Normalized Objective Value} = \frac{\text{Objective Value} - \text{min(Objective Value)}}{\text{max(Objective Value)} - \text{min(Objective Value)}} \tag{4.2}$$

- Normalized Time Taken: The computation time is similarly normalized to a scale of 0 to 1:

$$\text{Normalized Time Taken} = \frac{\text{Time Taken} - \min(\text{Time Taken})}{\max(\text{Time Taken}) - \min(\text{Time Taken})} \tag{4.3}$$

This scoring formula ensures that higher objective values and lower computation times contribute positively to the score, achieving a balance between quality and efficiency. By normalizing both metrics, the model standardizes the scales, allowing them to be combined meaningfully in the scoring equation.

Each RCL method combination was evaluated multiple times across different datasets, and the average score was calculated for each unique pair of RCL Construction Method and RCL Selection Method

4.2.2 Visualization of Results

The results are visualized in scatter plots, with the X-axis representing the computation time and the Y-axis depicting the objective value achieved by the Greedy Randomized algorithm for each RCL method combination. Each point on the plots corresponds to a specific RCL method, with red dots highlighting the best-performing combinations in terms of both objective value and runtime (computational time), while blue dots represent other method combinations.

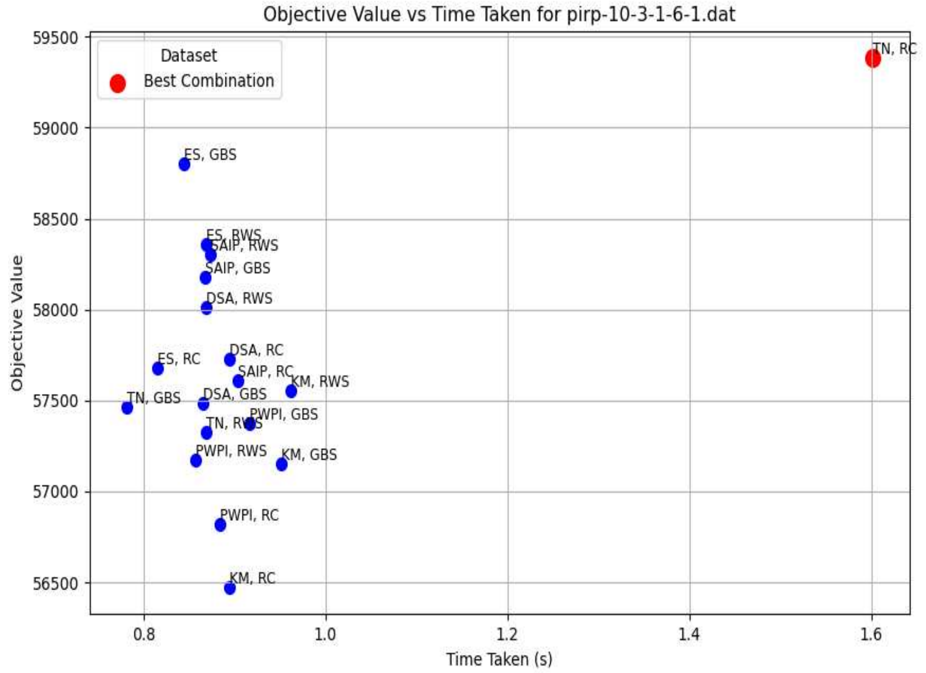

Figure 4.1: Objective Value vs Time Taken for `pirp-10-3-1-6-1.dat`

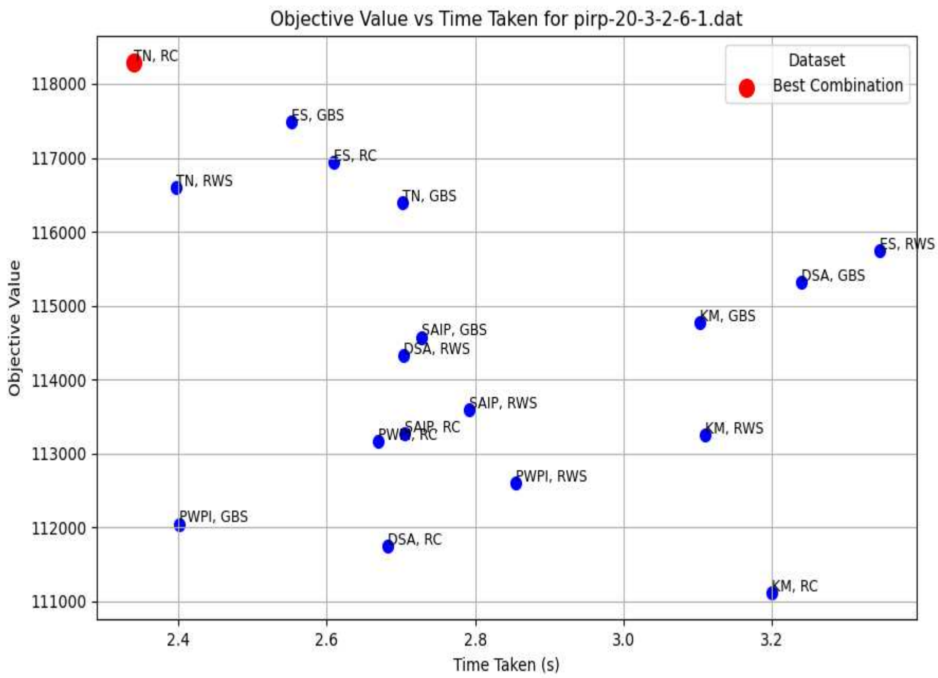

Figure 4.2: Objective Value vs Time Taken for `pirp-20-3-2-6-1.dat`

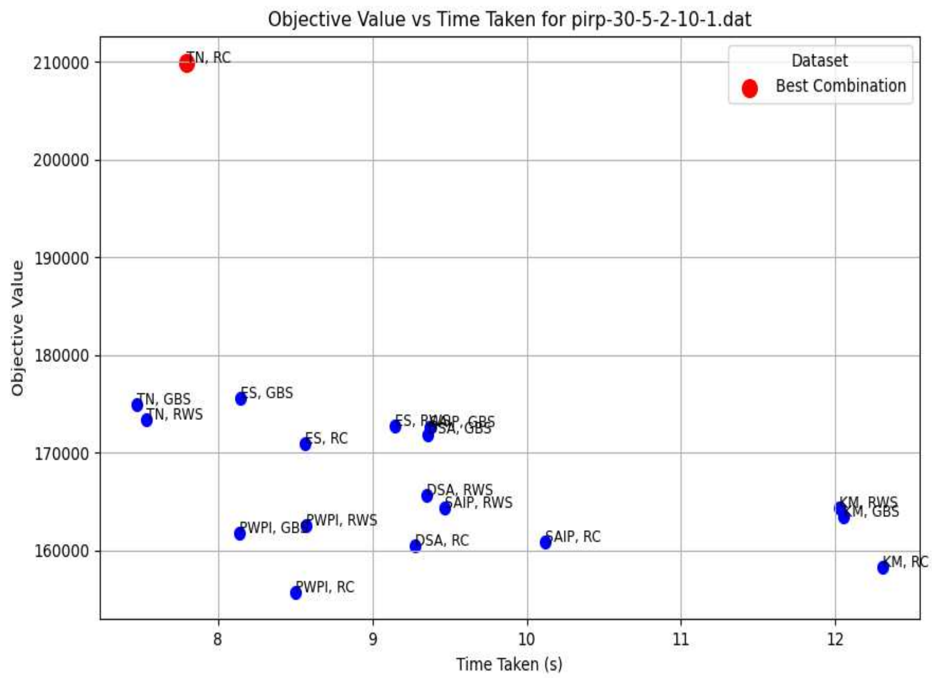

Figure 4.3: Objective Value vs Time Taken for `pirp-30-5-2-10-1.dat`

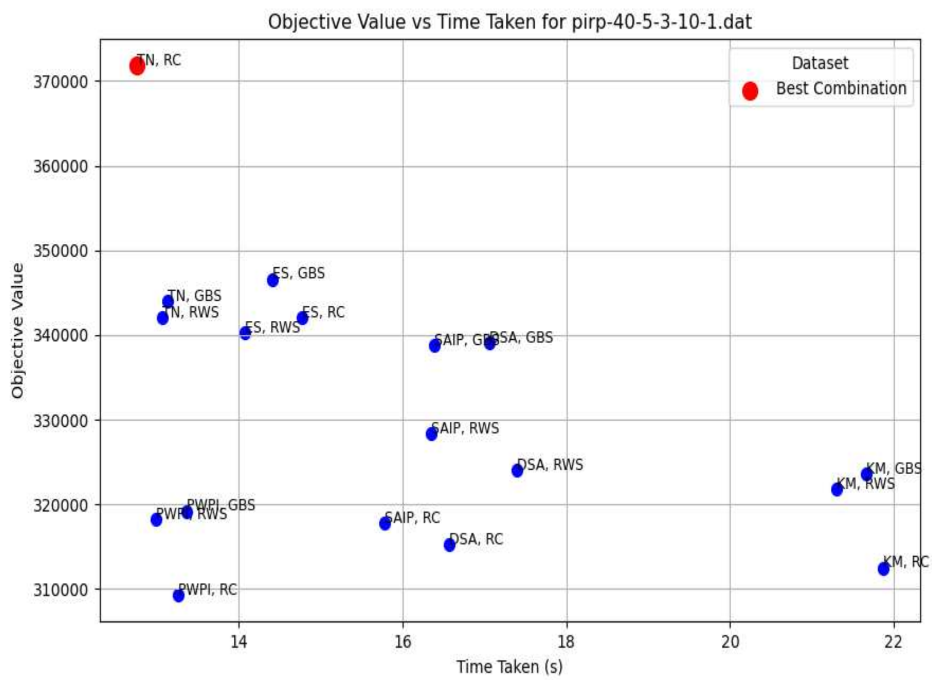

Figure 4.4: Objective Value vs Time Taken for `pirp-40-5-3-10-1.dat`

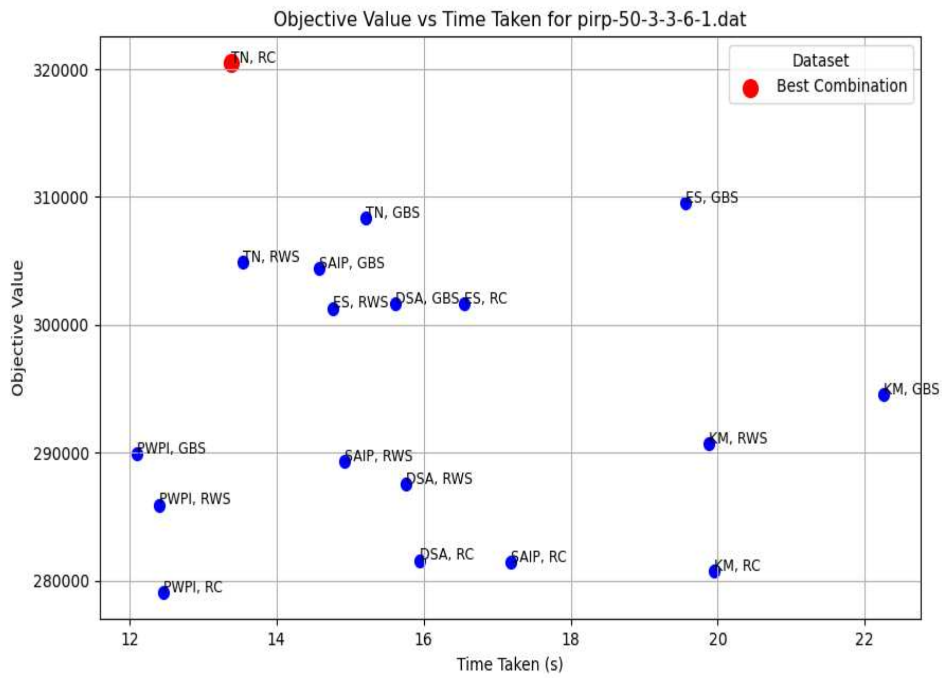

Figure 4.5: Objective Value vs Time Taken for `pirp-50-3-3-6-1.dat`

4.2.3 Results and Analysis of RCL Methods

The following key observations highlight the strengths and weaknesses of each approach:

- Top N and Random Choice (TN, RC) consistently outperform other combinations across all datasets, achieving the highest objective values while maintaining relatively low computation times. This demonstrates that Top N construction, when combined with a simple random selection mechanism, effectively balances exploration and exploitation.

- More exploratory methods, such as the Elitist Strategy (ES) and Simulated Annealing-Inspired Probabilistic RCL (SAIP), tend to explore a wider solution space but generally take more computation time. These strategies can be valuable for finding diverse solutions, but their higher computation times may not justify their use in all cases.

- K-Means RCL (KM) incurs the highest computation time due to the added overhead of clustering nodes, although it can achieve good results when combined with more sophisticated selection methods like Greedy-Biased Stochastic Selection (GBS).

The analysis clearly shows that the combination of Top N Construction and Random Choice Selection offers the best overall performance across the datasets tested. This combination not only achieves the highest objective values but also completes the computation in the shortest time. Based on these findings, Top N and Random Choice was used as the preferred strategy within the GRASP heuristic for solving all the datasets in the PIRP.

4.3 Comparison of GRASP and Exact Solver

In this section, a detailed comparison of the GRASP heuristic and the exact solver is provided, focusing on two key metrics: solution quality, measured by the objective value, and computational efficiency, measured by runtime. Given that demand in the PIRP is modeled as a stochastic variable, the problem instances are not identical for every run, meaning that the exact solver and GRASP work with slightly different demand realizations. This should be kept in mind when interpreting the results. Nevertheless, the comparison gives a clear indication of the performance difference between both methods.

Another important aspect is the number of iterations the exact solver was able to run for different dataset sizes. While some datasets allowed the exact solver to run up to 10 iterations, others, particularly those with larger numbers of periods or greater complexity, were solved with fewer iterations (5, 3, 2, or 1). The more iterations, the more certain we can be about the solution quality and its comparison with GRASP. On the other hand, GRASP was consistently run for 1000 iterations across all datasets, providing a solid basis for comparison.

4.3.1 Objective Value Comparison

Figure 4.6 compares the objective value achieved by the GRASP heuristic against the exact solver across multiple datasets. The x-axis represents the different dataset instances, and the y-axis shows the objective value as a percentage, indicating how close GRASP's solution is to the exact solver's optimal value.

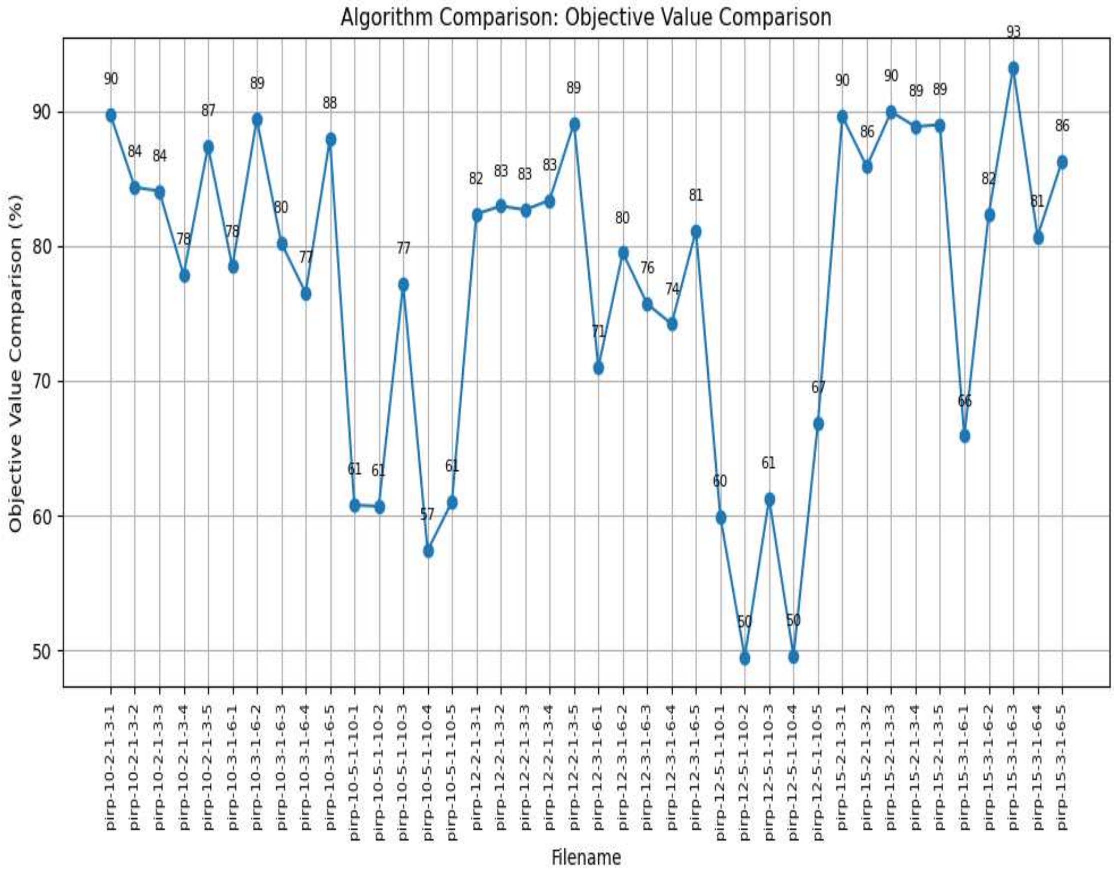

Figure 4.6: Algorithm Comparison: Objective Value Comparison

- **Dataset Sizes and Problem Instances:** The datasets in this comparison consist of small instances with $n = 10$, $n = 12$, and $n = 15$. Larger datasets were computationally infeasible for the exact solver, so they are not included in the figure.
- **Performance Based on Periods:** GRASP's performance shows a distinct trend based on the number of periods. For datasets with 3 periods, GRASP achieved an average of 85.82% of the exact solver's value. For 6-period datasets, GRASP's performance dropped to an average of 80.17%, while for 10-period datasets, it further dropped to 60.41%. This highlights the increased difficulty of maintaining solution quality as the time horizon expands.

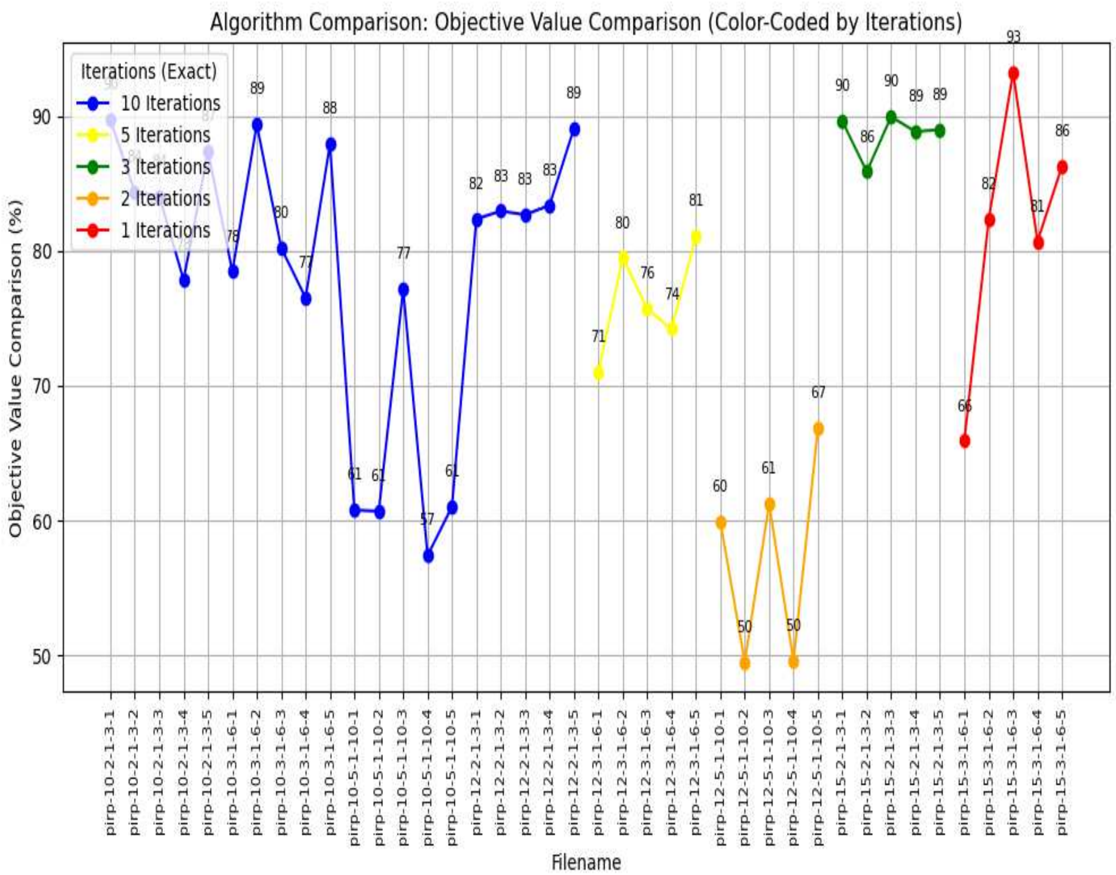

Figure 4.7: Objective Value Comparison (Color-Coded by Iterations)

Figure 4.7 extends the comparison by color-coding the number of iterations that the exact solver was able to complete for each dataset. For simpler datasets, the exact solver was able to run up to 10 iterations, while for more complex datasets, it could only run 1 or 2 iterations. This figure highlights the level of certainty in the results: the more iterations, the more accurate the exact solver's solution.

4.3.2 Time Comparison

The runtime comparison between GRASP and the exact solver illustrates how increasing problem complexity significantly impacts computational time. As datasets grow larger, with more customers, periods, and product parameters, the exact solver requires much longer runtimes, whereas GRASP remains computationally efficient.

Figure 4.8 shows how much faster GRASP is compared to the exact solver across various datasets. The y-axis represents how many times faster GRASP is than the exact solver, with values greater than 1 indicating that GRASP outperforms the exact solver by that factor. The x-axis lists the dataset filenames, which vary by customer count n, periods H, and product age limits.

- **Smaller datasets** (with fewer customers and simpler configurations) show relatively minor differences, with GRASP performing about 20–30 times faster than the exact solver.
- **Larger datasets** show exponential differences in runtime, with GRASP being up to 1000 times faster in some instances, even though the exact solver was only run once. As the datasets increase in complexity, the exact solver's runtime increases dramatically, making it computationally infeasible, while GRASP maintains reasonable runtimes.

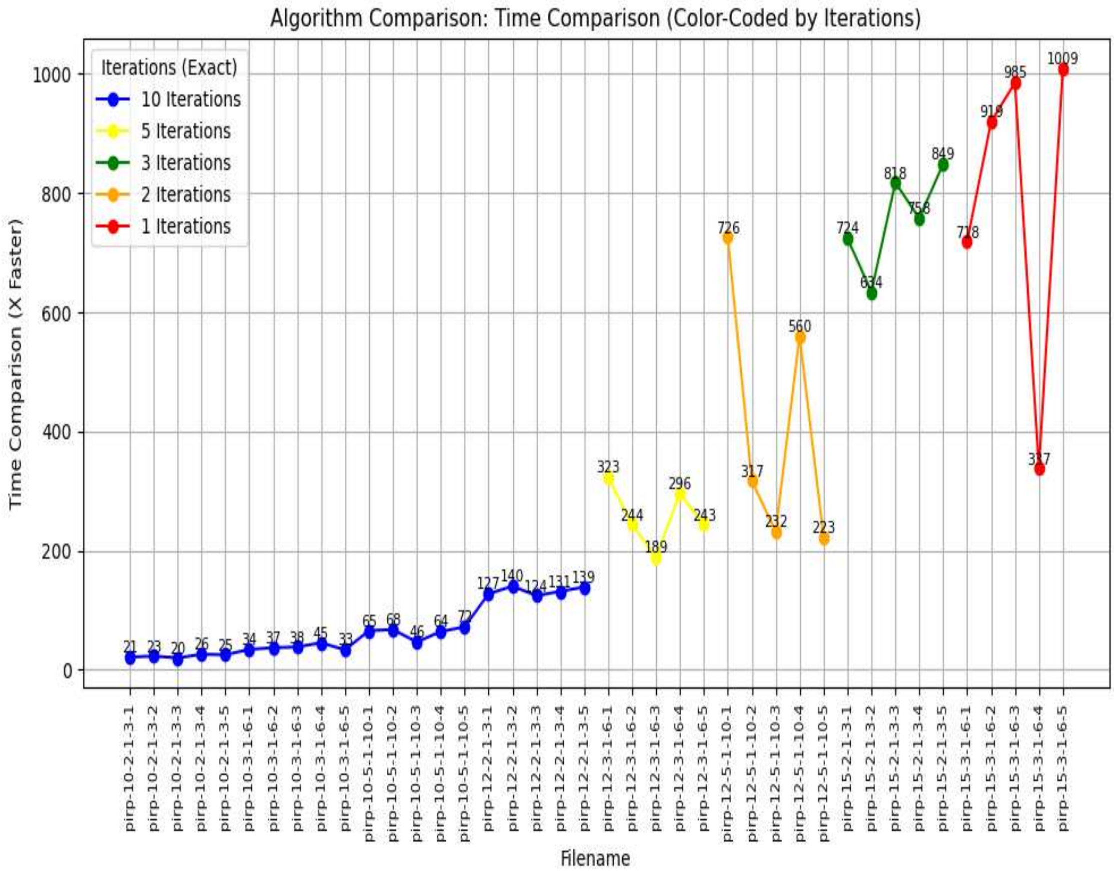

Figure 4.8: Time Comparison (GRASP vs. Exact Solver in X Faster terms)

To further break down the runtime, Figures 4.9 to 4.13 show detailed runtime comparisons for specific iteration groups (1, 2, 3, 5, and 10 iterations) of the exact solver, compared to the 1000 iterations of GRASP. The y-axis shows runtime in seconds, and the x-axis lists the datasets. Each figure focuses on one specific iteration group, helping to visualize how the exact solver's runtime scales with increasing complexity for each iteration count.

Figure 4.9 compares the runtime of GRASP and the exact solver for datasets where the exact solver completed only one iteration. The exact solver's runtime varies from 2500 seconds to 7700 seconds, while GRASP consistently completes 1000 iterations in under 10 seconds.

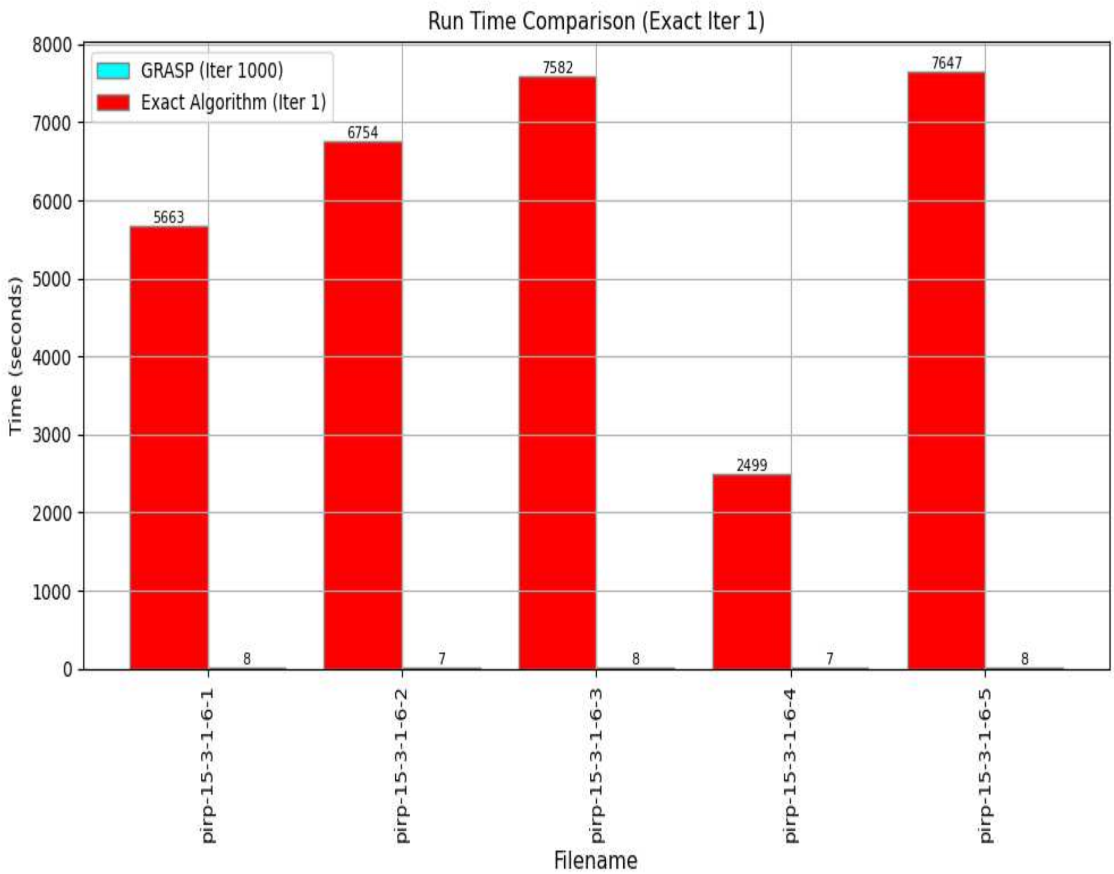

Figure 4.9: Runtime Comparison: Exact Solver (1 Iteration) vs. GRASP (1000 Iterations)

Figure 4.10 compares the runtime of GRASP and the exact solver for datasets where the exact solver completed two iterations. The exact solver's runtime varies from 2500 seconds to 8000 seconds, while GRASP consistently completes 1000 iterations in under 10 seconds.

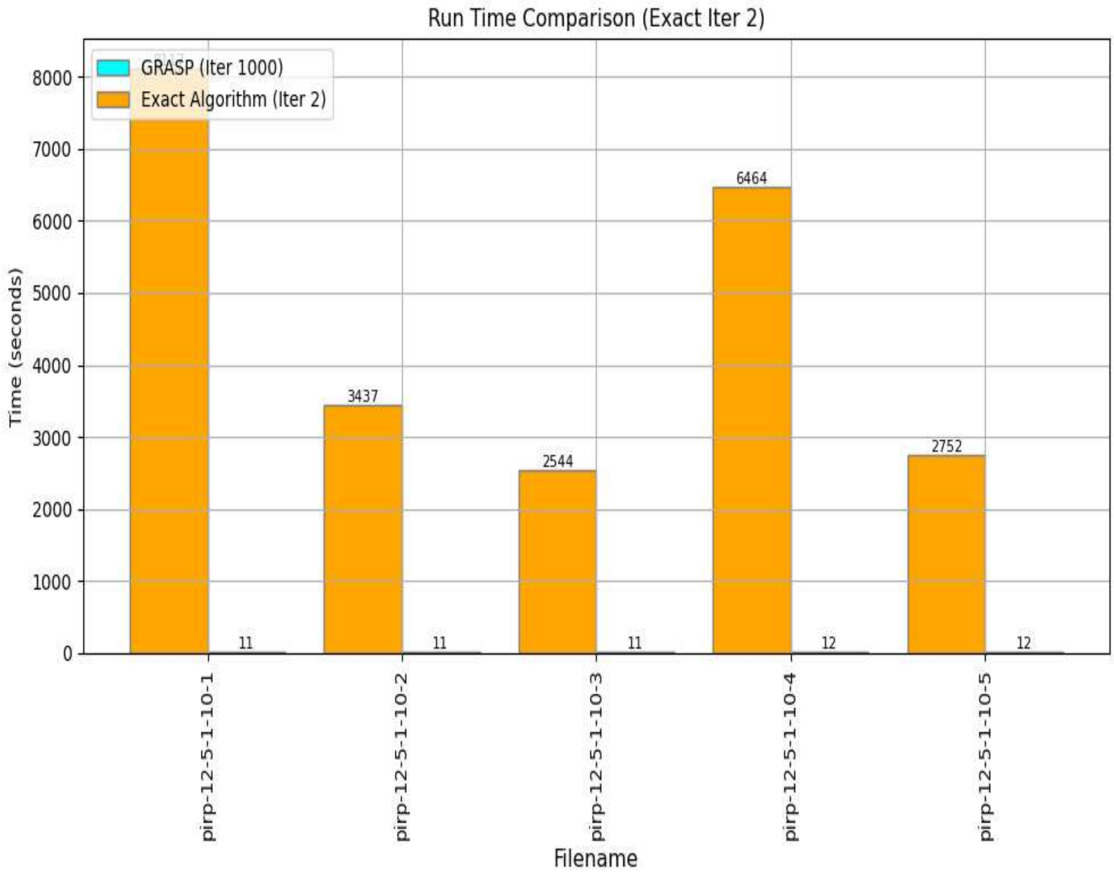

Figure 4.10: Runtime Comparison: Exact Solver (2 Iterations) vs. GRASP (1000 Iterations)

Figure 4.11 presents the runtime comparison for datasets where the exact solver ran for 3 iterations. The exact solver's runtime ranges from 1600 seconds to 2200 seconds, depending on the dataset, while GRASP consistently completes 1000 iterations within 5 seconds across all datasets.

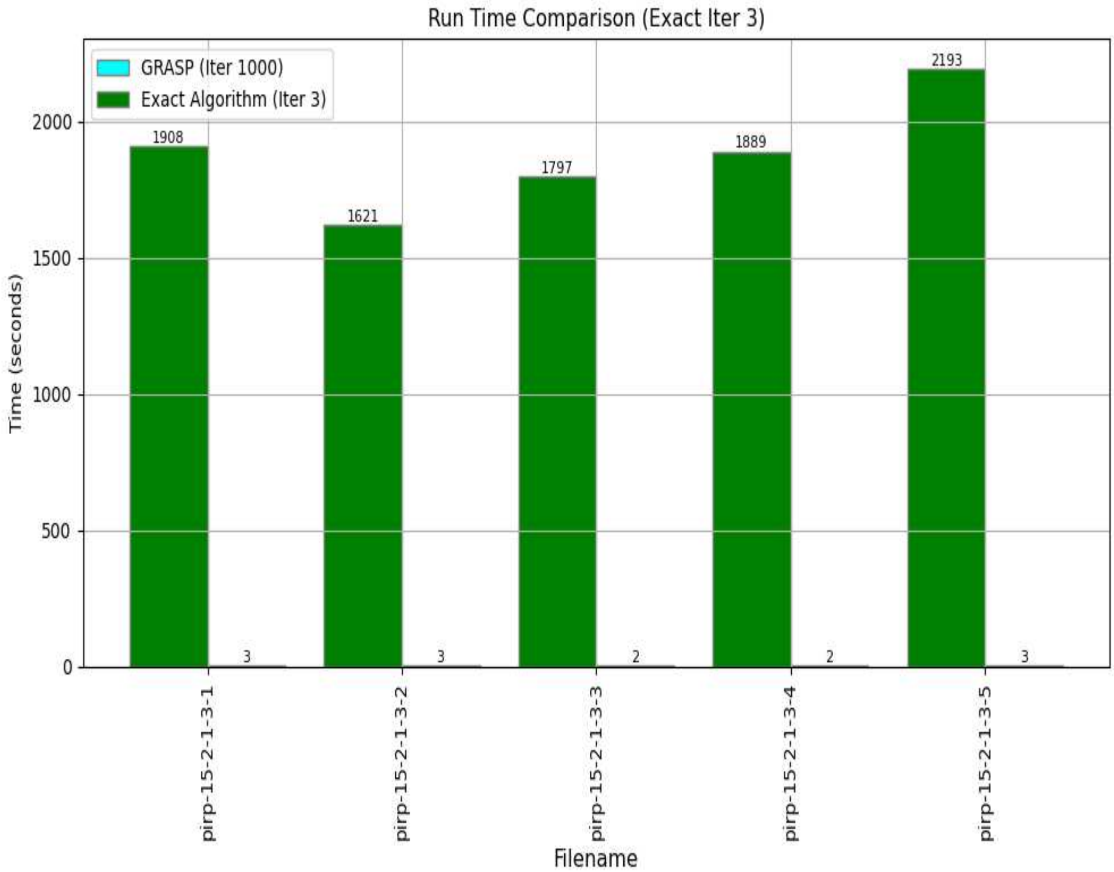

Figure 4.11: Runtime Comparison: Exact Solver (3 Iterations) vs. GRASP (1000 Iterations)

Figure 4.12 illustrates the runtime comparison for datasets where the exact solver completed 5 iterations. The exact solver's runtime spans from 1000 seconds to 1600 seconds, whereas GRASP consistently finishes 1000 iterations within 7 seconds for all datasets

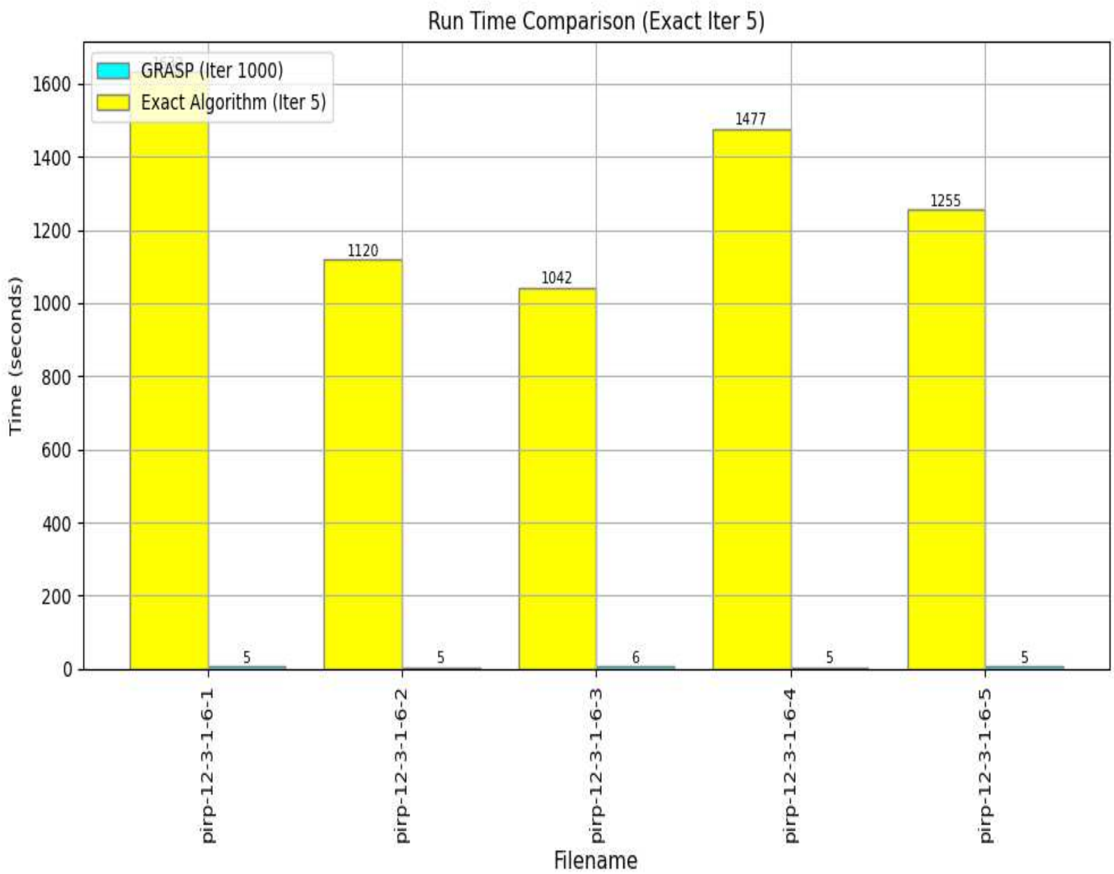

Figure 4.12: Runtime Comparison: Exact Solver (5 Iterations) vs. GRASP (1000 Iterations)

Figure 4.13 presents the runtime comparison for datasets where the exact solver completed 10 iterations. The exact solver's runtime ranges from 22 seconds to 600 seconds, while GRASP consistently completes 1000 iterations in under 10 seconds across all datasets.

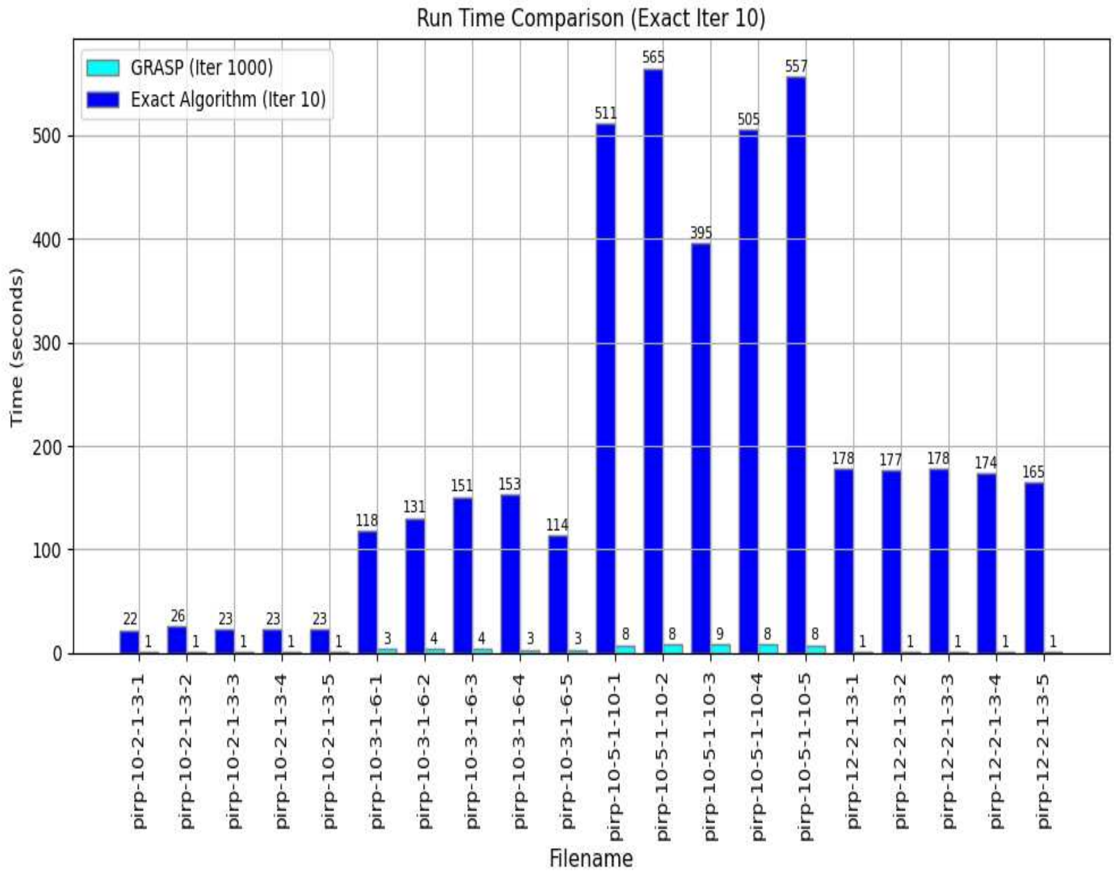

Figure 4.13: Runtime Comparison: Exact Solver (10 Iterations) vs. GRASP (1000 Iterations)

4.3.3 Scalability Discussion

In this section, the scalability of GRASP compared to the exact solver is discussed using two key types of figures: combined runtime and objective value comparisons (Figures 4.14 - 4.18), and GRASP's performance on large datasets that the exact solver couldn't solve (Figure 4.19). These figures demonstrate how GRASP scales effectively with increasing dataset complexity.

Combined Objective Value and Time Comparison

Figures 4.14 - 4.18 provides a detailed breakdown of both the objective value and runtime for GRASP and the exact solver across multiple datasets. Each figure is categorized by the number of iterations for the exact solver (1, 2, 3, 5, 10 iterations). This combined view allows for observation off trade-offs between solution quality and computational efficiency across various dataset complexities.

Figure 4.14 shows the combined runtime and objective value comparison for GRASP (1000 iterations) and the exact solver (1 iteration) across five datasets. The objective values for the exact solver range from 66% to 93% of GRASP's values, while its runtime spans from 2499 seconds to 7647 seconds. GRASP maintains a runtime of under 10 seconds for all datasets.

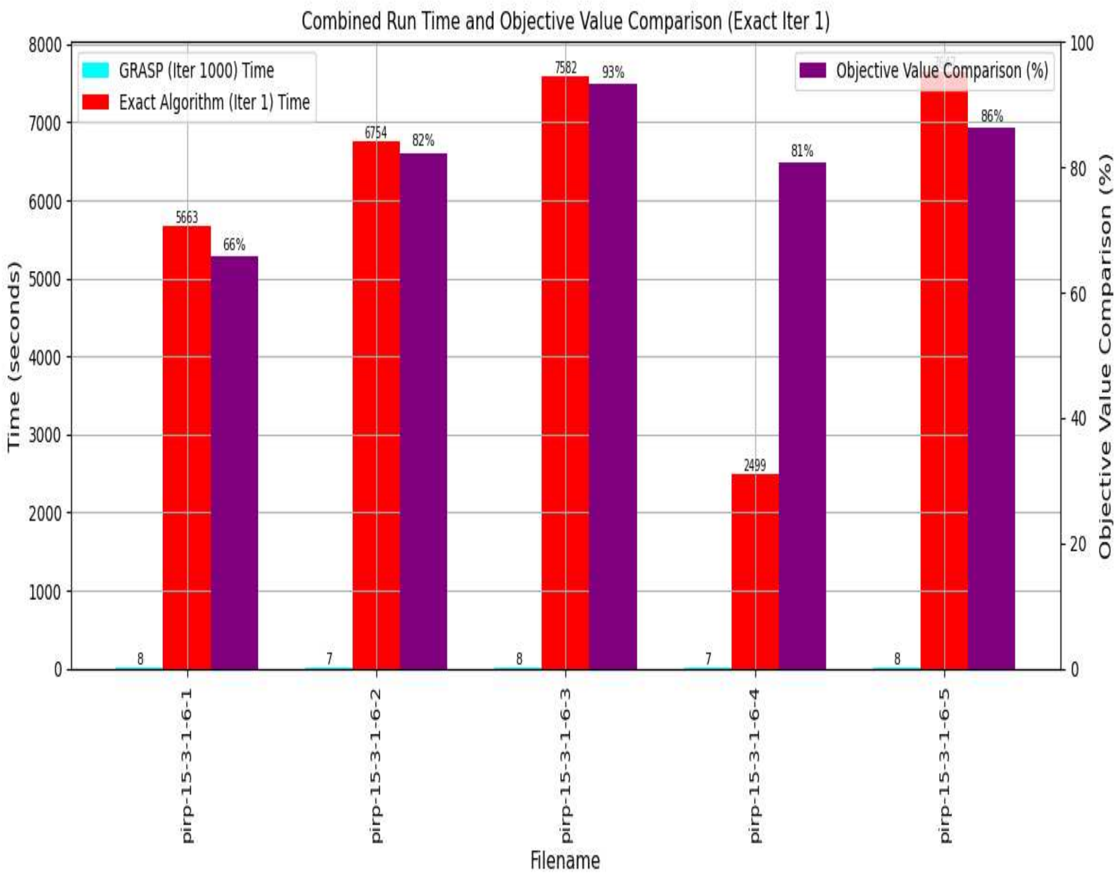

Figure 4.14: Combined Objective Value and Runtime Comparison for Exact Solver (1 Iteration) vs. GRASP

Figure 4.15 shows the combined runtime and objective value comparison for GRASP

(1000 iterations) and the exact solver (2 iterations) across five datasets. The objective values for the exact solver range from 50% to 67% of GRASP's values, while its runtime spans from 2544 seconds to 8000 seconds. GRASP consistently completes all iterations in under 10 seconds for all datasets.

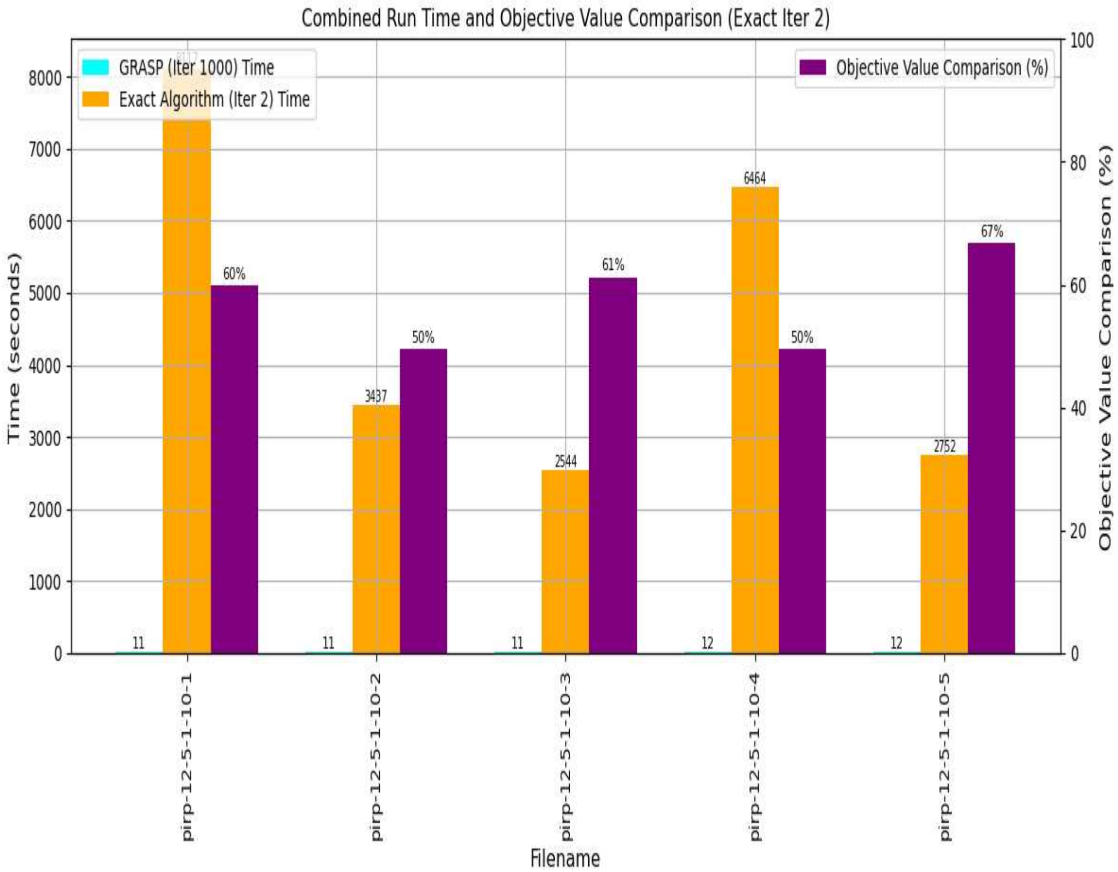

Figure 4.15: Combined Objective Value and Runtime Comparison for Exact Solver (2 Iterations) vs. GRASP

Figure 4.16 illustrates the combined runtime and objective value comparison for GRASP (1000 iterations) and the exact solver (3 iterations) across five datasets. The exact solver achieves objective values ranging from 86% to 90% of GRASP's, with runtimes varying between 1621 and 2193 seconds. In contrast, GRASP maintains consistent runtimes under 5 seconds for all datasets.

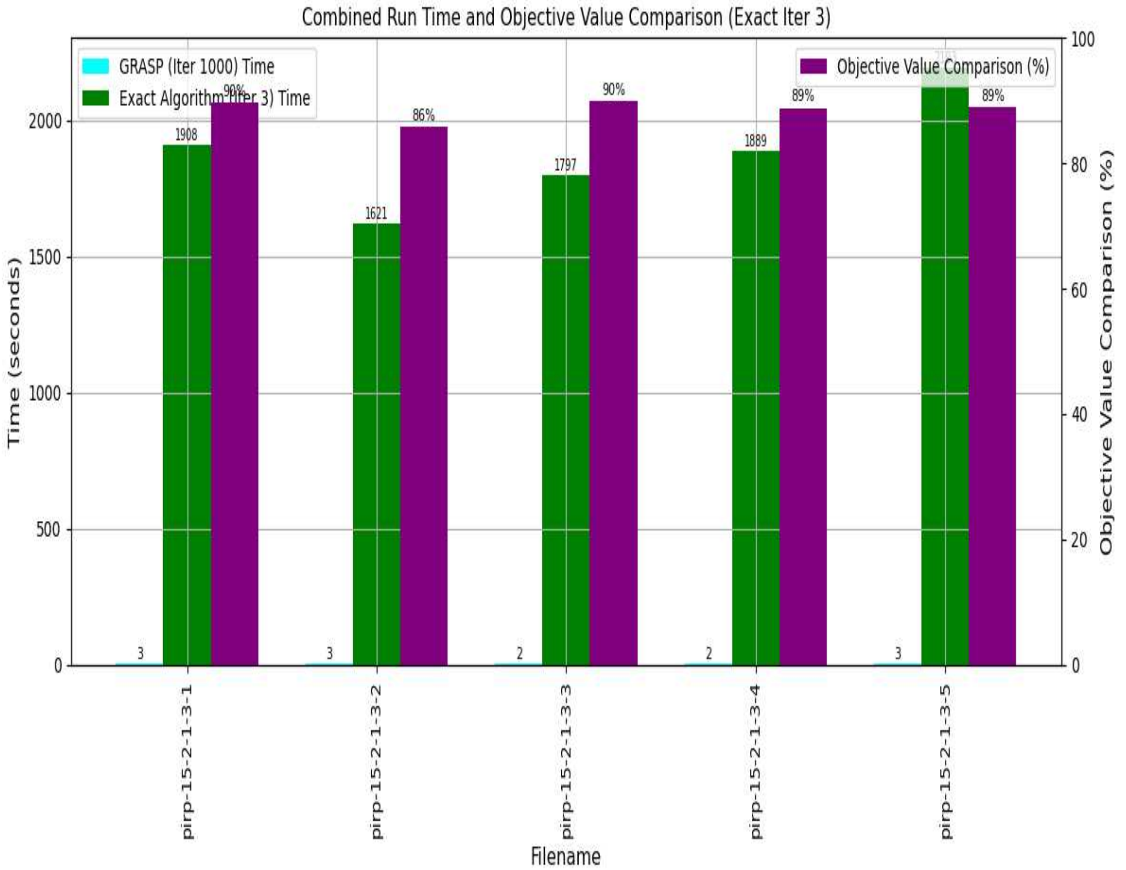

Figure 4.16: Combined Objective Value and Runtime Comparison for Exact Solver (3 Iterations) vs. GRASP

Figure 4.17 presents the combined runtime and objective value comparison for GRASP (1000 iterations) and the exact solver (5 iterations) across five datasets. The exact solver achieves objective values between 71% and 81% of GRASP's, with runtimes ranging from 1042 to 1632 seconds. GRASP consistently completes its iterations in under 6 seconds for all datasets.

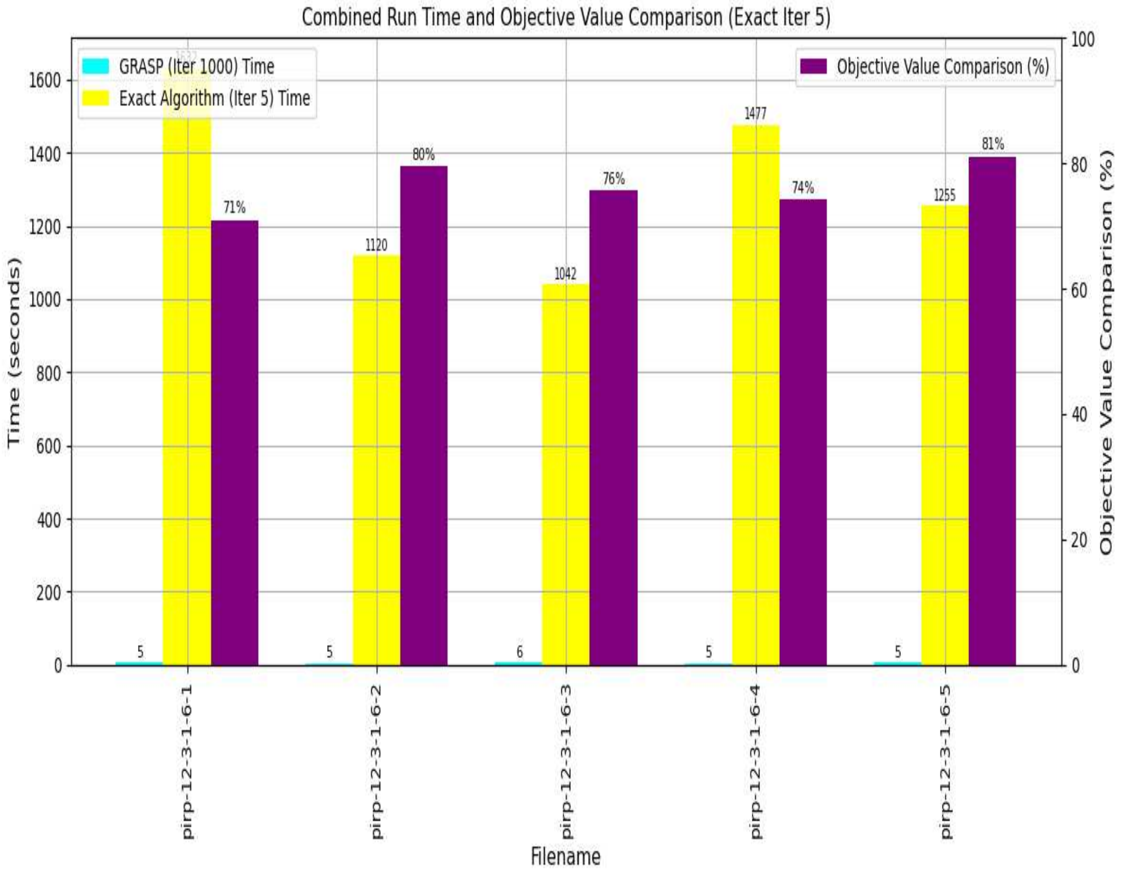

Figure 4.17: Combined Objective Value and Runtime Comparison for Exact Solver (5 Iterations) vs. GRASP

Figure 4.18 illustrates the combined runtime and objective value comparison for GRASP (1000 iterations) and the exact solver (10 iterations) across multiple datasets. The exact solver achieves objective values ranging from 77% to 90% of GRASP's, with runtimes varying between 22 and 565 seconds. GRASP, as before, completes all its iterations consistently in under 10 seconds for all datasets.

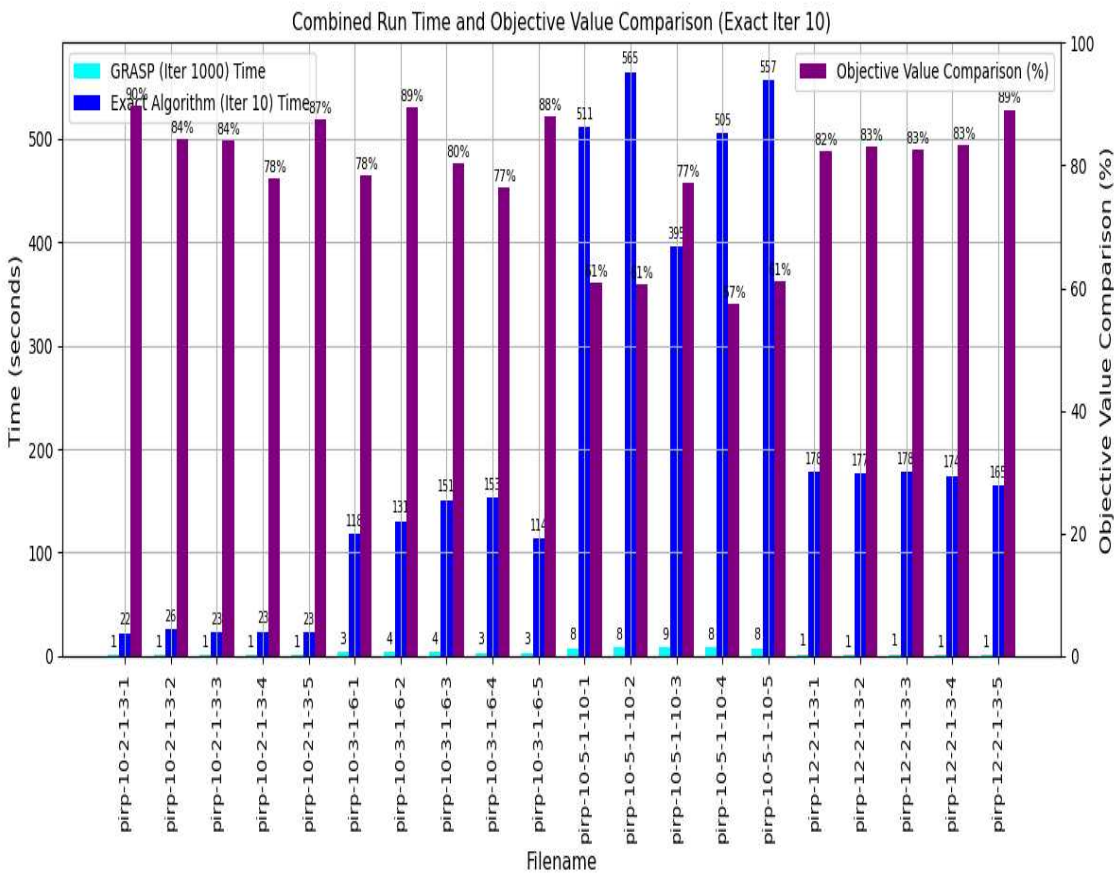

Figure 4.18: Combined Objective Value and Runtime Comparison for Exact Solver (10 Iterations) vs. GRASP

While this figure revisits the objective value and runtime comparisons, it reinforces the earlier findings that GRASP consistently achieves reasonable objective values while maintaining superior runtime performance. As the dataset complexity increases, the exact solver's runtime becomes a bottleneck, especially as the number of iterations grows.

Scalability of GRASP for Large Datasets

In addition to the combined comparisons, figure 4.19 focuses specifically on GRASP's runtime for large datasets that the exact solver could not solve at all. This demonstrates GRASP's ability to handle large-scale problems effectively.

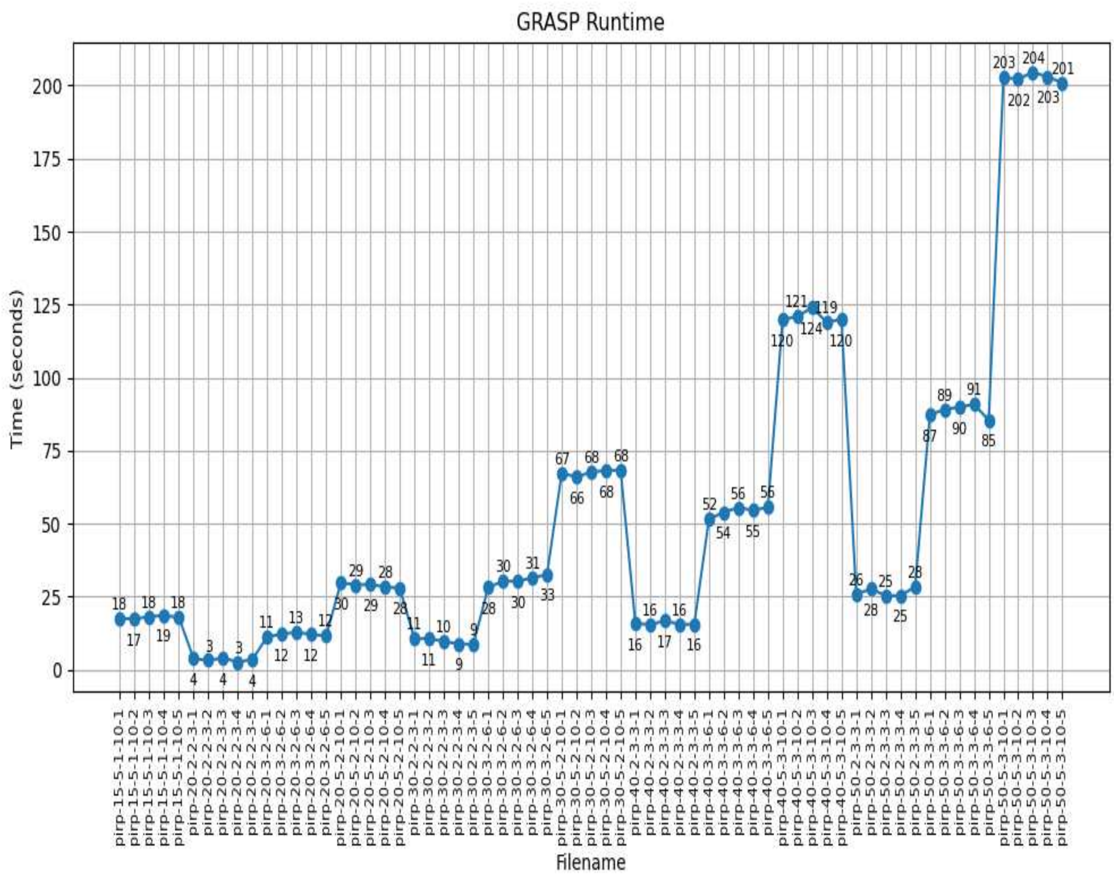

Figure 4.19: GRASP Runtime for Large Datasets Unsuitable for Exact Solver

This figure is particularly significant because it highlights GRASP's potential to solve problems that are too large or complex for the exact solver to handle, due to its exponential runtime growth. GRASP consistently maintains feasible runtimes, even as the dataset size grows beyond what the exact solver can manage.

The scalability of GRASP is thus clearly demonstrated. While the exact solver becomes infeasible for large datasets due to exponential increases in runtime, GRASP continues to provide good-quality solutions within a reasonable time frame. This reinforces the practical advantages of GRASP, especially for large-scale, real-world perishable inventory routing problems where exact methods cannot be applied.

4.4 Estimation of GRASP Performance on Larger Datasets

In this section, we explore the estimated performance of the GRASP heuristic on datasets that were too large for the exact solver to handle. Given the computational challenges posed by larger datasets, it was not feasible to directly compare GRASP and the exact solver on these instances. Instead, a simple estimation method was employed to predict how GRASP might perform on these larger datasets. The estimation was based on a normal distribution, leveraging the observed correlation between the number of periods and the objective value comparison from previous smaller dataset comparisons.

While these estimations provide a useful indication of GRASP's performance, it is important to note that the primary objective of this thesis was not to develop an intricate estimation model but rather to demonstrate GRASP's potential scalability. The methodology used here serves as a simple but effective way to visualize GRASP's performance across larger datasets.

The estimation process utilized the normal distribution, generating predictions for GRASP's objective value based on the number of periods in each dataset. This was based on the correlation observed between the number of periods and GRASP's performance on smaller datasets where the exact solver was also run. The normal distribution was centered around the mean objective value comparison for each period group (3, 6, or 10 periods), and the spread was determined by the standard deviation. This statistical method provided a straightforward way to estimate GRASP's objective values on larger datasets. The color-coded plots in this section visualize these estimations.

Figure 4.20 shows the estimated objective value comparison for GRASP across larger datasets, color-coded by the number of periods (3, 6, or 10). The x-axis represents the filenames of the datasets, and the y-axis displays the estimated objective value comparison as a percentage. GRASP's estimated performance generally declines as the number of periods increases, with datasets involving 10 periods showing the lowest estimated objective values. This is consistent with the trend observed in smaller datasets, where increasing the number of periods led to more complex problem instances and lower solution quality. However, GRASP still demonstrates strong performance across many instances, particularly for datasets with fewer periods.

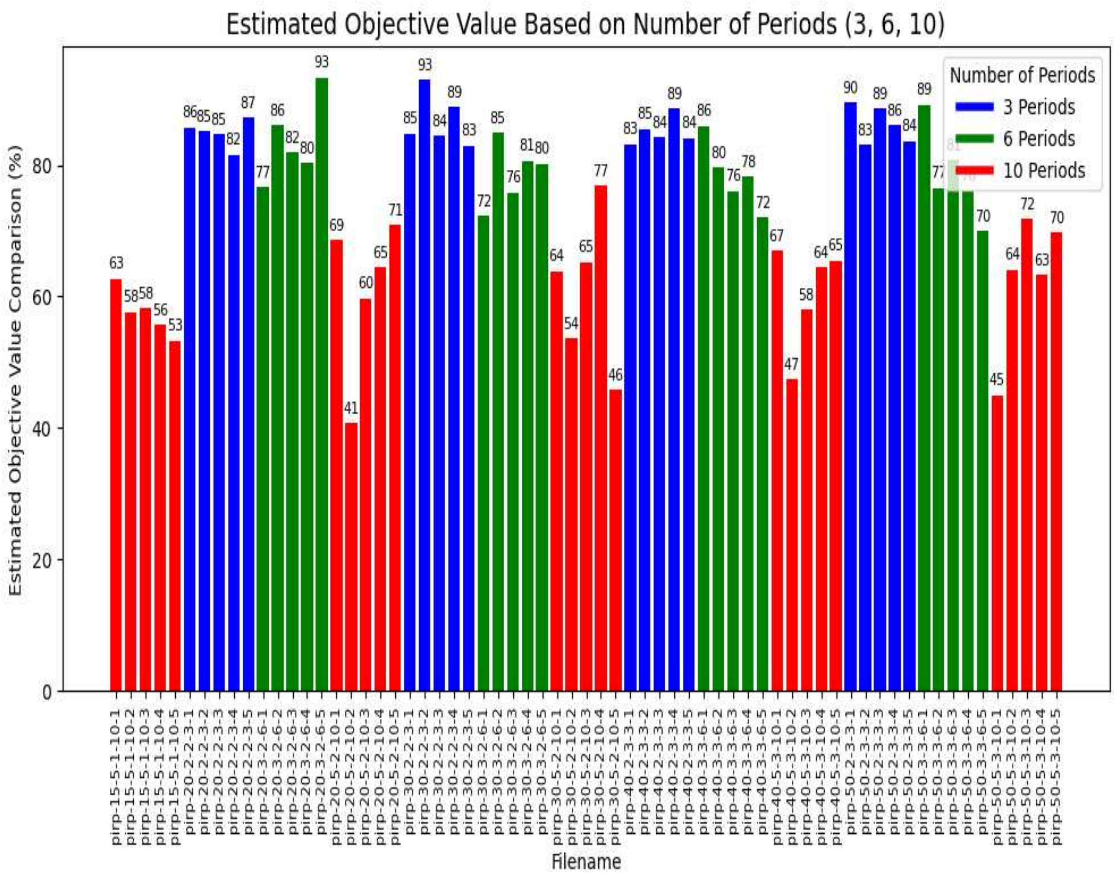

Figure 4.20: Estimated Objective Value Comparison for Larger Datasets (Color-Coded by Periods)

Figure 4.21 illustrates the estimated objective value comparison for GRASP across datasets with 3 periods. The objective values range between 80% and 93%, with most datasets clustering around the upper range. Notably, datasets such as `pirp-20-2-3-3` and `pirp-40-2-3-3` achieve the highest estimated objective values of 93%. These results indicate that GRASP consistently performs well for datasets with fewer periods, maintaining a high level of solution quality.

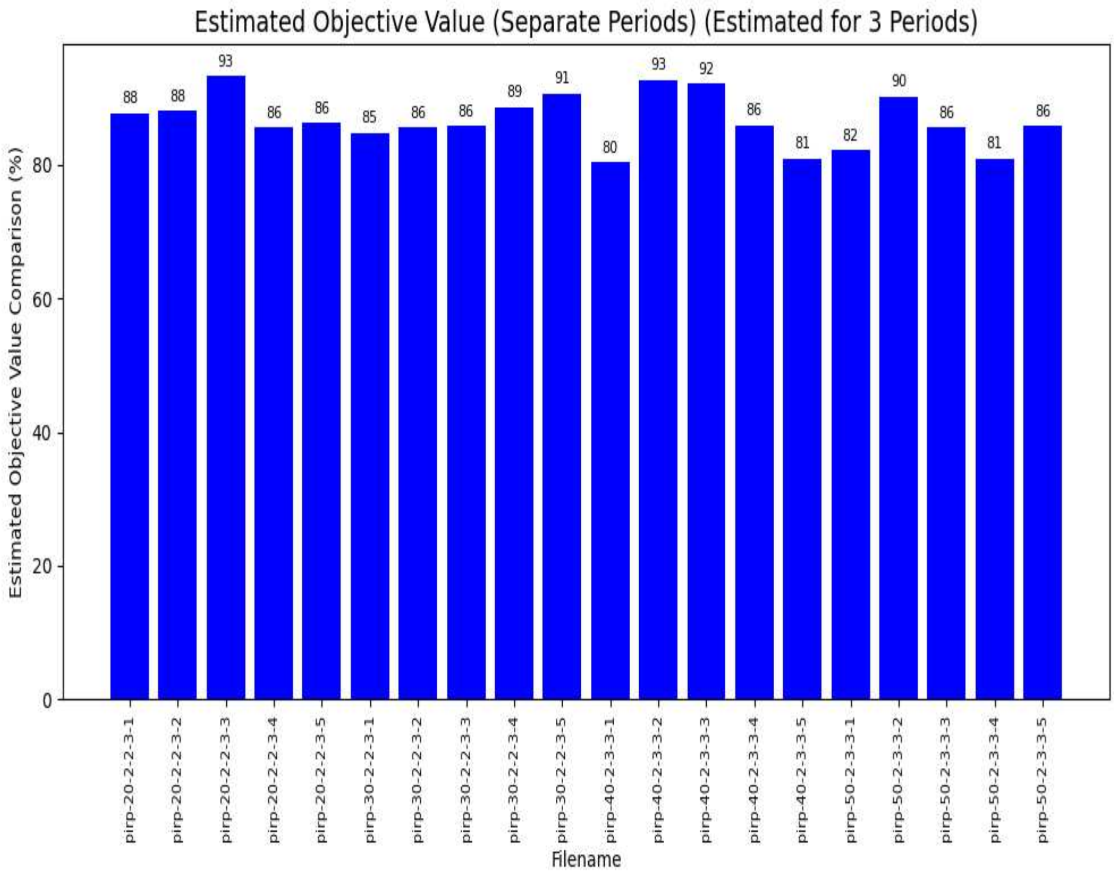

Figure 4.21: Estimated Objective Value Comparison for GRASP (3 Periods)

Figure 4.22 shows the estimated objective value comparison for GRASP across datasets with 6 periods. The objective values range from 67% to 87%, with the majority falling between 75% and 85%. Notable peaks include `pirp-40-3-6-5` and `pirp-30-3-6-1`, which achieve the highest estimated objective values of 87%. These results highlight the slight decrease in GRASP's performance compared to datasets with 3 periods, indicating the growing complexity of solving instances with more periods.

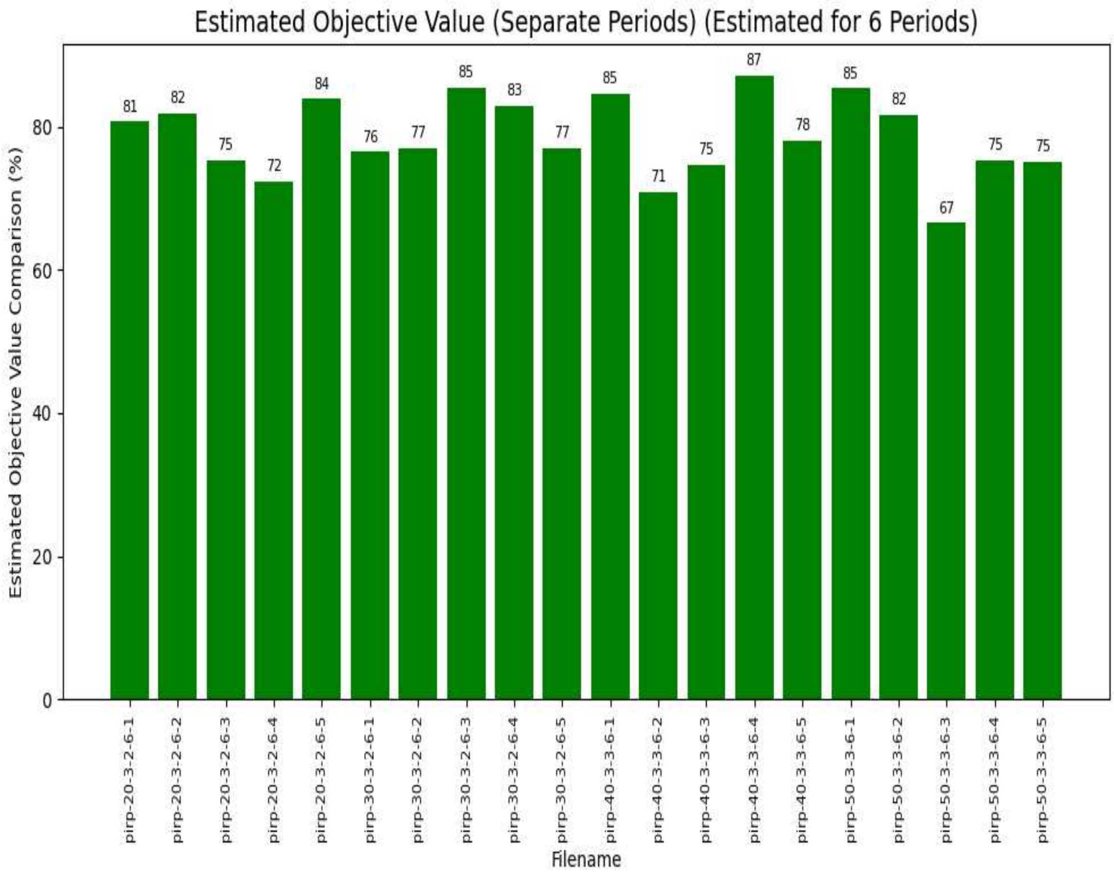

Figure 4.22: Estimated Objective Value Comparison for GRASP (6 Periods)

Figure 4.23 displays the estimated objective value comparison for GRASP across datasets with 10 periods. The estimated objective values show greater variability compared to datasets with fewer periods, ranging from 36% to 75%. Most datasets, however, fall within the range of 50% to 70%, with exceptions at the lower end (`pirp-50-5-10-3`, 36%) and the higher end (`pirp-30-5-10-2`, 75%). This pattern highlights the challenges posed by longer planning horizons and greater problem complexity, while still demonstrating GRASP's potential to provide reasonable solutions across most instances.

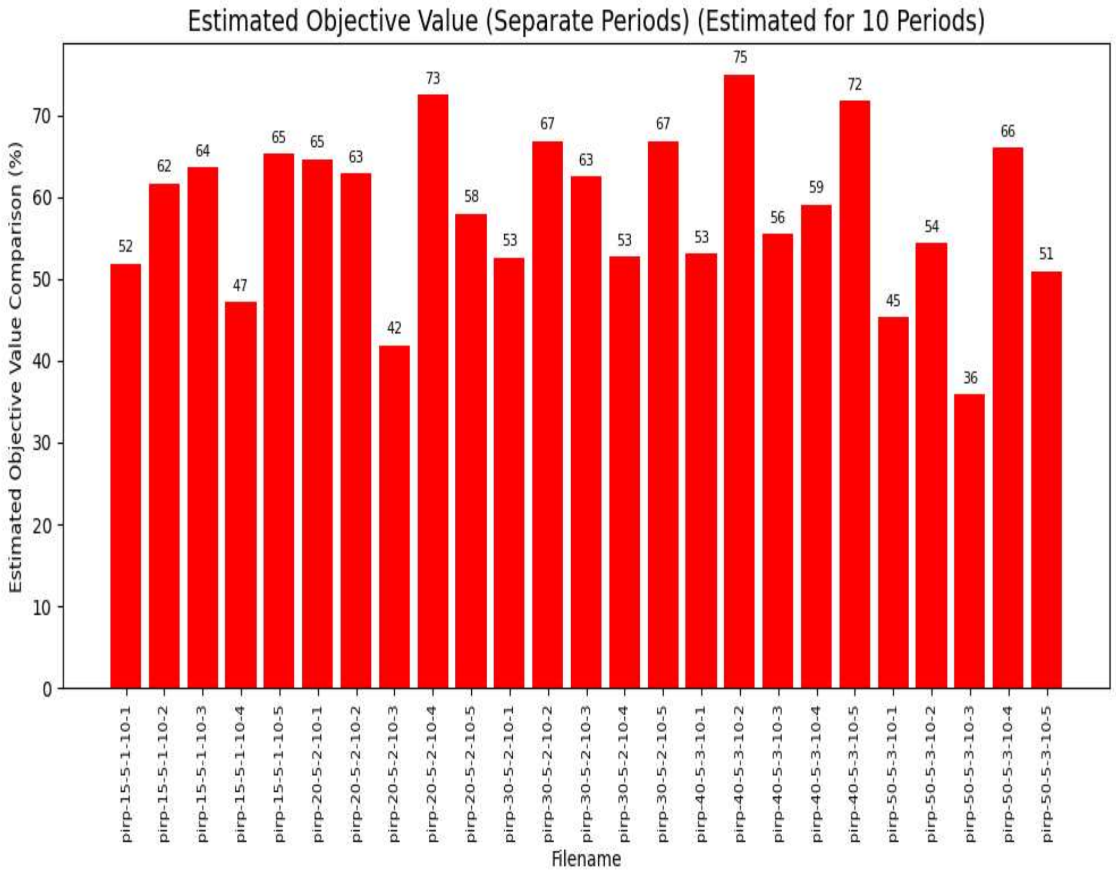

Figure 4.23: Estimated Objective Value Comparison for GRASP (10 Periods)

Figures 4.21 to 4.23 provide a breakdown of the estimated objective values for GRASP, categorized by the number of periods (3, 6, or 10). Each figure offers a focused analysis of GRASP's performance across datasets with the same number of periods, highlighting key trends.

The results indicate that GRASP consistently achieves high objective value estimates for datasets with 3 and 6 periods, with most estimates falling within narrow ranges, reflecting stable performance. However, for datasets with 10 periods, the performance is more varied, with objective values spanning a wider range. This suggests that, while GRASP scales well to larger datasets, it faces challenges when the number of periods increase.

This analysis provides a useful estimation of GRASP's performance on larger datasets, showcasing its scalability and robustness in solving complex perishable goods supply chain problems. However, it is important to note that the primary focus of this thesis was not to develop a detailed estimation model for GRASP's performance. Rather, the simple estimation methods used here serve to give a rough indication of how GRASP might perform on datasets that are computationally infeasible for the exact solver. Despite the limitations of this approach, the results demonstrate that GRASP is capable of providing feasible solutions even for very large instances, reinforcing its value as a scalable metaheuristic for real-world supply chain applications.

4.5 Variable Analysis

This section analyzes the differences in variable values between the exact solver and the GRASP metaheuristic for solving the PIRP. The dataset `pirp-10-5-1-10-1` was chosen for this analysis as it represents a scenario with 10 planning periods, which yielded the worst outcomes for GRASP in terms of objective value when compared to the exact solver. The exact solver achieved an average objective value of 122,952.55, while GRASP obtained an average of 74,722.85, resulting in a 60.77% objective value comparison. This deeper examination aims to provide insight into the decisions made by each approach regarding routing, delivery, and inventory utilization.

The analysis focuses on the following key aspects:

- The routes taken by the vehicle in each period.
- The quantities delivered for products of different ages.
- The usage of initial inventory to satisfy customer demands.

4.5.1 Period-Wise Comparison of Inventory and Routing Decisions

Table 4.1: Depot Inventory Utilization for Period 1

Inventory Age (H)	Initial Inventory Used (Exact)	Initial Inventory Used (GRASP)
H = 0	2798	2798
H = 1	0	0
H = 2	0	0
H = 3	0	0
H = 4	0	0
H = 5	0	0

Table 4.2: Inventory Utilization and Delivery Results for Period 1

Node ID	Demand	Initial Inventory Used (Exact)	Initial Inventory Used (GRASP)	Delivered Quantity (Exact)	Delivered Quantity (GRASP)
1	146	-	146 (H=1)	146 (H=0)	-
2	80	80 (H=1)	80 (H=1)	-	-
3	87	-	87 (H=1)	87 (H=0)	-
4	101	-	101 (H=1)	101 (H=0)	-
5	189	-	189 (H=1)	189 (H=0)	-
6	63	-	63 (H=1)	63 (H=0)	-
7	54	-	54 (H=1)	54 (H=0)	-
8	62	62 (H=1)	62 (H=1)	-	-
9	135	-	135 (H=1)	135 (H=0)	-
10	183	183 (H=1)	183 (H=1)	-	-

Table 4.3: Vehicle Routing for Period 1

Method	Vehicle Route
Exact	Node 0 → Node 7 → Node 6 → Node 4 → Node 9 → Node 1 → Node 5 → Node 3 → Node 0
GRASP	No route available

In Period 1, the Exact method demonstrates a clear distinction between nodes utilizing Initial Inventory (Nodes 2, 8, 10) and those receiving direct deliveries. GRASP, on the other hand, fulfills the demand for all nodes using the Initial Inventory, without generating a route for this period.

Table 4.4: Depot Inventory Utilization for Period 2

Inventory Age (H)	Initial Inventory Used (Exact)	Initial Inventory Used (GRASP)
H = 0	2798	2798
H = 1	2023	2798
H = 2	0	0
H = 3	0	0
H = 4	0	0
H = 5	0	0

Table 4.5: Inventory Utilization and Delivery Results for Period 2

Node ID	Demand	Initial Inventory Used (Exact)	Initial Inventory Used (GRASP)	Delivered Quantity (Exact)	Delivered Quantity (GRASP)
1	177	-	-	177 (H=0)	177 (H=0)
2	102	-	102 (H=2)	102 (H=0)	-
3	124	-	124 (H=2)	124 (H=0)	-
4	37	-	37 (H=2)	37 (H=1)	-
5	141	-	-	141 (H=0)	141 (H=0)
6	209	-	209 (H=2)	209 (H=1)	-
7	61	-	61 (H=2)	61 (H=0)	-
8	208	-	208 (H=2)	208 (H=0)	-
9	57	-	57 (H=2)	57 (H=0)	-
10	71	-	71 (H=2)	71 (H=0)	-

Table 4.6: Vehicle Routing for Period 2

Method	Vehicle Route
Exact	Node 0 → Node 1 → Node 4 → Node 9 → Node 2 → Node 5 → Node 7 → Node 8 → Node 3 → Node 10 → Node 6 → Node 0
GRASP	Node 0 → Node 1 → Node 5 → Node 0

In Period 2, the Exact method exclusively fulfills demand through direct deliveries to all nodes, while the GRASP method primarily utilizes the Initial Inventory at each customer to meet demand, delivering only to nodes 1 and 5.

Table 4.7: Depot Inventory Utilization for Period 3

Inventory Age (H)	Initial Inventory Used (Exact)	Initial Inventory Used (GRASP)
H = 0	2798	2798
H = 1	1857	2480
H = 2	1777	2798
H = 3	0	0
H = 4	0	0
H = 5	0	0

Table 4.8: Inventory Utilization and Delivery Results for Period 3

Node ID	Demand	Initial Inventory Used (Exact)	Initial Inventory Used (GRASP)	Delivered Quantity (Exact)	Delivered Quantity (GRASP)
1	107	-	-	107 (H=0)	107 (H=0)
2	189	-	189 (H=3)	189 (H=0)	-
3	201	-	-	201 (H=1)	201 (H=0)
4	181	-	-	181 (H=0)	181 (H=0)
5	197	-	-	197 (H=1)	197 (H=0)
6	47	-	47 (H=3)	47 (H=1)	-
7	95	-	95 (H=3)	95 (H=0)	-
8	40	-	40 (H=3)	40 (H=0)	-
9	181	-	181 (H=3)	181 (H=0)	-
10	124	-	124 (H=3)	124 (H=0)	-

Table 4.9: Vehicle Routing for Period 3

Method	Vehicle Route
Exact	Node 0 → Node 7 → Node 2 → Node 1 → Node 10 → Node 8 → Node 4 → Node 9 → Node 6 → Node 5 → Node 3 → Node 0
GRASP	Node 0 → Node 5 → Node 1 → Node 4 → Node 3 → Node 0

In Period 3, the Exact method fulfills all demands through deliveries. However, while most deliveries consist of fresh products (H=0), some products with an older age (H=1) are also used. On the other hand, the GRASP method primarily utilizes the Initial Inventory at the customers' locations to meet demand. However, it begins delivering to more customers compared to previous periods.

Table 4.10: Depot Inventory Utilization for Period 4

Inventory Age (H)	Initial Inventory Used (Exact)	Initial Inventory Used (GRASP)
H = 0	2798	2798
H = 1	1881	2112
H = 2	1.412	2.480
H = 3	1.777	2.798
H = 4	0	0
H = 5	0	0

Table 4.11: Inventory Utilization and Delivery Results for Period 4

Node ID	Demand	Initial Inventory Used (Exact)	Initial Inventory Used (GRASP)	Delivered Quantity (Exact)	Delivered Quantity (GRASP)
1	144	-	144 (H=4)	144 (H=1)	-
2	80	-	80 (H=4)	80 (H=0)	-
3	99	-	99 (H=4)	99 (H=0)	-
4	201	-	201 (H=4)	201 (H=0)	-
5	160	-	-	160 (H=0)	160 (H=0)
6	192	-	192 (H=4)	192 (H=1)	-
7	160	-	-	160 (H=0)	160 (H=0)
8	113	-	-	113 (H=0)	113 (H=0)
9	146	-	146 (H=4)	146 (H=1)	-
10	168	-	-	168 (H=0)	168 (H=0)

Table 4.12: Vehicle Routing for Period 4

Method	Vehicle Route
Exact	Node 0 → Node 5 → Node 1 → Node 6 → Node 9 → Node 3 → Node 8 → Node 7 → Node 10 → Node 2 → Node 4 → Node 0
GRASP	Node 0 → Node 10 → Node 5 → Node 8 → Node 7 → Node 0

In Period 4, the Exact method continues to fulfill all demands through direct deliveries, utilizing both fresh and aged inventory from the depot. Most deliveries use fresh products (H=0). The GRASP method primarily relies on the Initial Inventory at customers' locations, minimizing depot deliveries. However, it begins delivering to specific customers like Nodes 5, 7, 8, and 10.

Table 4.13: Depot Inventory Utilization for Period 5

Inventory Age (H)	Initial Inventory Used (Exact)	Initial Inventory Used (GRASP)
H = 0	2798	2798
H = 1	1817	2197
H = 2	1399	2112
H = 3	1412	2480
H = 4	1777	2798
H = 5	0	0

Table 4.14: Inventory Utilization and Delivery Results for Period 5

Node ID	Demand	Initial Inventory Used (Exact)	Initial Inventory Used (GRASP)	Delivered Quantity (Exact)	Delivered Quantity (GRASP)
1	180	-	-	180 (H=0)	180 (H=0)
2	199	-	-	199 (H=0)	199 (H=0)
3	30	-	30 (H=5)	30 (H=1)	-
4	31	-	31 (H=5)	31 (H=1)	-
5	86	-	-	86 (H=0)	86 (H=0)
6	65	-	65 (H=5)	65 (H=1)	-
7	198	-	-	198 (H=0)	198 (H=0)
8	137	-	-	137 (H=0)	137 (H=0)
9	39	-	-	39 (H=0)	-
10	119	-	-	119 (H=1)	119 (H=0)

Table 4.15: Vehicle Routing for Period 5

Method	Vehicle Route
Exact	Node 0 → Node 4 → Node 8 → Node 3 → Node 5 → Node 7 → Node 10 → Node 2 → Node 6 → Node 9 → Node 0
GRASP	Node 0 → Node 1 → Node 5 → Node 2 → Node 7 → Node 8 → Node 9 → Node 10 → Node 0

In Period 5, the Exact method continues to deliver to all nodes while relying on fresh (H=0) and aged inventory (H=1) from the depot. Meanwhile, as the Initial Inventory in the GRASP method approaches the end of its usable lifespan (products of age H=5 are discarded), we observe a shift in strategy, with GRASP beginning to fulfill more demand through direct deliveries.

Table 4.16: Depot Inventory Utilization for Period 6

Inventory Age (H)	Initial Inventory Used (Exact)	Initial Inventory Used (GRASP)
H = 0	2798	2798
H = 1	2096	1840
H = 2	1435	2197
H = 3	1399	2112
H = 4	1412	2480
H = 5	1351	2798

Table 4.17: Inventory Utilization and Delivery Results for Period 6

Node ID	Demand	Initial Inventory Used (Exact)	Initial Inventory Used (GRASP)	Delivered Quantity (Exact)	Delivered Quantity (GRASP)
1	196	-	-	196 (H=0)	196 (H=0)
2	39	-	-	39 (H=5)	39 (H=0)
3	49	-	-	49 (H=0)	49 (H=0)
4	47	-	-	47 (H=0)	47 (H=0)
5	190	-	-	190 (H=0)	190 (H=0)
6	158	-	-	158 (H=1)	158 (H=0)
7	173	-	-	173 (H=5)	173 (H=0)
8	180	-	-	180 (H=5)	180 (H=0)
9	88	-	-	88 (H=0)	88 (H=0)
10	156	-	-	156 (H=0)	156 (H=0)

Table 4.18: Vehicle Routing for Period 6

Method	Vehicle Route
Exact	Node 0 → Node 1 → Node 3 → Node 5 → Node 6 → Node 9 → Node 4 → Node 8 → Node 7 → Node 2 → Node 10 → Node 0
GRASP	Node 0 → Node 7 → Node 2 → Node 4 → Node 10 → Node 3 → Node 5 → Node 9 → Node 1 → Node 8 → Node 6 → Node 0

In Period 6, the Exact method continues to fulfill demand through deliveries, with a reliance on older inventory from the depot, including products aged up to H=5. The GRASP method, on the other hand, shifts entirely to delivering fresh products, as the Initial Inventory at each customer has reached or exceeded age H=5 and has been discarded. Consequently, both methods rely solely on deliveries to meet demand in this and all subsequent periods, but the Exact method uses a mix of fresh and aged products, while the GRASP method exclusively delivers fresh inventory.

Table 4.19: Depot Inventory Utilization for Period 7

Inventory Age (H)	Initial Inventory Used (Exact)	Initial Inventory Used (GRASP)
H = 0	2798	2798
H = 1	2072	1522
H = 2	1938	1840
H = 3	1435	2197
H = 4	1399	2112
H = 5	1412	2480

Table 4.20: Inventory Utilization and Delivery Results for Period 7

Node ID	Demand	Initial Inventory Used (Exact)	Initial Inventory Used (GRASP)	Delivered Quantity (Exact)	Delivered Quantity (GRASP)
1	94	-	-	94 (H=0)	94 (H=0)
2	164	-	-	164 (H=0)	164 (H=0)
3	188	-	-	188 (H=0)	188 (H=0)
4	110	-	-	110 (H=0)	110 (H=0)
5	48	-	-	48 (H=0)	48 (H=0)
6	69	-	-	69 (H=0)	69 (H=0)
7	135	-	-	135 (H=0)	135 (H=0)
8	60	-	-	60 (H=0)	60 (H=0)
9	71	-	-	71 (H=0)	71 (H=0)
10	37	-	-	37 (H=0)	37 (H=0)

Table 4.21: Vehicle Routing for Period 7

Method	Vehicle Route
Exact	Node 0 → Node 2 → Node 6 → Node 4 → Node 9 → Node 1 → Node 3 → Node 5 → Node 8 → Node 10 → Node 7 → Node 0
GRASP	Node 0 → Node 6 → Node 2 → Node 4 → Node 5 → Node 9 → Node 8 → Node 3 → Node 10 → Node 7 → Node 1 → Node 0

In Period 7, both the Exact and GRASP methods deliver products of the same age (H=0) to satisfy all demands. However, the vehicle routing differs slightly between the two methods.

Table 4.22: Depot Inventory Utilization for Period 8

Inventory Age (H)	Initial Inventory Used (Exact)	Initial Inventory Used (GRASP)
H = 0	2798	2798
H = 1	1822	1822
H = 2	2072	1522
H = 3	1938	1840
H = 4	1435	2197
H = 5	1399	2112

Table 4.23: Inventory Utilization and Delivery Results for Period 8

Node ID	Demand	Initial Inventory Used (Exact)	Initial Inventory Used (GRASP)	Delivered Quantity (Exact)	Delivered Quantity (GRASP)
1	167	-	-	167 (H=0)	167 (H=0)
2	185	-	-	185 (H=0)	185 (H=0)
3	208	-	-	208 (H=0)	208 (H=0)
4	84	-	-	84 (H=0)	84 (H=0)
5	95	-	-	95 (H=0)	95 (H=0)
6	140	-	-	140 (H=0)	140 (H=0)
7	56	-	-	56 (H=0)	56 (H=0)
8	103	-	-	103 (H=0)	103 (H=0)
9	193	-	-	193 (H=0)	193 (H=0)
10	197	-	-	197 (H=0)	197 (H=0)

Table 4.24: Vehicle Routing for Period 8

Method	Vehicle Route
Exact	Node 0 → Node 2 → Node 4 → Node 9 → Node 1 → Node 5 → Node 7 → Node 6 → Node 3 → Node 10 → Node 8 → Node 0
GRASP	Node 0 → Node 1 → Node 7 → Node 9 → Node 2 → Node 10 → Node 5 → Node 4 → Node 3 → Node 6 → Node 8 → Node 0

Similarly to Period 7, the deliveries made by the Exact and GRASP methods were identical in terms of the freshness of the product (H = 0). However, like in Period 7, the vehicle routes differed slightly between the two methods, showing minor variations in the sequence of node visits.

Table 4.25: Depot Inventory Utilization for Period 9

Inventory Age (H)	Initial Inventory Used (Exact)	Initial Inventory Used (GRASP)
H = 0	2798	2798
H = 1	1370	1370
H = 2	1822	1822
H = 3	2072	1522
H = 4	1938	1840
H = 5	1435	2197

Table 4.26: Inventory Utilization and Delivery Results for Period 9

Node ID	Demand	Initial Inventory Used (Exact)	Initial Inventory Used (GRASP)	Delivered Quantity (Exact)	Delivered Quantity (GRASP)
1	104	-	-	104 (H=0)	104 (H=0)
2	131	-	-	131 (H=0)	131 (H=0)
3	95	-	-	95 (H=0)	95 (H=0)
4	200	-	-	200 (H=1)	200 (H=0)
5	153	-	-	153 (H=0)	153 (H=0)
6	182	-	-	182 (H=0)	182 (H=0)
7	165	-	-	165 (H=1)	165 (H=0)
8	164	-	-	164 (H=0)	164 (H=0)
9	103	-	-	103 (H=0)	103 (H=0)
10	73	-	-	73 (H=0)	73 (H=0)

Table 4.27: Vehicle Routing for Period 9

Method	Vehicle Route
Exact	Node 0 → Node 4 → Node 10 → Node 2 → Node 3 → Node 6 → Node 1 → Node 9 → Node 7 → Node 8 → Node 5 → Node 0
GRASP	Node 0 → Node 10 → Node 4 → Node 7 → Node 3 → Node 8 → Node 6 → Node 9 → Node 2 → Node 1 → Node 5 → Node 0

In Period 9, the Exact method fulfills demand using both fresh products (H=0) and older products (H=1). In contrast, the GRASP method exclusively delivers fresh products (H=0), demonstrating a preference for maintaining product freshness in its deliveries.

Table 4.28: Depot Inventory Utilization for Period 10

Inventory Age (H)	Initial Inventory Used (Exact)	Initial Inventory Used (GRASP)
H = 0	2798	2798
H = 1	1.793	1.428
H = 2	1.005	1.370
H = 3	1.822	1.822
H = 4	2.072	1.522
H = 5	1.938	1.840

Table 4.29: Inventory Utilization and Delivery Results for Period 10

Node ID	Demand	Initial Inventory Used (Exact)	Initial Inventory Used (GRASP)	Delivered Quantity (Exact)	Delivered Quantity (GRASP)
1	158	-	-	158 (H=1)	158 (H=0)
2	170	-	-	170 (H=0)	170 (H=0)
3	78	-	-	78 (H=0)	78 (H=0)
4	128	-	-	128 (H=0)	128 (H=0)
5	159	-	-	159 (H=1)	159 (H=0)
6	84	-	-	84 (H=0)	84 (H=0)
7	209	-	-	209 (H=0)	209 (H=0)
8	169	-	-	169 (H=0)	169 (H=0)
9	143	-	-	143 (H=0)	143 (H=0)
10	157	-	-	157 (H=0)	157 (H=0)

Table 4.30: Vehicle Routing for Period 10

Method	Vehicle Route
Exact	Node 0 → Node 8 → Node 7 → Node 10 → Node 1 → Node 6 → Node 5 → Node 3 → Node 4 → Node 2 → Node 9 → Node 0
GRASP	Node 0 → Node 10 → Node 6 → Node 4 → Node 2 → Node 3 → Node 9 → Node 8 → Node 1 → Node 7 → Node 5 → Node 0

In Period 10, the Exact method shows a mixture of fresh (H=0) and aged (H=1) products used to meet demand, whereas the GRASP method exclusively utilizes fresh products (H=0). This difference highlights a strategic variation in inventory management between the two methods.

4.5.2 Conclusion

The results from the GRASP heuristic and the Exact solver highlight key differences in their approaches to solving the PIRP, driven by their distinct strategies for utilizing available inventory. GRASP heavily relies on the initial inventory at customer locations during the early periods, reducing reliance on depot deliveries and lowering transportation costs. In contrast, the Exact solver adopts a more balanced approach, flexibly combining depot and customer inventory to achieve an optimal allocation in each period.

After Period 5, when customer-held inventory is discarded, GRASP exclusively relies on fresh products (H=0) from the depot. This strict strategy limits its flexibility, whereas the Exact solver continues to leverage both fresh and aged products (H=1 and higher), allowing for more efficient inventory utilization. These differences in strategy most likely contribute to variations in the objective values, with GRASP's rigidity sometimes leading to suboptimal solutions, while the Exact solver's flexibility results in globally optimal solutions.

In summary, due to the inherently greedy nature of GRASP, there is a notable difference in how the two methods meet customer demand. GRASP prioritizes utilizing initial inventory and delivering fresh products, which does not result in near-optimal solutions. On the other hand, the Exact solver demonstrates greater flexibility, often delivering products of varying ages while utilizing less of the initial inventory, ultimately achieving the optimal objective value.

4.6 Sensitivity Analysis

Sensitivity analysis is an important tool to explore how variations in key parameters influence the performance of optimization algorithms. This chapter examines how changes in inventory holding costs and vehicle capacities affect the objective value of the GRASP heuristic compared to the exact algorithm.

Although the results did not reveal significant correlations or trends, this chapter presents the tested parameter adjustments, summarizes the corresponding outcomes, and provides a brief discussion of the observed effects.

4.6.1 Impact of Inventory Holding Cost Changes

Overview

This section examines the impact of changes in inventory holding costs on the objective values obtained by GRASP. The analysis considers six scenarios: the baseline with original values, two reductions of 25% (`pirp-n-S-K-H-instance-IHCD25`) and 50% (`pirp-n-S-K-H-instance-IHCD50`), and three increases of 25% (`pirp-n-S-K-H-instance-IHCI25`), 50% (`pirp-n-S-K-H-instance-IHCI50`), and 100% (`pirp-n-S-K-H-instance-IHCI100`).

The datasets analyzed include `pirp-10-2-1-3-1`, `pirp-10-3-1-6-1`, and `pirp-10-5-1-10-1`. For each dataset, the objective values achieved by GRASP under the adjusted parameters are compared to those obtained by the exact algorithm. These metrics provide insight into how modifications to inventory holding costs influence the performance of GRASP.

25% Decrease Of The Inventory Holding Cost

Table 4.31: Impact of 25% Decrease in Inventory Holding Costs (IHCD25) on GRASP Performance

Filename	EA Obj. Value	GRASP Obj. Value	% Change in Objective	Change (%)
pirp-10-2-1-3-1-IHCD25	36130.67575	33456.49573	92.6%	+13.8%
pirp-10-2-1-3-1	35519.59000	27982.59132	78.8%	
pirp-10-3-1-6-1-IHCD25	85332.60000	69217.66959	81.1%	+3.0%
pirp-10-3-1-6-1	83940.12800	65536.57114	78.1%	
pirp-10-5-1-10-1-IHCD25	139635.10000	80045.93114	57.3%	+2.4%
pirp-10-5-1-10-1	124786.18600	68480.86401	54.9%	

The analysis of the 25% decrease in inventory holding costs (IHCD25) across three datasets reveals the following:

- pirp-10-2-1-3-1: GRASP's performance improved significantly with a 13.8% increase compared to the exact algorithm under this adjustment. This suggests that reduced holding costs positively impact GRASP's ability to approximate the exact solution.
- pirp-10-3-1-6-1: A small improvement of 3.0% was observed, indicating a smaller but still positive impact from the reduction in holding costs.
- pirp-10-5-1-10-1: GRASP's performance improved by 2.4% compared to the exact algorithm.

While GRASP consistently performs better with a 25% decrease in inventory holding costs, the degree of improvement varies across datasets. The significant improvement observed in pirp-10-2-1-3-1 is not consistently replicated in the other two datasets. This variability suggests that while reduced holding costs can positively impact GRASP's relative performance, the effect is influenced by dataset complexity. Thus, there is limited evidence of a strong correlation.

50% Decrease Of The Inventory Holding Cost

Table 4.32: Impact of 50% Decrease in Inventory Holding Costs (IHCD50) on GRASP Performance

Filename	EA Obj. Value	GRASP Obj. Value	% Change in Objective	Change (%)
pirp-10-2-1-3-1-IHCD50	36673.86650	35963.87723	98.1%	+19.3%
pirp-10-2-1-3-1	35519.59000	27982.59132	78.8%	
pirp-10-3-1-6-1-IHCD50	96140.13800	75171.16660	78.2%	+0.1%
pirp-10-3-1-6-1	83940.12800	65536.57114	78.1%	
pirp-10-5-1-10-1-IHCD50	131647.00000	62460.49814	47.4%	-7.5%
pirp-10-5-1-10-1	124786.18600	68480.86401	54.9%	

The analysis of the 50% decrease in inventory holding costs (`IHCD50`) across three datasets reveals the following:

- `pirp-10-2-1-3-1`: GRASP's performance improved significantly with a 19.3% increase compared to the exact algorithm under this adjustment. This confirms that larger reductions in holding costs can have a positive impact on GRASP's relative performance for smaller datasets.
- `pirp-10-3-1-6-1`: A minimal improvement of 0.1% was observed, indicating that the reduction in holding costs had almost no impact on GRASP's ability to match the exact algorithm for this dataset.
- `pirp-10-5-1-10-1`: GRASP's performance declined by 7.5% compared to the exact algorithm, suggesting that for more complex datasets, a large reduction in holding costs may negatively impact GRASP's relative performance.

The results for the 50% decrease in inventory holding costs indicate mixed outcomes. While datasets, such as `pirp-10-2-1-3-1`, show significant improvements, more complex datasets do not follow this trend. This variability suggests that the impact of reduced holding costs on GRASP's performance is highly dataset-specific, and there is no consistent correlation across all datasets.

25% Increase Of The Inventory Holding Cost

Table 4.33: Impact of 25% Increase in Inventory Holding Costs (IHCI25) on GRASP Performance

Filename	EA Obj. Value	GRASP Obj. Value	% Change in Objective	Change (%)
pirp-10-2-1-3-1-IHCI25	35111.98325	34678.58123	98.8%	+20.0%
pirp-10-2-1-3-1	35519.59000	27982.59132	78.8%	
pirp-10-3-1-6-1-IHCI25	78698.26500	57939.53944	73.6%	-4.5%
pirp-10-3-1-6-1	83940.12800	65536.57114	78.1%	
pirp-10-5-1-10-1-IHCI25	107045.17600	54786.18858	51.2%	-3.7%
pirp-10-5-1-10-1	124786.18600	68480.86401	54.9%	

The analysis of the 25% increase in inventory holding costs (`IHCI25`) across three datasets reveals the following:

- `pirp-10-2-1-3-1`: GRASP's performance improved significantly with a 20.0% increase compared to the exact algorithm.
- `pirp-10-3-1-6-1`: A 4.5% decline in performance was observed, suggesting that increased holding costs can negatively impact GRASP's performance.
- `pirp-10-5-1-10-1`: GRASP's performance declined by 3.7% compared to the exact algorithm, indicating that for larger datasets, increased holding costs do not favor GRASP's relative performance.

The results for the 25% increase in inventory holding costs reveal a mixed effect on GRASP's performance. While datasets such as `pirp-10-2-1-3-1` benefit significantly, more complex datasets show a decline in relative performance. These findings suggest that the impact of higher holding costs is influenced by dataset complexity.

50% Increase Of The Inventory Holding Cost

Table 4.34: Impact of 50% Increase in Inventory Holding Costs (IHCI50) on GRASP Performance

Filename	EA Obj. Value	GRASP Obj. Value	% Change in Objective	Change (%)
pirp-10-2-1-3-1-IHCI50	35069.03250	29714.99591	84.7%	+5.9%
pirp-10-2-1-3-1	35519.59000	27982.59132	78.8%	
pirp-10-3-1-6-1-IHCI50	73340.16000	50834.53299	69.3%	-8.8%
pirp-10-3-1-6-1	83940.12800	65536.57114	78.1%	
pirp-10-5-1-10-1-IHCI50	121907.88300	71292.50131	58.5%	+3.6%
pirp-10-5-1-10-1	124786.18600	68480.86401	54.9%	

The analysis of the 50% increase in inventory holding costs (`IHCI50`) across three datasets reveals the following:

- `pirp-10-2-1-3-1`: GRASP's performance improved by 5.9% compared to the exact algorithm.
- `pirp-10-3-1-6-1`: A significant decline of 8.8% was observed, showing that higher holding costs negatively affect GRASP's performance for this specific dataset.
- `pirp-10-5-1-10-1`: GRASP's performance improved by 3.6% compared to the exact algorithm. This improvement, while small, indicates a slight benefit for GRASP in larger datasets under increased holding costs.

The results indicate mixed outcomes for GRASP under a 50% increase in inventory holding costs. While datasets with lower complexity show relative performance improvements, datasets with moderate complexity exhibit a decline. Larger complexities see a small improvement, suggesting that increased holding costs influence GRASP's performance variably depending on the problem's complexity.

100% Increase Of The Inventory Holding Cost

Table 4.35: Impact of 100% Increase in Inventory Holding Costs (IHCI100) on GRASP Performance

Filename	EA Obj. Value	GRASP Obj. Value	% Change in Objective	Change (%)
pirp-10-2-1-3-1-IHCI100	34459.97600	30551.26984	88.7%	+10.0%
pirp-10-2-1-3-1	35519.59000	27982.59132	78.8%	
pirp-10-3-1-6-1-IHCI100	79557.37800	58069.26372	73.0%	-5.1%
pirp-10-3-1-6-1	83940.12800	65536.57114	78.1%	
pirp-10-5-1-10-1-IHCI100	119159.32600	53989.86682	45.3%	-9.6%
pirp-10-5-1-10-1	124786.18600	68480.86401	54.9%	

The analysis of a 100% increase in inventory holding costs (`IHCI100`) reveals the following insights:

- `pirp-10-2-1-3-1`: GRASP's performance improves significantly, with a 10.0% increase compared to the exact algorithm. This indicates that increased holding costs can favor GRASP in simpler datasets.
- `pirp-10-3-1-6-1`: A decline of 5.1% is observed, suggesting that as complexity grows, higher holding costs negatively affect GRASP's performance.
- `pirp-10-5-1-10-1`: GRASP's performance drops by 9.6%, highlighting that increased holding costs amplify the challenges in solving more complex datasets.

The results suggest that while GRASP performs better under increased holding costs for less complex datasets, its relative performance declines as the complexity increases. This trend indicates that higher holding costs might not benefit GRASP's adaptability across different dataset configurations.

4.6.2 Impact of Vehicle Capacity Changes

Overview

This section examines the impact of changes in vehicle capacity on the objective values obtained by GRASP. The analysis considers three scenarios: the baseline with original vehicle capacity values, a 20% reduction (`pirp-n-S-K-H-instance-VCD20`), and a 40% reduction (`pirp-n-S-K-H-instance-VCD40`).

The datasets analyzed include `pirp-10-2-1-3-1`, `pirp-10-3-1-6-1`, and `pirp-10-5-1-10-1`. For each dataset, the objective values achieved by GRASP under the adjusted parameters are compared to those obtained by the exact algorithm. These metrics provide insight into how changes in vehicle capacity influence the performance of GRASP.

20% Decrease in Vehicle Capacity

Table 4.36: Impact of 20% Decrease in Vehicle Capacity (VCD20) on GRASP Performance

Filename	EA Obj. Value	GRASP Obj. Value	% Change in Objective	Change (%)
pirp-10-2-1-3-1-VCD20	35842.45900	35411.02129	98.8%	+20.0%
pirp-10-2-1-3-1	35519.59000	27982.59132	78.8%	
pirp-10-3-1-6-1-VCD20	80498.77500	62748.74526	77.9%	-0.2%
pirp-10-3-1-6-1	83940.12800	65536.57114	78.1%	
pirp-10-5-1-10-1-VCD20	124319.87100	63220.39563	50.9%	-4.0%
pirp-10-5-1-10-1	124786.18600	68480.86401	54.9%	

The analysis of the 20% decrease in vehicle capacity (`VCD20`) across the three datasets reveals the following:

- `pirp-10-2-1-3-1`: GRASP's performance improved significantly with a 20.0% increase compared to the exact algorithm. This suggests that a moderate reduction in vehicle capacity benefits GRASP in simpler datasets.
- `pirp-10-3-1-6-1`: A slight decrease of 0.2% was observed, indicating that this adjustment had minimal impact on GRASP's performance in moderately complex datasets.
- `pirp-10-5-1-10-1`: GRASP's performance decreased by 4.0% compared to the exact algorithm. The reduced vehicle capacity appears to introduce challenges in handling more complex datasets.

While GRASP demonstrates notable improvements in simpler datasets under the 20% decrease in vehicle capacity, its performance declines in more complex datasets. These findings suggest that the impact of reduced vehicle capacity is influenced by the dataset complexity.

40% Decrease in Vehicle Capacity

Table 4.37: Impact of 40% Decrease in Vehicle Capacity (VCD40) on GRASP Performance

Filename	EA Obj. Value	GRASP Obj. Value	% Change in Objective	Change (%)
pirp-10-2-1-3-1-VCD40	31600.16700	26656.71494	84.4%	+5.6%
pirp-10-2-1-3-1	35519.59000	27982.59132	78.8%	
pirp-10-3-1-6-1-VCD40	61067.43600	48856.91255	80.0%	+1.9%
pirp-10-3-1-6-1	83940.12800	65536.57114	78.1%	
pirp-10-5-1-10-1-VCD40	93396.80500	70659.42105	75.7%	+20.8%
pirp-10-5-1-10-1	124786.18600	68480.86401	54.9%	

The analysis of the 40% decrease in vehicle capacity (`VCD40`) across the three datasets reveals the following:

- `pirp-10-2-1-3-1`: GRASP's performance improved by 5.6% compared to the exact algorithm. This indicates that reduced vehicle capacity slightly benefits GRASP in simpler datasets.
- `pirp-10-3-1-6-1`: A improvement of 1.9% was observed in this dataset of moderate complexity.
- `pirp-10-5-1-10-1`: GRASP's performance showed a significant improvement of 20.8%, demonstrating its ability to handle more complex datasets.

The results suggest that GRASP performs better when vehicle capacity is reduced by 40%.

4.6.3 Conclusion

The sensitivity analysis highlights the impact of changes in inventory holding costs and vehicle capacity on the performance of GRASP relative to the exact algorithm. While some parameter adjustments, such as a 25% decrease in holding costs or a 40% decrease in vehicle capacity, resulted in noticeable improvements in GRASP's relative performance, the effects were inconsistent across datasets. This variability suggests that the relationship between parameter changes and GRASP's performance depends heavily on the complexity and configuration of the datasets. From this analysis, no clear correlation was found between the parameter changes and the performance of GRASP.

Chapter 5

Conclusion

5.1 Introduction

This chapter summarizes the findings from the comparative analysis of the GRASP and the exact solver for the PIRP. The focus lies on evaluating their performance, scalability, and overall efficiency in addressing the challenges associated with supply chain management of perishable goods.

The PIRP presents unique complexities due to the dual requirements of maintaining inventory freshness and optimizing routing efficiency. This research aimed to evaluate GRASP's potential as a scalable alternative to the exact solver, which, while delivering optimal solutions, struggles with computational limitations for larger datasets. By examining GRASP's performance in relation to objective value and runtime efficiency, this study provides insights into its strengths and limitations as a practical solution for real-world supply chain challenges.

This chapter is structured as follows: an overview of the thesis is provided, followed by answers to the main research question. The discussion then extends to the research limitations, future recommendations, and managerial insights.

5.2 An Overview of the Structure of the Thesis

This thesis is structured to address the research question, starting from the foundational aspects of the problem to the comparative analysis and insights derived from the results. Each chapter plays a distinct role in building a comprehensive understanding of the PIRP and the effectiveness of the proposed solutions.

The **Introduction** sets the stage by outlining the research objectives, significance of the PIRP, and the motivation behind exploring GRASP as an alternative to the exact solver. This is followed by the **Literature Review**, which examines existing studies on inventory routing problems, perishable goods logistics, and metaheuristic optimization techniques, thereby situating this research within the broader academic context.

The **Methodology** chapter details the implementation of GRASP and the exact solver for the PIRP, including the problem formulation, algorithmic design, and dataset generation. It highlights the methodological approach applied to ensure a fair and meaningful comparison between the two approaches.

The **Data Analysis and Results Discussion** chapter presents a detailed comparison of GRASP and the exact solver across various metrics, including objective value, runtime efficiency, and scalability. Through this analysis, the chapter emphasizes GRASP's strengths and limitations as a practical tool for large-scale supply chain problems.

Finally, the **Conclusion** synthesizes the findings, providing answers to the main research question and offering managerial insights, limitations, and recommendations for future research.

5.3 Answers to the Main Question of the Thesis

This research demonstrates that the GRASP metaheuristic can effectively address the multi-period inventory routing problem under uncertainty in perishable goods supply chains. Through its randomized adaptive search and greedy construction, GRASP identifies high-quality, feasible solutions efficiently.

Compared to the exact solver, GRASP offers a practical trade-off: it achieves near-optimal solutions for smaller datasets and delivers scalable performance for larger, more complex instances, where the exact solver often becomes computationally infeasible. While it prioritizes efficiency over guaranteed optimality, GRASP proves to be a valuable approach for solving PIRPs in dynamic and time-sensitive supply chain scenarios.

5.4 Conclusion

This thesis has explored the application of the GRASP metaheuristic in solving the multi-period inventory routing problem under uncertainty, specifically for perishable goods supply chains. By comparing GRASP's performance with that of an exact solver, this research has addressed critical aspects of solution quality, runtime efficiency, scalability, and practical applicability.

Performance on Objective Value

The results show that GRASP performs impressively when compared to the exact solver, especially for smaller datasets with fewer periods. For instances with 3 periods, GRASP achieves up to 90% of the exact solver's optimal objective value. As dataset complexity increases, particularly with 6 and 10 periods, GRASP's performance starts to diverge slightly, maintaining between 50% and 90% of the exact solver's optimal value for these more complex datasets.

While GRASP may not always match the exact solver's optimality in the most complex scenarios, it consistently delivers high-quality, feasible solutions that are close to optimal. This makes GRASP a valuable alternative, particularly when solving large-scale or time-sensitive problems where exact methods may not be computationally feasible.

Runtime Efficiency

A key strength of GRASP is its runtime efficiency. The exact solver's runtime grows exponentially with dataset complexity, making it impractical for larger problem instances. In contrast, GRASP demonstrates remarkable scalability, maintaining reasonable runtimes even as the dataset size increases. In some cases, GRASP was found to be up to 1000 times faster than the exact solver, particularly when the exact solver could only complete one iteration.

This efficiency makes GRASP highly suitable for real-world applications where computational time is a critical factor, particularly in dynamic and time-sensitive supply chain environments.

Scalability of GRASP

GRASP's scalability becomes increasingly apparent as the problem size grows. While the exact solver struggled to handle larger datasets due to the computational limitations, GRASP consistently provides feasible solutions across all dataset sizes, including those with a higher number of periods and customers. Even with larger datasets, GRASP's performance remains strong, confirming its practicality and adaptability in the context of perishable goods supply chains.

The estimation methods applied to larger datasets further reinforced this finding, showing that GRASP continues to offer viable solutions even in cases where the exact solver becomes computationally infeasible.

Key Takeaways on GRASP

In conclusion, the GRASP heuristic has proven to be a highly effective approach for solving the PIRP, particularly when compared to the exact solver. Its ability to consistently deliver near-optimal solutions in a fraction of the time required by the exact solver, combined with its scalability, makes GRASP an attractive option for real-world applications. The findings of this research highlight GRASP's potential in addressing large-scale and complex supply chain problems, offering a practical and efficient solution for industries dealing with perishable goods.

5.5 Research Limitations and Future Recommendations

This study encountered two main limitations, which also present opportunities for future research.

First, computational resources constrained the ability to test larger datasets. With access to advanced computational infrastructure, such as supercomputers or cloud-based platforms, future studies could evaluate GRASP's performance on more extensive and complex datasets. This would provide deeper insights into its scalability and reinforce confidence in its application for real-world supply chain problems.

Second, the absence of real-world data restricted the ability to validate GRASP's effectiveness in practical scenarios. While the generated datasets were methodologically sound, future research could benefit from collaborating with industries to obtain real-world data from perishable goods supply chains. This would allow for a more accurate assessment of GRASP's real-life applicability and performance.

In conclusion, addressing these limitations offers valuable directions for future research. By leveraging advanced computational resources and real-world data, researchers can enhance the evaluation of GRASP, ensuring its readiness for practical implementation in dynamic supply chain environments.

5.6 Managerial Insights

The findings of this thesis offer several actionable insights for managers and practitioners in industries dealing with perishable goods supply chains. The application of GRASP highlights its practicality in addressing multi-period inventory routing problems under uncertainty, making it a valuable tool for optimizing supply chain operations.

One of GRASP's primary strengths is its ability to provide high-quality solutions within short timeframes. This makes it particularly effective for large-scale problems and time-sensitive decision-making scenarios, where traditional exact solvers may not be computationally feasible. Managers can leverage GRASP to improve operational efficiency, particularly in situations where rapid response and adaptability are crucial.

Additionally, GRASP's scalability ensures its suitability for dynamic and complex supply chains with multiple periods, customers, and constraints. Practitioners can adopt GRASP as part of their decision-making toolkit to tackle real-world challenges, balancing operational costs with service level requirements.

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Appendix

Dataset Explanation and Example

This appendix provides the datasets used for testing, displayed in their raw format for easy reference and reproducibility. Below is an explanation of the dataset structure, followed by the raw data.

Dataset Breakdown

Each dataset contains three main sections:

1. **First Line: General Information**
   - `10`: Number of customers (n)
   - `2`: Maximum age of the products (s)
   - `1`: Number of vehicles (K)
   - `3`: Number of periods (H)
   - `1535`: Capacity of the vehicle (Q_k)
2. **Second Line: Depot Information**
   - `793`: X-coordinate of the depot
   - `335`: Y-coordinate of the depot
   - `2457`: Initial inventory at the depot
   - `2457 2457 2457`: Replenishments for periods 1 to H
   - `0.92 0.28 0.34`: Holding costs for products of ages 0 to s

3. **Customer Information:** Each subsequent line provides data for a customer in the following format:

   - `X Y U Inv d1 d2 d3 rev0 rev1 rev2 h0 h1 h2`

   Where:

   - `X, Y`: Coordinates of the customer
   - `U`: Capacity of the customer (C_i)
   - `Inv`: Initial inventory of the customer (I_i^0)
   - `d1, d2, d3`: Demand in periods 1, 2, and 3
   - `rev0, rev1, rev2`: Revenue for products of ages 0, 1, and 2
   - `h0, h1, h2`: Holding costs for products of ages 0, 1, and 2

Raw Dataset: `pirp-10-2-1-3-1.dat`

```
10 2 1 3 1535
793 335 2457 2457 2457 2457 0.92 0.28 0.34
567 429 332 250 82 166 101 12 12 4 0.3 0.63 0.92
229 373 206 103 103 46 61 14 10 6 0.19 0.48 0.28
996 281 366 220 146 183 152 14 10 4 0.25 0.38 0.59
434 364 576 384 192 75 104 17 11 5 0.5 0.91 0.93
739 12 324 162 162 90 146 14 10 6 0.86 0.82 0.39
301 280 414 207 207 102 82 15 7 6 0.41 0.36 0.37
567 856 555 504 51 185 39 16 13 6 0.53 1.01 0.89
708 715 298 265 33 149 120 16 10 5 0.49 0.54 0.62
193 500 196 122 74 98 31 14 9 5 0.64 0.64 0.76
275 407 284 142 142 41 47 18 10 4 0.21 0.61 0.53
```

Raw Dataset: `pirp-10-2-1-3-2.dat`

```
10 2 1 3  1460
857 947 2337 2337 2337 2337 0.17 0.08 0.29
413 259 318 245 73 122 159 10 8 5 0.27 0.66 1.02
256 576 408 272 136 102 49 17 9 6 0.11 0.98 0.27
887 183 152 111 41 65 76 18 12 4 0.99 0.42 1.02
356 495 410 287 123 43 205 18 8 4 0.87 1 0.73
37 637 378 298 80 40 189 13 12 5 0.75 1.01 0.81
865 867 210 150 60 60 105 11 11 6 0.27 0.5 0.62
733 377 549 401 148 139 183 16 11 6 0.21 0.54 0.53
214 664 360 321 39 86 180 11 9 5 0.64 0.88 0.98
195 776 375 270 105 35 125 16 13 4 0.42 0.7 0.74
```

936 748 555 370 185 83 185 11 7 6 0.5 0.09 0.92

Raw Dataset: `pirp-10-2-1-3-3.dat`

```
10 2 1 3  1345
691 473 2152 2152 2152 2152 0.84 0.91 0.27
710 51 328 295 33 78 164 10 9 6 0.15 0.78 0.39
862 407 384 192 192 106 102 17 11 4 0.89 0.7 0.57
858 169 404 280 124 202 79 16 9 6 0.99 0.97 1.13
267 348 152 97 55 36 76 15 11 5 0.55 0.35 1.21
817 916 534 479 55 130 178 11 10 6 0.42 0.65 0.78
562 122 306 204 102 40 41 16 11 6 0.49 0.15 0.63
616 291 202 140 62 48 101 18 10 6 0.62 1.22 0.96
64 532 525 446 79 175 85 17 10 5 0.8 0.42 0.68
774 159 164 104 60 77 82 19 12 4 0.98 0.45 0.84
482 437 416 208 208 66 191 19 11 5 0.77 1.05 0.58
```

Raw Dataset: `pirp-10-2-1-3-4.dat`

```
10 2 1 3  1550
781 970 2480 2480 2480 2480 0.35 0.3 0.61
25 407 380 236 144 190 65 12 12 5 0.62 0.29 0.51
432 738 312 156 156 81 119 14 9 5 0.05 0.4 1.11
66 111 510 351 159 170 152 14 12 6 0.84 0.4 1.04
788 629 546 389 157 112 182 10 9 5 0.22 0.24 1.06
326 917 510 340 170 111 166 19 12 6 0.66 0.55 0.42
442 608 268 234 34 38 134 13 9 4 0.64 0.18 1.01
610 934 480 320 160 38 77 10 8 4 0.2 0.98 1.43
134 881 316 241 75 32 158 17 11 4 0.59 0.44 0.79
136 126 308 158 150 154 141 17 11 6 0.89 0.89 0.57
670 44 330 272 58 110 42 11 9 4 0.49 0.22 0.95
```

Raw Dataset: `pirp-10-2-1-3-5.dat`

```
10 2 1 3  1577
20 497 2524 2524 2524 2524 0.16 0.46 0.44
824 577 591 394 197 103 164 15 13 4 0.71 1.01 1
749 314 498 332 166 36 31 12 8 4 0.02 0.77 0.82
643 783 543 497 46 49 181 16 12 5 0.32 0.54 0.05
590 166 363 258 105 121 31 10 12 6 0.74 0.37 0.75
931 378 438 381 57 146 73 10 12 6 0.79 1.16 1.17
378 547 516 416 100 40 172 17 11 4 0.59 0.94 0.71
52 937 507 368 139 169 95 17 12 6 0.44 1.08 0.78
234 641 588 459 129 187 196 13 11 5 0.42 0.92 1.06
401 167 402 270 132 94 201 16 9 4 0.71 0.45 0.74
41 189 582 549 33 57 194 14 12 6 0.01 0.43 0.73
```

Raw Dataset: `pirp-10-3-1-6-1.dat`

```
10 3 1 6  1614
538 606 2583 2583 2583 2583 2583 2583 2583 0.04 0.78 0.28 1.22
669 82 360 265 95 94 180 95 149 104 17 14 9 5 0.64 0.21 0.42 0.95
305 320 360 259 101 40 135 91 151 180 16 12 9 6 0.44 0.2 0.62 0.33
881 930 567 478 89 189 40 158 101 63 10 15 7 6 0.94 1 1.12 1.25
107 445 388 194 194 90 100 194 66 72 18 10 6 5 0.79 0.64 0.48 0.48
939 811 418 376 42 151 145 209 169 111 15 11 8 6 0.67 0.78 0.5 1
299 640 400 318 82 102 182 200 115 75 13 9 8 6 0.98 0.39 0.26 1.35
579 884 360 241 119 63 146 180 85 130 11 10 8 5 0.05 0.3 0.76 0.37
498 36 398 266 132 78 198 199 142 198 18 14 10 4 0.53 0.54 0.83 0.36
253 892 579 532 47 59 40 193 43 153 12 13 8 5 0.25 1.05 0.7 0.41
43 39 492 412 80 98 46 92 164 147 13 14 8 4 0.28 0.77 0.55 0.39
```

Raw Dataset: `pirp-10-3-1-6-2.dat`

```
10 3 1 6  1747
385 757 2796 2796 2796 2796 2796 2796 2796 0.76 0.58 0.63 1.4
195 133 567 378 189 77 49 147 127 139 13 13 9 5 0.31 0.72 1.18 0.74
634 546 585 431 154 173 148 195 184 125 16 11 8 6 0.31 0.95 1.11 1.18
498 455 621 455 166 85 157 30 125 207 12 13 6 5 0.45 1.03 1 0.75
151 773 618 574 44 137 67 141 206 144 10 11 7 5 0.39 0.31 0.95 0.98
394 305 418 321 97 87 209 70 124 78 11 14 8 5 0.3 0.87 0.22 1.37
566 781 537 445 92 161 143 179 139 52 10 12 7 5 0.13 0.4 0.62 0.49
648 477 597 398 199 105 141 67 115 173 11 9 10 5 0.57 0.41 0.42 1.24
179 135 540 387 153 43 145 180 161 42 19 10 10 5 0.56 0.7 0.74 1.14
84 666 591 523 68 84 197 177 69 169 18 11 11 6 0.56 0.42 0.69 0.28
454 748 417 317 100 119 128 50 30 139 17 10 7 5 0.14 0.62 0.77 1.06
```

Raw Dataset: `pirp-10-3-1-6-3.dat`

```
10 3 1 6  1516
500 900 2426 2426 2426 2426 2426 2426 2426 0.26 0.67 0.05 0.56
218 940 612 487 125 204 89 73 192 41 19 12 9 4 0.51 1.04 0.74 0.56
431 254 570 511 59 166 190 78 75 44 15 9 10 6 0.33 1.08 0.44 0.96
893 926 322 169 153 123 116 161 46 144 10 11 8 5 0.7 0.36 0.08 0.93
696 218 606 569 37 187 148 185 33 202 14 12 7 6 0.52 0.73 0.53 0.09
713 642 414 384 30 124 115 138 93 82 14 14 10 5 0.76 0.91 1.29 0.75
635 761 352 176 176 86 89 34 139 94 13 12 9 4 0.78 0.18 0.68 1.06
433 989 621 477 144 140 86 49 207 40 15 10 9 6 0.34 0.31 0.73 0.72
261 469 304 152 152 121 133 80 100 110 19 10 8 4 0.98 0.67 0.86 0.88
523 20 564 458 106 188 186 93 41 47 13 12 11 6 0.73 0.25 0.07 0.7
630 378 384 284 100 104 155 82 122 192 16 12 9 5 0.82 0.76 0.65 0.16
```

Raw Dataset: `pirp-10-3-1-6-4.dat`

```
10 3 1 6  1565
418 419 2504 2504 2504 2504 2504 2504 2504 0.25 0.34 0.41 0.54
120 123 567 485 82 126 73 189 41 82 19 13 9 4 0.04 0.25 0.45 1.09
801 863 525 465 60 175 136 169 155 38 15 9 9 6 0.25 0.93 1.02 0.27
138 83 615 535 80 59 65 205 91 107 13 13 8 6 0.95 0.44 1.41 1.03
93 903 606 506 100 177 92 57 202 158 10 13 10 5 0.86 0.28 0.39 0.93
54 853 258 162 96 118 70 129 85 129 11 12 9 4 0.66 0.92 0.66 0.47
931 731 366 183 183 57 152 118 161 69 10 13 9 6 0.26 0.39 0.2 0.19
537 679 336 220 116 51 50 121 168 126 10 14 7 5 0.88 0.31 0.63 0.52
335 911 378 211 167 61 162 152 144 189 17 13 8 4 0.05 1.17 0.29 0.19
871 503 447 314 133 33 108 47 110 149 12 9 7 4 0.98 0.86 0.62 0.19
674 245 540 452 88 53 162 180 149 96 16 10 8 5 0.55 0.83 0.72 0.61
```

Raw Dataset: `pirp-10-3-1-6-5.dat`

```
10 3 1 6  1625
271 48 2601 2601 2601 2601 2601 2601 2601 0.33 0.93 0.7 1.19
905 766 396 336 60 198 46 130 171 195 12 10 7 4 0.13 0.45 1.26 0.77
229 18 567 380 187 56 139 189 131 180 14 12 10 5 0.02 0.85 0.17 0.55
978 782 573 542 31 160 191 30 50 171 14 14 8 4 0.51 0.28 0.43 0.8
290 567 570 507 63 46 70 106 190 95 10 10 7 6 0.82 0.19 0.47 0.4
240 99 507 415 92 85 63 49 42 169 17 8 9 5 0.6 1 0.42 1.03
183 96 588 421 167 194 181 196 37 193 17 9 7 4 0.67 0.36 0.63 1
774 388 603 402 201 148 144 134 188 127 14 12 8 6 0.02 0.28 0.81 0.48
781 963 290 208 82 145 62 55 113 99 13 11 9 5 0.11 0.35 0.71 0.72
71 288 477 410 67 159 55 116 94 34 17 11 8 6 0.74 1.01 0.92 1.21
78 241 374 273 101 157 85 154 187 105 17 12 9 6 0.42 0.56 0.71 0.49
```

Raw Dataset: `pirp-10-5-1-10-1.dat`

```
10 5 1 10  1748
949 289 2798 2798 2798 2798 2798 2798 2798 2798 2798 2798 2798 0.88 0.75 0.74 0.81 0.57 0.09
358 312 588 442 146 177 107 144 180 196 94 167 104 158 16 11 9 8 9 6 0 0.38 0.52 0.66 0.75 0.19
987 888 597 517 80 102 189 80 199 39 164 185 131 170 10 14 11 9 8 4 0.66 0.25 0.83 0.68 0.84 1.4
233 157 416 329 87 124 201 99 30 49 188 208 95 78 18 17 11 8 7 5 0.93 0.26 0.24 0.51 1.24 0.25
81 516 603 502 101 37 181 201 31 47 110 84 200 128 11 16 8 10 7 5 0.02 0.37 0.33 1.25 0.24 1.06
711 805 394 205 189 141 197 160 86 190 48 95 153 159 15 16 10 7 6 6 0.91 1.06 0.37 0.33 0.77 0.95
346 235 627 564 63 209 47 192 65 158 69 140 182 84 13 13 12 8 6 4 0.91 0.49 0.31 0.57 0.36 0.87
120 967 627 573 54 61 95 160 198 173 135 56 165 209 17 10 13 10 7 4 0.63 0.65 0.86 0.56 0.86 0.48
47 924 416 354 62 208 40 113 137 180 60 103 164 169 12 16 14 8 6 6 0.35 0.45 0.84 1.29 0.42 0.55
959 728 579 444 135 57 181 146 39 88 71 193 103 143 10 16 11 12 7 6 0.97 0.43 1.08 0.89 0.64 0.07
532 122 591 408 183 71 124 168 119 156 37 197 73 157 10 9 11 8 9 5 0.75 0.84 0.65 0.18 1.06 0.3
```

Raw Dataset: `pirp-10-5-1-10-2.dat`

```
10 5 1 10  1686
831 593 2698 2698 2698 2698 2698 2698 2698 2698 2698 2698 2698 0.8 1.14 0.59 0.54 0.88 0.79
753 704 549 468 81 174 120 55 80 51 141 40 183 73 11 14 14 7 6 4 0.38 0.68 0.4 0.95 1.32 0.78
225 191 549 426 123 155 97 166 144 130 183 78 148 96 15 12 9 8 7 6 0.91 0.11 0.9 0.73 1.37 1.11
624 937 621 542 79 193 115 145 43 172 197 207 183 144 10 17 9 11 7 6 0.97 0.98 0.41 1.07 0.42 1.11
46 126 402 344 58 62 199 172 151 35 201 165 33 191 12 9 11 10 8 5 0.15 1.12 0.48 0.61 0.86 0.98
470 182 362 184 178 181 110 160 57 116 178 154 91 93 19 10 10 10 7 6 0.09 0.69 0.84 0.57 0.55 0.75
387 184 588 455 133 185 62 196 190 72 178 54 81 79 17 16 9 11 7 5 0.38 0.89 0.7 0.99 0.35 0.59
905 409 612 408 204 90 117 73 75 164 90 42 162 37 14 15 14 9 7 6 0.84 0.94 0.95 0.38 0.24 1.32
932 554 408 352 56 30 204 115 106 150 84 200 106 101 17 9 13 10 8 4 0.24 0.8 1.17 1.15 0.75 0.93
645 958 414 369 45 57 134 116 67 106 130 105 150 207 13 10 12 8 8 5 0.94 1.13 1.39 0.49 0.99 1.07
669 382 344 222 122 103 152 172 130 109 142 137 84 75 10 17 10 10 6 6 0.56 0.55 0.64 1.02 1.02 0.63
```

Raw Dataset: `pirp-10-5-1-10-3.dat`

```
10 5 1 10  1642
166 928 2628 2628 2628 2628 2628 2628 2628 2628 2628 2628 2628 0.44 0.26 0.52 0.29 0.75 0.5
93 61 621 555 66 136 156 46 159 122 207 73 98 199 11 11 11 11 8 4 0.66 0.41 0.42 0.58 1.28 0.77
194 868 376 346 30 188 141 71 99 34 172 116 132 126 13 11 11 8 7 4 0.41 0.87 0.2 0.9 1.03 0.9
770 492 382 191 191 156 46 107 30 80 95 177 33 71 11 16 9 9 6 5 0.88 1.21 0.84 1.37 0.97 1.02
765 947 402 259 143 129 171 184 141 153 88 115 201 50 19 14 13 9 8 6 0.46 0.9 0.39 0.4 0.03 1.12
577 512 606 522 84 50 140 156 202 178 176 113 36 155 15 10 13 8 8 4 0.21 0.56 0.69 0.57 0.73 0.82
599 591 410 312 98 55 168 95 196 205 139 134 59 155 14 12 8 11 6 4 0.5 0.84 0.51 0.7 0.97 1.53
899 165 406 331 75 128 65 200 60 77 203 63 47 110 14 12 12 8 7 5 0.84 0.47 0.32 0.75 1.05 0.62
716 295 543 497 46 61 43 178 181 74 103 106 139 168 18 10 13 11 8 6 0.11 0.62 0.59 0.5 0.54 0.84
242 277 376 198 178 95 93 188 128 49 43 76 72 153 17 12 13 9 8 6 0.54 0.66 0.34 1.17 1 0.29
735 726 618 421 197 45 120 140 167 183 89 80 89 206 14 17 11 9 8 5 0.88 1.18 0.52 0.4 0.58 1.21
```

Raw Dataset: `pirp-10-5-1-10-4.dat`

```
10 5 1 10  1825
123 51 2920 2920 2920 2920 2920 2920 2920 2920 2920 2920 2920 0.68 0.74 0.51 1 0.95 0.87
524 859 612 558 54 180 34 40 175 97 204 165 178 150 11 17 13 10 7 4 0.6 0.67 0.86 0.62 1.03 1.02
124 15 552 391 161 119 107 153 63 111 184 181 104 138 11 16 12 7 7 6 0.96 1.09 0.98 0.78 0.09 0.93
993 749 348 174 174 108 44 102 42 48 69 147 157 80 17 12 13 10 6 4 0.52 0.95 0.85 1.02 1.2 0.85
340 40 410 233 177 178 160 99 162 205 101 184 169 160 12 13 10 10 6 5 0.99 0.98 0.1 1.14 1.01 0.52
599 987 624 418 206 199 126 208 103 38 208 101 138 163 12 12 11 9 8 5 0.03 0.79 0.16 0.48 0.92 1.14
456 808 522 417 105 133 155 110 160 174 137 171 169 142 10 12 12 8 7 4 0.36 1.04 1.13 0.97 0.56 0.81
966 691 555 521 34 104 139 146 183 87 106 185 164 178 18 9 9 8 9 6 0.56 1 0.6 0.86 0.4 0.78
283 90 408 225 183 136 194 204 53 192 135 196 108 166 16 12 9 10 8 4 0.82 1.14 0.99 1.11 0.42 0.54
706 449 386 236 150 41 56 106 117 171 76 154 193 104 15 17 12 11 9 6 0.13 0.79 0.74 1.14 0.75 1.36
856 587 624 531 93 37 186 39 79 104 208 175 110 185 11 16 9 8 8 6 0.62 0.7 0.79 0.99 1.18 1.41
```

Raw Dataset: `pirp-10-5-1-10-5.dat`

```
10 5 1 10  1523
116 600 2438 2438 2438 2438 2438 2438 2438 2438 2438 2438 2438 0.09 1.03 0.99 0.95 0.61 1.05
403 880 348 306 42 104 66 48 174 94 89 94 95 174 13 17 13 10 6 6 0.78 0.17 1.33 0.93 0.35 0.99
922 326 543 483 60 45 172 76 124 87 77 181 45 50 11 17 12 9 7 4 0.59 1.05 0.75 0.99 0.85 0.94
814 439 358 310 48 173 129 120 152 163 179 110 174 40 17 11 9 10 6 6 0.71 0.53 0.65 1.08 0.51 0.92
26 180 376 205 171 49 43 182 91 137 41 35 188 130 16 14 12 10 6 6 0.16 0.8 0.71 0.64 0.96 1.09
559 505 394 244 150 119 197 70 37 43 182 48 152 138 10 12 9 9 6 4 0.26 0.54 0.58 0.3 0.53 1.21
505 456 552 374 178 78 59 106 95 150 184 97 148 166 15 15 11 10 9 4 0.16 0.15 0.76 0.94 0.57 1.01
894 894 564 523 41 58 131 49 49 188 145 96 145 41 13 15 12 11 7 4 0.79 0.26 1.2 0.33 0.91 1.02
518 643 364 303 61 118 88 124 51 62 79 115 54 182 14 12 14 11 8 5 0.09 0.61 0.71 1.06 0.32 0.98
536 774 624 537 87 46 208 111 186 146 115 94 47 151 18 16 12 9 7 4 0.05 0.54 0.63 0.74 0.45 0.98
719 830 410 350 60 190 116 181 101 205 47 197 42 155 13 9 8 10 6 6 0.95 0.15 0.29 0.44 0.35 0.11
```

Raw Dataset: `pirp-12-2-1-3-1.dat`

```
12 2 1 3 1708
6 265 3000 3000 3000 3000 0.49 0.94 0.88
88 561 232 116 116 105 38 11 11 6 0.11 0.09 0.08
35 582 483 389 94 148 161 10 10 7 0.1 0.09 0.08
761 764 296 148 148 73 94 11 11 5 0.11 0.08 0.07
474 738 522 406 116 77 174 20 20 6 0.2 0.13 0.11
237 746 591 453 138 197 124 12 12 4 0.12 0.08 0.07
246 266 304 245 59 115 152 14 14 6 0.14 0.1 0.09
132 145 486 393 93 67 162 14 14 6 0.14 0.1 0.09
71 983 242 121 121 43 74 10 10 5 0.1 0.07 0.07
703 850 396 198 198 115 150 10 10 6 0.1 0.08 0.07
34 411 324 216 108 84 73 15 15 4 0.15 0.1 0.08
441 375 152 79 73 63 76 11 11 5 0.11 0.08 0.07
438 207 398 234 164 199 108 17 17 5 0.17 0.11 0.09
```

Raw Dataset: `pirp-12-2-1-3-2.dat`

```
12 2 1 3 1804
259 162 3000 3000 3000 3000 0.77 0.47 0.79
877 9 390 195 195 54 145 11 11 4 0.11 0.07 0.06
459 177 513 378 135 171 129 16 16 6 0.16 0.11 0.09
80 184 537 365 172 179 127 19 19 6 0.19 0.12 0.1
117 989 363 242 121 75 72 18 18 7 0.18 0.12 0.11
668 2 600 570 30 143 200 16 16 7 0.16 0.12 0.1
240 418 357 270 87 119 114 13 13 5 0.13 0.09 0.08
268 730 591 444 147 107 197 18 18 4 0.18 0.11 0.09
14 240 324 240 84 48 162 13 13 7 0.13 0.1 0.09
212 672 312 230 82 104 97 15 15 7 0.15 0.11 0.1
758 335 258 129 129 68 55 12 12 7 0.12 0.1 0.09
```

576 23 396 266 130 83 198 15 15 6 0.15 0.1 0.09
328 583 352 285 67 176 128 20 20 4 0.2 0.12 0.09

Raw Dataset: `pirp-12-2-1-3-3.dat`

```
12 2 1 3 1692
985 950 3000 3000 3000 3000 0.24 0.17 1.37
163 980 412 206 206 51 84 12 12 4 0.12 0.08 0.07
303 551 462 320 142 154 79 19 19 7 0.19 0.13 0.11
38 637 627 460 167 209 100 13 13 6 0.13 0.1 0.08
9 867 418 331 87 75 209 11 11 7 0.11 0.09 0.08
775 960 352 240 112 155 176 12 12 5 0.12 0.09 0.07
550 114 182 152 30 91 68 11 11 6 0.11 0.09 0.08
918 89 450 302 148 150 80 10 10 5 0.1 0.07 0.07
20 455 444 296 148 60 126 12 12 7 0.12 0.1 0.09
726 9 220 110 110 99 71 12 12 5 0.12 0.09 0.07
663 152 387 306 81 129 93 16 16 6 0.16 0.11 0.09
996 392 276 138 138 45 39 13 13 7 0.13 0.1 0.09
911 357 380 279 101 59 190 19 19 6 0.19 0.12 0.1
```

Raw Dataset: `pirp-12-2-1-3-4.dat`

```
12 2 1 3 1760
633 97 3000 3000 3000 3000 1.41 1.01 0.09
533 276 564 476 88 188 132 11 11 4 0.11 0.07 0.06
827 924 519 362 157 173 78 12 12 7 0.12 0.1 0.09
608 975 402 263 139 100 201 15 15 6 0.15 0.1 0.09
787 905 202 132 70 101 85 13 13 6 0.13 0.1 0.08
543 316 420 293 127 140 108 20 20 6 0.2 0.13 0.11
110 598 420 210 210 100 141 14 14 6 0.14 0.1 0.09
80 969 402 337 65 201 35 16 16 6 0.16 0.11 0.09
41 467 522 461 61 174 92 14 14 4 0.14 0.09 0.07
484 496 414 304 110 147 207 14 14 7 0.14 0.1 0.09
33 406 210 105 105 54 62 20 20 6 0.2 0.13 0.11
193 9 303 202 101 74 58 17 17 4 0.17 0.1 0.08
9 438 474 413 61 123 158 19 19 6 0.19 0.12 0.1
```

Raw Dataset: `pirp-12-2-1-3-5.dat`

```
12 2 1 3 1581
194 461 3000 3000 3000 3000 1.24 0.31 1.37
889 512 606 476 130 200 202 14 14 5 0.14 0.1 0.08
361 155 346 280 66 99 173 17 17 7 0.17 0.12 0.1
852 1 376 188 188 86 172 20 20 4 0.2 0.12 0.09
```

```
805 990 398 329 69 137 199 14 14 5 0.14 0.1 0.08
429 354 195 162 33 65 59 18 18 6 0.18 0.12 0.1
406 424 333 222 111 62 55 12 12 7 0.12 0.1 0.09
688 909 360 284 76 120 31 10 10 6 0.1 0.08 0.07
368 417 324 162 162 110 154 16 16 6 0.16 0.11 0.09
638 899 282 188 94 49 45 14 14 5 0.14 0.1 0.08
201 342 372 281 91 35 124 14 14 4 0.14 0.09 0.07
729 486 567 434 133 189 36 16 16 7 0.16 0.12 0.1
118 242 279 223 56 92 93 15 15 6 0.15 0.1 0.09
```

Raw Dataset: `pirp-12-3-1-6-1.dat`

```
12 3 1 6 1798
884 563 3000 3000 3000 3000 3000 3000 3000 0.82 1.26 0.44 1.2
619 205 348 182 166 61 42 151 174 103 15 15 15 4 0.15 0.1 0.08 0.07
574 93 597 493 104 39 199 66 105 105 17 17 17 6 0.17 0.12 0.1 0.09
784 730 396 238 158 84 130 79 65 198 20 20 20 4 0.2 0.12 0.09 0.08
977 199 585 511 74 34 186 55 195 106 17 17 17 4 0.17 0.1 0.08 0.07
573 935 340 258 82 105 170 63 69 96 15 15 15 7 0.15 0.11 0.1 0.09
90 133 284 150 134 124 31 36 142 87 18 18 18 6 0.18 0.12 0.1 0.09
249 260 594 497 97 198 98 187 182 171 16 16 16 5 0.16 0.1 0.09 0.08
664 776 576 429 147 192 102 97 92 63 14 14 14 5 0.14 0.1 0.08 0.07
371 480 362 230 132 119 100 120 75 181 13 13 13 6 0.13 0.1 0.08 0.08
136 383 588 392 196 137 125 191 91 109 20 20 20 5 0.2 0.12 0.1 0.09
751 190 326 278 48 116 136 138 146 163 10 10 10 4 0.1 0.07 0.06 0.06
673 593 630 420 210 69 166 142 137 142 13 13 13 4 0.13 0.09 0.07 0.06
```

Raw Dataset: `pirp-12-3-1-6-2.dat`

```
12 3 1 6 1890
874 646 3000 3000 3000 3000 3000 3000 3000 0.98 0.55 1.14 0.62
494 183 404 345 59 177 43 45 53 202 17 17 17 4 0.17 0.1 0.08 0.07
198 409 400 260 140 200 155 64 84 138 13 13 13 7 0.13 0.1 0.09 0.09
741 686 388 238 150 194 63 116 61 92 15 15 15 6 0.15 0.1 0.09 0.08
680 252 600 441 159 35 181 159 59 200 16 16 16 6 0.16 0.11 0.09 0.09
522 676 358 207 151 97 108 179 157 51 15 15 15 6 0.15 0.1 0.09 0.08
399 536 627 418 209 51 196 102 199 165 15 15 15 7 0.15 0.11 0.1 0.09
373 146 513 413 100 61 162 171 169 94 10 10 10 4 0.1 0.07 0.06 0.06
601 840 615 432 183 189 68 79 182 205 10 10 10 6 0.1 0.08 0.07 0.07
575 909 621 565 56 148 198 33 207 143 18 18 18 5 0.18 0.12 0.09 0.08
881 873 340 306 34 100 170 170 122 105 15 15 15 4 0.15 0.1 0.08 0.07
500 302 552 396 156 104 184 35 106 92 10 10 10 4 0.1 0.07 0.06 0.06
576 832 408 358 50 132 75 204 154 141 11 11 11 7 0.11 0.09 0.08 0.08
```

Raw Dataset: `pirp-12-3-1-6-3.dat`

```
12 3 1 6 1828
545 425 3000 3000 3000 3000 3000 3000 3000 0.11 1.32 1.22 0.96
729 674 621 569 52 50 72 207 55 34 14 14 14 7 0.14 0.1 0.09 0.09
200 396 416 208 208 68 157 169 159 142 16 16 16 6 0.16 0.11 0.09 0.09
586 676 418 210 208 34 87 141 209 61 13 13 13 7 0.13 0.1 0.09 0.09
124 575 630 525 105 103 184 107 144 210 19 19 19 5 0.19 0.12 0.1 0.09
586 758 525 474 51 110 155 80 175 164 15 15 15 4 0.15 0.1 0.08 0.07
662 155 370 306 64 95 160 185 68 117 15 15 15 6 0.15 0.1 0.09 0.08
689 221 308 154 154 116 150 55 44 140 12 12 12 4 0.12 0.08 0.07 0.06
489 247 624 501 123 145 140 208 40 112 16 16 16 6 0.16 0.11 0.09 0.09
788 245 406 336 70 69 183 203 66 74 20 20 20 4 0.2 0.12 0.09 0.08
715 260 471 364 107 120 153 70 117 157 18 18 18 5 0.18 0.12 0.09 0.08
937 308 546 376 170 128 182 72 141 125 16 16 16 6 0.16 0.11 0.09 0.09
12 75 546 374 172 97 182 71 82 151 11 11 11 7 0.11 0.09 0.08 0.08
```

Raw Dataset: `pirp-12-3-1-6-4.dat`

```
12 3 1 6 1791
649 924 3000 3000 3000 3000 3000 3000 3000 0.85 1.49 0.99 0.5
720 680 570 510 60 37 190 181 189 154 15 15 15 6 0.15 0.1 0.09 0.08
61 899 378 281 97 44 188 117 189 78 11 11 11 5 0.11 0.08 0.07 0.07
958 919 390 203 187 44 140 69 195 92 20 20 20 4 0.2 0.12 0.09 0.08
435 649 292 146 146 43 73 60 46 92 17 17 17 7 0.17 0.12 0.1 0.1
545 119 522 385 137 139 174 72 67 151 16 16 16 7 0.16 0.12 0.1 0.09
182 81 366 261 105 81 136 158 101 183 19 19 19 4 0.19 0.12 0.09 0.08
535 562 384 344 40 141 192 82 37 145 13 13 13 7 0.13 0.1 0.09 0.09
130 68 370 248 122 96 34 185 163 123 15 15 15 4 0.15 0.1 0.08 0.07
641 553 618 448 170 198 190 206 161 206 14 14 14 7 0.14 0.1 0.09 0.09
712 73 588 488 100 54 128 196 64 167 18 18 18 6 0.18 0.12 0.1 0.09
762 567 513 374 139 45 145 171 92 62 14 14 14 6 0.14 0.1 0.09 0.08
369 861 459 365 94 153 94 44 84 59 16 16 16 7 0.16 0.12 0.1 0.09
```

Raw Dataset: `pirp-12-3-1-6-5.dat`

```
12 3 1 6 1890
965 923 3000 3000 3000 3000 3000 3000 3000 0.5 1.0 0.49 0.76
68 721 603 402 201 107 79 74 58 121 15 15 15 6 0.15 0.1 0.09 0.08
768 439 382 191 191 135 181 116 191 158 19 19 19 7 0.19 0.13 0.11 0.1
921 969 398 321 77 119 199 153 43 76 18 18 18 6 0.18 0.12 0.1 0.09
183 622 328 267 61 89 86 164 93 157 20 20 20 5 0.2 0.12 0.1 0.09
380 862 412 206 206 120 147 182 51 63 19 19 19 4 0.19 0.12 0.09 0.08
842 226 618 442 176 114 182 206 137 55 16 16 16 5 0.16 0.1 0.09 0.08
455 754 528 474 54 136 167 127 176 163 15 15 15 5 0.15 0.1 0.08 0.07
798 452 406 289 117 157 203 69 156 182 12 12 12 4 0.12 0.08 0.07 0.06
```

174 21 394 197 197 92 135 154 129 98 20 20 20 5 0.2 0.12 0.1 0.09
863 925 394 297 97 98 197 77 105 175 11 11 11 4 0.11 0.07 0.06 0.06
366 372 447 334 113 100 149 117 89 65 17 17 17 7 0.17 0.12 0.1 0.1
751 473 567 465 102 189 87 67 134 35 17 17 17 4 0.17 0.1 0.08 0.07

Raw Dataset: pirp-12-5-1-10-1.dat

12 5 1 10 1785
351 31 3000 3000 3000 3000 3000 3000 3000 3000 3000 3000 3000 0.3 1.09 1.25 1.49 0.93 1.08
676 909 410 208 202 119 162 136 149 205 79 109 47 156 13 13 13 13 13 6 0.13 0.1 0.08 0.08 0.07 0.07
0 611 630 517 113 39 107 35 210 155 179 119 30 134 20 20 20 20 20 4 0.2 0.12 0.09 0.08 0.07 0.07
247 534 420 294 126 118 163 144 163 183 210 202 110 151 10 10 10 10 10 7 0.1 0.09 0.08 0.08 0.08 0.07
850 413 522 387 135 103 144 133 42 41 174 51 45 121 19 19 19 19 19 7 0.19 0.13 0.11 0.1 0.09 0.09
587 148 558 392 166 166 167 164 131 70 183 186 94 133 11 11 11 11 11 6 0.11 0.09 0.08 0.07 0.07 0.07
303 336 609 425 184 80 81 203 159 40 203 96 97 31 13 13 13 13 13 4 0.13 0.09 0.07 0.06 0.06 0.06
163 270 414 369 45 207 187 146 154 180 169 123 122 61 12 12 12 12 12 6 0.12 0.09 0.08 0.07 0.07 0.07
737 98 290 165 125 139 108 145 43 87 44 50 43 50 14 14 14 14 14 7 0.14 0.1 0.09 0.09 0.08 0.08
153 89 414 208 206 179 126 200 92 207 88 144 193 78 19 19 19 19 19 4 0.19 0.12 0.09 0.08 0.07 0.07
772 503 540 444 96 33 162 103 149 131 81 180 85 121 14 14 14 14 14 4 0.14 0.09 0.07 0.07 0.06 0.06
237 519 492 391 101 68 53 90 146 164 68 111 142 67 20 20 20 20 20 7 0.2 0.14 0.11 0.1 0.1 0.09
880 320 266 221 45 52 133 85 102 36 69 62 68 60 14 14 14 14 14 7 0.14 0.1 0.09 0.09 0.08 0.08

Raw Dataset: pirp-12-5-1-10-2.dat

12 5 1 10 1811
941 177 3000 3000 3000 3000 3000 3000 3000 3000 3000 3000 3000 1.39 1.24 1.34 1.39 0.78 1.46
594 846 418 328 90 209 180 142 151 197 39 106 186 115 10 10 10 10 10 4 0.1 0.07 0.06 0.06 0.05 0.05
150 376 594 532 62 198 194 130 40 152 129 57 119 181 10 10 10 10 10 5 0.1 0.07 0.07 0.06 0.06 0.06
22 178 416 310 106 44 161 205 78 184 121 208 141 129 16 16 16 16 16 7 0.16 0.12 0.1 0.09 0.09 0.09
333 848 624 587 37 208 39 189 65 165 62 81 188 158 16 16 16 16 16 4 0.16 0.1 0.08 0.07 0.06 0.06
506 545 366 205 161 110 58 134 183 43 88 180 75 140 13 13 13 13 13 4 0.13 0.09 0.07 0.06 0.06 0.06
466 232 224 159 65 112 46 38 94 58 41 106 89 111 17 17 17 17 17 5 0.17 0.11 0.09 0.08 0.07 0.07
614 858 600 496 104 181 137 171 110 41 177 109 200 130 15 15 15 15 15 4 0.15 0.1 0.08 0.07 0.06 0.06
949 347 420 275 145 164 91 74 202 151 209 210 47 77 12 12 12 12 12 6 0.12 0.09 0.08 0.07 0.07 0.07
482 727 404 270 134 188 202 48 43 199 166 34 71 47 17 17 17 17 17 5 0.17 0.11 0.09 0.08 0.07 0.07
879 49 612 549 63 138 74 100 101 159 204 98 112 194 16 16 16 16 16 6 0.16 0.11 0.09 0.09 0.08 0.08
240 383 624 493 131 34 159 116 34 208 150 101 131 38 12 12 12 12 12 6 0.12 0.09 0.08 0.07 0.07 0.07
321 266 510 410 100 46 58 65 107 166 68 160 167 170 11 11 11 11 11 6 0.11 0.09 0.08 0.07 0.07 0.07

Raw Dataset: pirp-12-5-1-10-3.dat

12 5 1 10 1665
969 264 3000 3000 3000 3000 3000 3000 3000 3000 3000 3000 3000 0.52 0.42 0.88 0.86 0.3 0.53
532 296 600 400 200 170 35 31 133 89 72 122 168 89 12 12 12 12 12 7 0.12 0.1 0.09 0.08 0.08 0.08

```
824 595 552 442 110 184 102 166 170 85 51 30 64 107 15 15 15 15 15 5 0.15 0.1 0.08 0.07 0.07 0.07
377 330 513 342 171 136 51 93 145 70 117 115 45 164 12 12 12 12 12 5 0.12 0.09 0.07 0.07 0.06 0.06
896 17 398 199 199 127 86 192 90 140 77 56 91 31 10 10 10 10 10 6 0.1 0.08 0.07 0.07 0.07 0.07
248 953 606 566 40 128 105 60 38 64 90 54 202 92 11 11 11 11 11 7 0.11 0.09 0.08 0.08 0.08 0.08
986 679 404 218 186 75 117 202 71 131 122 147 33 168 14 14 14 14 14 6 0.14 0.1 0.09 0.08 0.08 0.07
987 904 390 258 132 77 56 49 195 121 190 134 175 51 11 11 11 11 11 6 0.11 0.09 0.08 0.07 0.07 0.07
608 299 420 340 80 75 41 84 112 134 160 210 131 35 11 11 11 11 11 4 0.11 0.07 0.06 0.06 0.05 0.05
185 689 570 389 181 89 148 122 73 57 48 190 84 71 15 15 15 15 15 7 0.15 0.11 0.1 0.09 0.09 0.08
610 340 609 498 111 77 68 99 203 180 196 147 31 64 15 15 15 15 15 5 0.15 0.1 0.08 0.07 0.07 0.07
584 260 370 211 159 185 91 179 31 162 132 98 104 116 10 10 10 10 10 4 0.1 0.07 0.06 0.06 0.05 0.05
236 724 374 225 149 157 36 187 164 31 89 142 44 89 18 18 18 18 18 4 0.18 0.11 0.09 0.07 0.07 0.06
```

Raw Dataset: `pirp-12-5-1-10-4.dat`

```
12 5 1 10 1707
783 727 3000 3000 3000 3000 3000 3000 3000 3000 3000 3000 3000 1.14 1.37 1.42 0.53 1.02 1.48
723 122 594 534 60 34 198 53 152 99 184 196 57 62 12 12 12 12 12 4 0.12 0.08 0.07 0.06 0.06 0.05
682 276 624 420 204 191 153 132 39 68 80 96 128 208 15 15 15 15 15 6 0.15 0.1 0.09 0.08 0.08 0.07
447 281 564 450 114 74 159 162 108 188 106 100 184 143 10 10 10 10 10 6 0.1 0.08 0.07 0.07 0.07 0.07
827 790 314 242 72 84 115 116 107 155 35 116 157 126 16 16 16 16 16 6 0.16 0.11 0.09 0.09 0.08 0.08
480 642 618 512 106 95 117 40 72 206 111 37 98 106 14 14 14 14 14 5 0.14 0.1 0.08 0.07 0.07 0.07
780 516 558 521 37 83 186 67 99 99 109 150 42 88 17 17 17 17 17 5 0.17 0.11 0.09 0.08 0.07 0.07
47 138 582 509 73 60 53 81 55 136 112 150 194 54 15 15 15 15 15 4 0.15 0.1 0.08 0.07 0.06 0.06
631 943 416 342 74 135 208 83 143 130 145 104 162 115 14 14 14 14 14 6 0.14 0.1 0.09 0.08 0.08 0.07
201 311 582 388 194 177 105 123 175 159 179 84 105 61 17 17 17 17 17 7 0.17 0.12 0.1 0.1 0.09 0.09
383 79 384 273 111 95 64 62 50 111 100 179 40 192 14 14 14 14 14 6 0.14 0.1 0.09 0.08 0.08 0.07
688 735 348 292 56 79 171 93 144 65 174 107 107 77 18 18 18 18 18 6 0.18 0.12 0.1 0.09 0.08 0.08
844 220 406 228 178 203 115 127 84 46 104 186 109 40 14 14 14 14 14 6 0.14 0.1 0.09 0.08 0.08 0.07
```

Raw Dataset: `pirp-12-5-1-10-5.dat`

```
12 5 1 10 1901
832 685 3000 3000 3000 3000 3000 3000 3000 3000 3000 3000 3000 1.01 0.4 0.31 0.45 1.11 0.99
331 823 384 336 48 67 33 151 174 81 192 184 120 92 16 16 16 16 16 7 0.16 0.12 0.1 0.09 0.09 0.09
808 599 612 560 52 144 59 204 110 91 186 85 53 201 17 17 17 17 17 6 0.17 0.12 0.1 0.09 0.08 0.08
10 1000 612 530 82 147 45 76 204 168 154 136 39 134 15 15 15 15 15 5 0.15 0.1 0.08 0.07 0.07 0.07
508 82 612 452 160 52 162 109 108 103 107 204 189 204 17 17 17 17 17 6 0.17 0.12 0.1 0.09 0.08 0.08
164 37 394 253 141 109 71 197 72 147 169 172 174 152 15 15 15 15 15 7 0.15 0.11 0.1 0.09 0.09 0.08
341 996 414 383 31 202 183 72 59 207 177 32 205 131 16 16 16 16 16 5 0.16 0.1 0.09 0.08 0.07 0.07
616 877 597 416 181 198 81 149 72 163 199 137 69 136 13 13 13 13 13 4 0.13 0.09 0.07 0.06 0.06 0.06
4 170 618 505 113 110 136 67 205 108 206 51 31 161 15 15 15 15 15 6 0.15 0.1 0.09 0.08 0.08 0.07
507 149 561 509 52 54 182 158 157 122 50 184 151 187 15 15 15 15 15 5 0.15 0.1 0.08 0.07 0.07 0.07
162 694 380 210 170 115 153 134 57 150 50 176 190 76 19 19 19 19 19 6 0.19 0.12 0.1 0.09 0.09 0.08
516 860 621 473 148 167 207 155 58 80 91 159 72 130 11 11 11 11 11 6 0.11 0.09 0.08 0.07 0.07 0.07
733 865 326 163 163 98 160 135 139 44 126 110 143 76 11 11 11 11 11 4 0.11 0.07 0.06 0.06 0.05 0.05
```

Raw Dataset: pirp-15-2-1-3-1.dat

```
15 2 1 3 2139
621 296 3000 3000 3000 3000 0.22 1.41 0.74
921 356 334 217 117 78 167 18 18 6 0.18 0.12 0.1
516 553 276 240 36 30 92 16 16 5 0.16 0.1 0.09
713 393 268 134 134 58 131 18 18 6 0.18 0.12 0.1
237 465 388 258 130 194 59 20 20 6 0.2 0.13 0.11
572 212 292 146 146 43 121 20 20 4 0.2 0.12 0.09
278 962 615 536 79 115 205 19 19 6 0.19 0.12 0.1
849 710 357 320 37 80 119 20 20 7 0.2 0.14 0.11
371 244 386 255 131 193 85 16 16 6 0.16 0.11 0.09
221 950 357 288 69 36 119 16 16 4 0.16 0.1 0.08
633 391 332 166 166 123 54 12 12 4 0.12 0.08 0.07
782 431 406 242 164 157 203 18 18 6 0.18 0.12 0.1
972 520 558 460 98 51 186 11 11 6 0.11 0.09 0.08
780 803 390 199 191 195 70 16 16 5 0.16 0.1 0.09
315 363 582 388 194 187 96 10 10 7 0.1 0.09 0.08
728 876 228 195 33 48 114 17 17 5 0.17 0.11 0.09
```

Raw Dataset: pirp-15-2-1-3-2.dat

```
15 2 1 3 2410
755 103 3000 3000 3000 3000 0.5 1.05 1.28
896 546 456 342 114 40 152 14 14 7 0.14 0.1 0.09
313 151 348 276 72 172 174 19 19 5 0.19 0.12 0.1
669 800 364 204 160 182 166 18 18 6 0.18 0.12 0.1
406 869 618 412 206 143 145 16 16 4 0.16 0.1 0.08
878 34 342 285 57 171 84 18 18 7 0.18 0.12 0.11
786 925 372 322 50 120 124 18 18 4 0.18 0.11 0.09
930 132 406 350 56 109 203 19 19 5 0.19 0.12 0.1
167 512 362 181 181 84 78 15 15 4 0.15 0.1 0.08
412 61 489 362 127 117 163 11 11 4 0.11 0.07 0.06
771 211 537 462 75 179 105 20 20 5 0.2 0.12 0.1
379 412 414 329 85 138 138 18 18 7 0.18 0.12 0.11
732 613 483 330 153 65 161 15 15 7 0.15 0.11 0.1
297 494 630 420 210 171 185 17 17 7 0.17 0.12 0.1
283 167 352 302 50 98 176 11 11 7 0.11 0.09 0.08
142 444 394 351 43 105 197 10 10 5 0.1 0.07 0.07
```

Raw Dataset: pirp-15-2-1-3-3.dat

```
15 2 1 3 2130
130 370 3000 3000 3000 3000 1.06 0.8 0.66
212 886 585 390 195 158 169 12 12 5 0.12 0.09 0.07
634 246 627 527 100 192 209 10 10 7 0.1 0.09 0.08
```

926 804 552 398 154 78 184 16 16 7 0.16 0.12 0.1
447 461 393 262 131 40 32 12 12 5 0.12 0.09 0.07
565 440 504 442 62 116 168 13 13 7 0.13 0.1 0.09
447 919 558 372 186 72 48 10 10 7 0.1 0.09 0.08
168 523 273 195 78 91 80 14 14 7 0.14 0.1 0.09
139 562 405 336 69 66 135 18 18 7 0.18 0.12 0.11
629 473 405 363 42 135 56 20 20 5 0.2 0.12 0.1
574 6 298 179 119 143 149 12 12 4 0.12 0.08 0.07
217 96 376 188 188 62 154 17 17 6 0.17 0.12 0.1
960 802 124 69 55 62 30 17 17 6 0.17 0.12 0.1
35 429 576 384 192 58 107 18 18 6 0.18 0.12 0.1
992 651 366 203 163 183 55 14 14 6 0.14 0.1 0.09
1 370 284 168 116 90 142 10 10 4 0.1 0.07 0.06

Raw Dataset: `pirp-15-2-1-3-4.dat`

15 2 1 3 2434
656 170 3000 3000 3000 3000 0.62 1.17 1.25
314 820 242 121 121 65 112 18 18 4 0.18 0.11 0.09
309 296 378 317 61 126 189 19 19 4 0.19 0.12 0.09
859 558 370 185 185 126 155 19 19 5 0.19 0.12 0.1
991 478 447 357 90 149 123 20 20 5 0.2 0.12 0.1
859 811 310 194 116 65 155 14 14 7 0.14 0.1 0.09
448 267 585 390 195 88 157 20 20 5 0.2 0.12 0.1
705 78 585 434 151 177 195 15 15 6 0.15 0.1 0.09
785 164 364 182 182 172 138 10 10 6 0.1 0.08 0.07
228 447 404 307 97 54 202 19 19 6 0.19 0.12 0.1
835 47 370 224 146 116 185 12 12 4 0.12 0.08 0.07
135 852 597 398 199 40 115 13 13 5 0.13 0.09 0.08
941 540 594 396 198 53 94 19 19 7 0.19 0.13 0.11
309 753 208 104 104 81 43 11 11 5 0.11 0.08 0.07
650 943 624 416 208 152 151 15 15 7 0.15 0.11 0.1
712 832 495 330 165 43 103 10 10 7 0.1 0.09 0.08

Raw Dataset: `pirp-15-2-1-3-5.dat`

15 2 1 3 2234
344 914 3000 3000 3000 3000 1.08 0.57 0.26
780 367 372 291 81 34 124 18 18 5 0.18 0.12 0.09
175 835 402 201 201 100 193 12 12 4 0.12 0.08 0.07
828 68 348 282 66 116 85 13 13 6 0.13 0.1 0.08
539 300 362 326 36 41 181 17 17 5 0.17 0.11 0.09
434 409 392 229 163 194 196 18 18 5 0.18 0.12 0.09
783 423 456 304 152 42 129 11 11 6 0.11 0.09 0.08
514 174 128 64 64 42 33 15 15 5 0.15 0.1 0.08
21 485 392 196 196 151 81 17 17 7 0.17 0.12 0.1

852 491 338 169 169 87 120 14 14 7 0.14 0.1 0.09
23 385 576 413 163 192 127 18 18 4 0.18 0.11 0.09
767 24 600 400 200 106 78 12 12 5 0.12 0.09 0.07
225 330 272 177 95 40 136 13 13 6 0.13 0.1 0.08
137 916 606 404 202 173 166 12 12 6 0.12 0.09 0.08
402 135 322 161 161 110 90 18 18 7 0.18 0.12 0.11
844 260 276 230 46 138 62 18 18 6 0.18 0.12 0.1

Raw Dataset: `pirp-15-3-1-6-1.dat`

```
15 3 1 6 1999
737 685 3000 3000 3000 3000 3000 3000 3000 0.42 1.27 0.55 0.78
237 576 591 442 149 134 59 112 152 197 20 20 20 7 0.2 0.14 0.11 0.1
391 252 218 167 51 36 109 52 90 102 11 11 11 4 0.11 0.07 0.06 0.06
162 88 228 154 74 63 114 55 40 56 11 11 11 7 0.11 0.09 0.08 0.08
449 379 370 296 74 140 106 59 185 171 16 16 16 7 0.16 0.12 0.1 0.09
271 944 302 255 47 140 98 151 44 120 14 14 14 7 0.14 0.1 0.09 0.09
780 857 624 513 111 75 183 208 76 167 10 10 10 4 0.1 0.07 0.06 0.06
802 991 420 384 36 181 201 202 37 210 17 17 17 4 0.17 0.1 0.08 0.07
998 482 380 341 39 66 40 190 45 61 13 13 13 4 0.13 0.09 0.07 0.06
615 95 582 445 137 194 108 158 123 131 15 15 15 7 0.15 0.11 0.1 0.09
635 630 392 331 61 196 39 188 75 92 11 11 11 6 0.11 0.09 0.08 0.07
124 490 292 217 75 65 73 57 66 146 19 19 19 7 0.19 0.13 0.11 0.1
462 126 418 334 84 117 209 34 140 152 11 11 11 6 0.11 0.09 0.08 0.07
197 811 352 244 108 75 58 102 150 176 15 15 15 4 0.15 0.1 0.08 0.07
38 335 474 385 89 61 34 158 38 103 11 11 11 7 0.11 0.09 0.08 0.08
269 239 507 393 114 113 35 169 42 145 17 17 17 6 0.17 0.12 0.1 0.09
```

Raw Dataset: `pirp-15-3-1-6-2.dat`

```
15 3 1 6 2075
119 351 3000 3000 3000 3000 3000 3000 3000 0.24 0.32 0.34 0.38
674 994 420 352 68 148 72 134 141 210 20 20 20 6 0.2 0.13 0.11 0.1
677 755 392 278 114 179 49 196 86 112 10 10 10 4 0.1 0.07 0.06 0.06
355 70 630 420 210 116 68 136 96 61 18 18 18 6 0.18 0.12 0.1 0.09
793 772 456 323 133 119 80 52 152 57 18 18 18 5 0.18 0.12 0.09 0.08
300 329 462 395 67 61 154 82 92 61 13 13 13 6 0.13 0.1 0.08 0.08
663 400 513 342 171 94 79 162 42 121 16 16 16 4 0.16 0.1 0.08 0.07
467 986 372 248 124 60 40 63 94 115 13 13 13 7 0.13 0.1 0.09 0.09
543 822 304 254 50 152 87 50 63 53 14 14 14 7 0.14 0.1 0.09 0.09
160 428 582 469 113 131 159 64 194 75 17 17 17 5 0.17 0.11 0.09 0.08
839 103 627 510 117 163 209 120 79 79 12 12 12 7 0.12 0.1 0.09 0.08
85 988 366 200 166 98 107 179 139 183 15 15 15 4 0.15 0.1 0.08 0.07
703 188 360 183 177 68 114 180 141 167 13 13 13 7 0.13 0.1 0.09 0.09
239 655 510 340 170 71 81 31 99 127 20 20 20 6 0.2 0.13 0.11 0.1
796 449 378 292 86 84 44 126 81 83 19 19 19 7 0.19 0.13 0.11 0.1
```

```
828 765 546 364 182 93 86 113 86 173 17 17 17 4 0.17 0.1 0.08 0.07
```

Raw Dataset: `pirp-15-3-1-6-3.dat`

```
15 3 1 6 2415
694 771 3000 3000 3000 3000 3000 3000 3000 0.91 0.92 0.32 1.2
491 358 326 205 121 101 163 133 68 51 13 13 13 6 0.13 0.1 0.08 0.08
145 625 388 194 194 68 38 86 44 140 13 13 13 4 0.13 0.09 0.07 0.06
396 71 334 170 164 104 103 167 164 138 14 14 14 6 0.14 0.1 0.09 0.08
682 245 336 169 167 64 62 151 168 59 14 14 14 4 0.14 0.09 0.07 0.07
386 270 585 505 80 131 56 174 170 195 11 11 11 5 0.11 0.08 0.07 0.07
214 451 406 203 203 140 104 155 83 110 11 11 11 5 0.11 0.08 0.07 0.07
207 619 328 164 164 56 32 86 145 40 10 10 10 6 0.1 0.08 0.07 0.07
760 445 418 371 47 121 138 139 195 209 20 20 20 7 0.2 0.14 0.11 0.1
294 622 612 506 106 145 204 198 141 129 15 15 15 6 0.15 0.1 0.09 0.08
455 424 350 195 155 66 112 175 140 162 13 13 13 4 0.13 0.09 0.07 0.06
328 299 354 268 86 177 128 174 102 157 15 15 15 6 0.15 0.1 0.09 0.08
191 733 624 509 115 131 186 91 59 208 15 15 15 6 0.15 0.1 0.09 0.08
122 775 603 523 80 165 191 43 49 201 17 17 17 5 0.17 0.11 0.09 0.08
549 333 624 577 47 108 128 208 154 208 19 19 19 6 0.19 0.12 0.1 0.09
87 474 582 419 163 194 180 163 141 133 19 19 19 5 0.19 0.12 0.1 0.09
```

Raw Dataset: `pirp-15-3-1-6-4.dat`

```
15 3 1 6 2092
489 720 3000 3000 3000 3000 3000 3000 3000 1.22 0.79 0.84 0.91
80 583 420 369 51 128 56 202 94 210 15 15 15 5 0.15 0.1 0.08 0.07
926 621 320 199 121 160 83 150 96 99 11 11 11 4 0.11 0.07 0.06 0.06
676 421 212 146 66 58 64 106 43 66 20 20 20 4 0.2 0.12 0.09 0.08
143 688 314 163 151 53 77 157 40 99 15 15 15 7 0.15 0.11 0.1 0.09
0 599 495 451 44 120 132 121 165 40 14 14 14 4 0.14 0.09 0.07 0.07
785 398 435 351 84 113 80 42 40 145 15 15 15 4 0.15 0.1 0.08 0.07
625 110 522 427 95 157 174 38 73 80 11 11 11 4 0.11 0.07 0.06 0.06
108 540 519 379 140 57 173 97 109 67 19 19 19 7 0.19 0.13 0.11 0.1
265 250 406 366 40 66 157 129 203 173 12 12 12 5 0.12 0.09 0.07 0.07
749 451 600 501 99 41 100 168 200 77 17 17 17 4 0.17 0.1 0.08 0.07
531 732 402 280 122 70 41 63 201 89 13 13 13 5 0.13 0.09 0.08 0.07
699 862 606 517 89 66 165 86 202 202 10 10 10 7 0.1 0.09 0.08 0.08
352 678 314 157 157 92 130 45 137 112 11 11 11 5 0.11 0.08 0.07 0.07
661 930 618 412 206 188 143 156 52 37 10 10 10 7 0.1 0.09 0.08 0.08
377 486 410 206 204 194 205 31 115 173 19 19 19 5 0.19 0.12 0.1 0.09
```

Raw Dataset: `pirp-15-3-1-6-5.dat`

```
15 3 1 6 2302
338 999 3000 3000 3000 3000 3000 3000 3000 1.39 1.03 0.88 0.59
145 869 410 266 144 205 120 38 67 119 16 16 16 4 0.16 0.1 0.08 0.07
679 682 582 388 194 58 94 153 183 36 13 13 13 7 0.13 0.1 0.09 0.09
834 985 594 491 103 60 198 77 119 184 20 20 20 5 0.2 0.12 0.1 0.09
398 520 352 176 176 91 33 56 126 154 11 11 11 6 0.11 0.09 0.08 0.07
615 649 290 176 114 145 113 100 102 142 18 18 18 7 0.18 0.12 0.11 0.1
862 354 412 285 127 206 109 123 134 171 15 15 15 7 0.15 0.11 0.1 0.09
425 257 567 378 189 118 134 131 140 117 19 19 19 4 0.19 0.12 0.09 0.08
854 206 540 415 125 37 63 167 180 118 12 12 12 4 0.12 0.08 0.07 0.06
293 17 378 244 134 120 42 124 189 146 17 17 17 4 0.17 0.1 0.08 0.07
208 203 552 429 123 94 92 181 58 184 15 15 15 5 0.15 0.1 0.08 0.07
787 790 408 254 154 98 111 69 149 204 17 17 17 4 0.17 0.1 0.08 0.07
436 514 344 291 53 30 172 108 41 137 19 19 19 5 0.19 0.12 0.1 0.09
531 311 398 328 70 135 60 199 67 175 20 20 20 4 0.2 0.12 0.09 0.08
406 95 418 322 96 184 79 87 209 159 11 11 11 6 0.11 0.09 0.08 0.07
183 198 618 412 206 75 123 205 125 90 10 10 10 7 0.1 0.09 0.08 0.08
```

Raw Dataset: `pirp-15-5-1-10-1.dat`

```
15 5 1 10 2220
786 255 3000 3000 3000 3000 3000 3000 3000 3000 3000 3000 3000 1.48 0.27 1.34 0.68 1.16 0.22
751 623 600 503 97 200 197 52 51 136 131 97 149 89 15 15 15 15 15 6 0.15 0.1 0.09 0.08 0.08 0.07
353 342 456 383 73 58 139 95 52 121 152 142 89 37 18 18 18 18 18 4 0.18 0.11 0.09 0.07 0.07 0.06
620 998 537 358 179 170 76 115 42 74 100 52 163 146 18 18 18 18 18 7 0.18 0.12 0.11 0.1 0.09 0.09
307 190 537 444 93 162 101 68 135 58 178 179 135 35 14 14 14 14 14 6 0.14 0.1 0.09 0.08 0.08 0.07
693 448 618 587 31 136 39 154 144 137 142 51 206 186 19 19 19 19 19 6 0.19 0.12 0.1 0.09 0.09 0.08
867 213 546 371 175 35 59 63 59 148 159 159 182 167 16 16 16 16 16 7 0.16 0.12 0.1 0.09 0.09 0.09
663 207 414 357 57 135 166 207 55 65 87 33 82 77 15 15 15 15 15 4 0.15 0.1 0.08 0.07 0.06 0.06
871 443 528 482 46 111 176 129 72 76 66 169 159 99 13 13 13 13 13 7 0.13 0.1 0.09 0.09 0.08 0.08
17 552 615 483 132 68 190 134 191 164 94 205 126 63 19 19 19 19 19 4 0.19 0.12 0.09 0.08 0.07 0.07
47 644 416 278 138 166 89 208 73 172 77 52 122 68 15 15 15 15 15 5 0.15 0.1 0.08 0.07 0.07 0.07
665 56 420 210 210 157 111 88 208 47 152 131 160 50 16 16 16 16 16 7 0.16 0.12 0.1 0.09 0.09 0.09
564 112 390 211 179 63 183 118 119 106 120 195 58 131 16 16 16 16 16 4 0.16 0.1 0.08 0.07 0.06 0.06
137 293 312 161 151 130 155 126 130 137 130 77 135 156 11 11 11 11 11 5 0.11 0.08 0.07 0.07 0.06 0.06
499 419 609 407 202 119 116 85 188 151 203 190 101 89 20 20 20 20 20 6 0.2 0.13 0.11 0.1 0.09 0.08
319 441 537 467 70 82 51 80 97 72 179 122 59 148 11 11 11 11 11 7 0.11 0.09 0.08 0.08 0.08 0.08
```

Raw Dataset: `pirp-15-5-1-10-2.dat`

```
15 5 1 10 2265
367 167 3000 3000 3000 3000 3000 3000 3000 3000 3000 3000 3000 0.73 0.95 0.98 0.28 1.05 1.41
435 220 370 242 128 35 69 126 133 85 145 57 185 49 14 14 14 14 14 7 0.14 0.1 0.09 0.09 0.08 0.08
23 995 432 321 111 45 95 103 126 81 105 144 62 95 12 12 12 12 12 7 0.12 0.1 0.09 0.08 0.08 0.08
```

```
537 990 346 199 147 139 162 121 73 109 82 57 169 173 15 15 15 15 15 7 0.15 0.11 0.1 0.09 0.09 0.08
128 906 406 351 55 203 125 98 68 36 163 32 198 112 17 17 17 17 17 6 0.17 0.12 0.1 0.09 0.08 0.08
770 659 624 584 40 135 77 118 138 40 208 35 162 106 12 12 12 12 12 5 0.12 0.09 0.07 0.07 0.06 0.06
307 326 615 415 200 83 73 87 174 196 200 205 100 92 12 12 12 12 12 6 0.12 0.09 0.08 0.07 0.07 0.07
693 58 525 486 39 30 117 175 102 120 73 102 47 32 12 12 12 12 12 4 0.12 0.08 0.07 0.06 0.06 0.05
616 254 543 469 74 181 166 118 170 143 42 99 148 76 14 14 14 14 14 4 0.14 0.09 0.07 0.07 0.06 0.06
912 848 618 422 196 54 104 206 162 168 58 202 161 100 12 12 12 12 12 6 0.12 0.09 0.08 0.07 0.07 0.07
331 270 420 257 163 136 171 210 79 86 178 193 187 181 15 15 15 15 15 4 0.15 0.1 0.08 0.07 0.06 0.06
140 396 380 209 171 164 48 123 73 190 172 35 44 188 10 10 10 10 10 4 0.1 0.07 0.06 0.06 0.05 0.05
679 177 525 418 107 175 133 71 109 127 169 175 153 122 19 19 19 19 19 4 0.19 0.12 0.09 0.08 0.07 0.07
671 680 386 331 55 121 170 124 124 48 193 97 113 141 14 14 14 14 14 5 0.14 0.1 0.08 0.07 0.07 0.07
688 423 606 521 85 170 99 105 90 202 113 120 170 123 11 11 11 11 11 4 0.11 0.07 0.06 0.06 0.05 0.05
820 87 588 450 138 115 196 174 126 113 120 139 86 86 13 13 13 13 13 5 0.13 0.09 0.08 0.07 0.07 0.06
```

Raw Dataset: `pirp-15-5-1-10-3.dat`

```
15 5 1 10 2231
605 974 3000 3000 3000 3000 3000 3000 3000 3000 3000 3000 3000 0.38 1.35 0.45 0.76 1.14 0.63
532 696 591 502 89 155 184 135 187 155 79 197 171 170 19 19 19 19 19 6 0.19 0.12 0.1 0.09 0.09 0.08
717 287 412 297 115 82 164 191 167 109 54 206 193 174 19 19 19 19 19 4 0.19 0.12 0.09 0.08 0.07 0.07
854 322 597 545 52 147 34 184 83 121 144 117 145 199 16 16 16 16 16 4 0.16 0.1 0.08 0.07 0.06 0.06
491 910 410 229 181 101 38 172 113 200 205 78 130 178 18 18 18 18 18 7 0.18 0.12 0.11 0.1 0.09 0.09
998 902 576 384 192 187 105 123 39 109 183 137 126 51 10 10 10 10 10 7 0.1 0.09 0.08 0.08 0.08 0.07
721 617 546 444 102 51 140 35 136 161 126 35 182 82 17 17 17 17 17 6 0.17 0.12 0.1 0.09 0.08 0.08
851 172 402 320 82 101 160 73 47 201 51 89 125 185 13 13 13 13 13 7 0.13 0.1 0.09 0.09 0.08 0.08
27 186 402 201 201 161 158 137 51 45 156 41 79 37 18 18 18 18 18 5 0.18 0.12 0.09 0.08 0.08 0.07
116 275 540 360 180 70 178 91 149 30 95 40 55 109 16 16 16 16 16 7 0.16 0.12 0.1 0.09 0.09 0.09
167 331 412 207 205 128 206 127 184 160 37 129 203 100 12 12 12 12 12 5 0.12 0.09 0.07 0.07 0.06 0.06
302 452 388 276 112 57 85 194 32 62 49 117 69 186 17 17 17 17 17 5 0.17 0.11 0.09 0.08 0.07 0.07
261 696 630 509 121 37 210 110 138 59 64 31 158 149 17 17 17 17 17 6 0.17 0.12 0.1 0.09 0.08 0.08
467 104 507 470 37 92 135 169 96 92 139 99 93 63 17 17 17 17 17 4 0.17 0.1 0.08 0.07 0.07 0.06
417 362 531 372 159 87 176 177 106 72 31 61 137 101 13 13 13 13 13 4 0.13 0.09 0.07 0.06 0.06 0.06
509 801 416 351 65 110 153 127 173 45 99 36 114 208 10 10 10 10 10 5 0.1 0.07 0.07 0.06 0.06 0.06
```

Raw Dataset: `pirp-15-5-1-10-4.dat`

```
15 5 1 10 2140
585 135 3000 3000 3000 3000 3000 3000 3000 3000 3000 3000 3000 1.39 0.18 0.79 1.0 1.47 1.22
947 632 410 373 37 205 114 41 203 150 101 146 187 152 13 13 13 13 13 5 0.13 0.09 0.08 0.07 0.07 0.06
92 315 411 367 44 129 75 137 67 117 99 124 32 81 10 10 10 10 10 5 0.1 0.07 0.07 0.06 0.06 0.06
96 907 621 554 67 95 170 143 114 123 169 71 207 89 20 20 20 20 20 7 0.2 0.14 0.11 0.1 0.1 0.09
728 908 406 366 40 198 203 90 153 136 96 110 136 168 19 19 19 19 19 5 0.19 0.12 0.1 0.09 0.08 0.07
501 103 362 229 133 102 137 181 83 33 46 54 76 64 15 15 15 15 15 5 0.15 0.1 0.08 0.07 0.07 0.07
303 565 591 485 106 197 124 148 56 59 76 80 195 131 17 17 17 17 17 6 0.17 0.12 0.1 0.09 0.08 0.08
395 713 410 236 174 152 108 160 149 205 158 65 98 117 15 15 15 15 15 5 0.15 0.1 0.08 0.07 0.07 0.07
802 324 555 510 45 172 55 87 33 65 185 100 102 45 17 17 17 17 17 7 0.17 0.12 0.1 0.1 0.09 0.09
```

```
78 766 597 465 132 42 171 185 196 73 146 199 52 95 12 12 12 12 12 6 0.12 0.09 0.08 0.07 0.07 0.07
824 76 282 164 118 141 67 136 46 118 76 73 137 107 13 13 13 13 13 7 0.13 0.1 0.09 0.09 0.08 0.08
62 899 412 305 107 60 206 150 149 63 51 49 108 78 10 10 10 10 10 5 0.1 0.07 0.07 0.06 0.06 0.06
596 733 296 161 135 111 59 148 48 107 142 81 119 83 15 15 15 15 15 5 0.15 0.1 0.08 0.07 0.07 0.07
779 836 404 373 31 175 89 92 134 75 65 155 192 202 19 19 19 19 19 7 0.19 0.13 0.11 0.1 0.09 0.09
565 483 570 503 67 117 63 90 129 98 133 190 135 109 20 20 20 20 20 5 0.2 0.12 0.1 0.09 0.08 0.07
853 646 380 204 176 111 46 190 111 45 183 90 135 153 16 16 16 16 16 5 0.16 0.1 0.09 0.08 0.07 0.07
```

Raw Dataset: `pirp-15-5-1-10-5.dat`

```
15 5 1 10 2282
324 295 3000 3000 3000 3000 3000 3000 3000 3000 3000 3000 3000 1.23 0.39 0.46 1.21 0.68 1.19
630 509 408 353 55 204 145 98 157 145 154 32 60 134 16 16 16 16 16 6 0.16 0.11 0.09 0.09 0.08 0.08
703 43 582 500 82 182 160 194 154 192 154 136 115 169 14 14 14 14 14 5 0.14 0.1 0.08 0.07 0.07 0.07
283 301 627 467 160 50 181 125 191 87 34 91 209 201 16 16 16 16 16 4 0.16 0.1 0.08 0.07 0.06 0.06
314 862 594 438 156 185 100 94 138 198 133 140 189 97 13 13 13 13 13 6 0.13 0.1 0.08 0.08 0.07 0.07
528 237 374 247 127 187 101 158 116 106 54 105 37 177 20 20 20 20 20 7 0.2 0.14 0.11 0.1 0.1 0.09
390 966 624 504 120 33 187 208 126 169 53 180 183 162 17 17 17 17 17 4 0.17 0.1 0.08 0.07 0.07 0.06
79 197 394 253 141 61 194 128 188 48 96 30 197 141 17 17 17 17 17 7 0.17 0.12 0.1 0.1 0.09 0.09
765 792 364 319 45 43 133 31 161 167 33 71 146 182 13 13 13 13 13 6 0.13 0.1 0.08 0.08 0.07 0.07
456 296 582 439 143 180 87 194 177 56 194 71 70 163 17 17 17 17 17 7 0.17 0.12 0.1 0.1 0.09 0.09
944 145 597 398 199 73 54 83 178 170 87 140 128 68 13 13 13 13 13 4 0.13 0.09 0.07 0.06 0.06 0.06
206 583 588 392 196 158 134 127 157 55 173 97 129 60 16 16 16 16 16 4 0.16 0.1 0.08 0.07 0.06 0.06
575 947 540 487 53 168 122 53 180 46 73 37 84 32 10 10 10 10 10 7 0.1 0.09 0.08 0.08 0.08 0.07
355 784 420 326 94 153 55 210 58 81 181 103 62 183 18 18 18 18 18 7 0.18 0.12 0.11 0.1 0.09 0.09
28 52 390 342 48 33 184 90 76 195 101 171 120 34 20 20 20 20 20 5 0.2 0.12 0.1 0.09 0.08 0.07
463 852 528 458 70 71 47 128 90 174 140 32 147 176 20 20 20 20 20 6 0.2 0.13 0.11 0.1 0.09 0.08
```

Raw Dataset: `pirp-20-2-2-3-1.dat`

```
20 2 2 3  1566
134 181 5012 5012 5012 5012 0.15 1.11 0.84
21 266 324 245 79 117 162 12 10 5 0.6 1.03 1.16
528 839 486 380 106 70 162 16 11 5 0.9 0.72 0.49
437 853 356 178 178 95 125 13 11 4 0.22 1.15 0.97
888 610 400 200 200 78 129 10 9 5 0.77 0.86 1.43
368 298 606 404 202 127 191 16 10 4 0.95 0.56 0.98
0 325 432 347 85 142 144 12 9 6 0.83 0.37 0.66
762 972 492 337 155 147 164 12 12 4 0.16 1.08 0.75
491 172 600 519 81 174 200 19 12 4 0.37 0.8 0.61
361 83 537 482 55 61 179 10 9 4 0.12 1.01 0.55
969 636 244 175 69 91 122 14 10 4 0.56 0.43 1.23
393 790 417 278 139 85 102 11 11 6 0.09 0.62 0.37
468 156 375 276 99 125 125 13 11 6 0.33 0.73 0.97
75 364 386 193 193 40 50 19 13 6 0.24 0.53 1.03
981 475 366 183 183 53 114 17 9 6 0.11 0.5 0.29
```

```
487 472 444 296 148 126 53 12 10 6 0.57 1.18 0.53
305 30 366 336 30 183 175 18 12 5 0.59 0.45 0.16
708 723 352 176 176 53 79 13 10 5 0.57 0.3 1.06
180 743 531 480 51 177 99 14 12 4 0.99 1.18 0.16
94 649 339 256 83 113 37 19 11 4 0.51 0.46 0.61
722 287 423 282 141 44 123 19 10 6 0.43 0.76 0.95
```

Raw Dataset: `pirp-20-2-2-3-2.dat`

```
20 2 2 3  1532
847 666 4903 4903 4903 4903 0.48 0.49 0.08
169 349 615 410 205 43 195 16 12 5 0.82 0.85 0.58
651 200 280 140 140 92 109 19 8 5 0.19 1.05 0.95
760 334 462 308 154 82 36 12 9 6 0.6 0.14 0.79
949 646 368 184 184 119 120 10 12 5 0.91 0.63 1.19
381 570 254 174 80 127 91 19 8 4 0.36 0.69 0.74
59 805 327 218 109 44 76 19 10 5 0.97 0.93 0.76
119 376 594 396 198 58 56 13 11 5 0.01 0.6 0.38
318 703 540 360 180 121 109 18 11 4 0.15 1.07 0.43
871 862 338 288 50 169 139 19 9 4 0.69 0.91 1.39
395 466 321 214 107 57 51 11 12 5 0.21 0.52 0.56
591 452 624 562 62 208 207 19 8 6 0.06 0.45 0.58
542 319 408 204 204 99 152 17 8 6 0.71 1.07 1.2
257 406 333 261 72 111 84 16 10 6 0.52 0.94 1.24
160 739 471 314 157 138 39 13 8 5 0.33 0.68 0.82
18 385 528 352 176 74 35 12 9 6 0.32 0.71 0.68
193 333 314 241 73 157 60 10 9 5 0.07 0.54 1.3
718 148 531 354 177 152 66 18 9 5 0.21 0.76 0.71
181 176 412 314 98 48 206 12 9 5 0.77 0.57 0.49
48 845 300 150 150 74 150 17 12 6 0.89 0.53 0.74
664 96 564 481 83 36 188 14 11 5 0.59 0.02 0.64
```

Raw Dataset: `pirp-20-2-2-3-3.dat`

```
20 2 2 3  1700
528 829 5440 5440 5440 5440 0.43 0.76 1.14
188 931 531 354 177 135 177 12 9 5 0.67 1.02 0.72
990 815 621 462 159 207 191 17 12 6 0.74 0.41 0.48
421 707 450 309 141 150 37 19 12 6 0.56 0.78 1.2
708 394 615 410 205 91 77 17 8 6 0.89 0.53 0.47
61 634 340 211 129 170 80 10 10 5 0.6 0.31 0.79
814 477 354 177 177 103 58 19 8 5 0.27 0.7 0.8
261 86 594 467 127 198 163 16 10 4 0.35 0.5 0.37
300 587 516 483 33 172 138 17 8 4 0.13 1.26 1.24
759 423 408 204 204 43 112 13 11 4 0.16 0.63 0.72
477 574 414 207 207 44 117 11 8 5 0.8 0.17 1.09
```

```
742 584 513 365 148 55 171 14 10 6 0.13 0.68 1.03
993 396 380 281 99 157 190 18 8 6 0.85 0.58 0.74
178 601 256 128 128 94 107 12 10 5 0.06 0.61 1.17
316 4 322 198 124 130 161 14 7 6 0.48 1.16 0.54
402 43 230 150 80 115 100 15 8 4 0.67 0.38 0.6
960 292 426 288 138 142 39 14 10 6 0.72 0.41 0.82
229 324 510 340 170 112 89 12 10 6 0.22 1.1 1.33
714 55 414 207 207 125 164 19 12 4 0.41 0.76 1.22
421 833 336 293 43 168 156 11 13 6 0.85 0.41 0.14
246 917 354 233 121 59 177 18 10 4 0.16 0.51 0.89
```

Raw Dataset: `pirp-20-2-2-3-4.dat`

```
20 2 2 3  1558
495 108 4988 4988 4988 4988 0.65 0.87 0.46
427 577 141 94 47 45 45 18 9 6 0.55 0.91 0.67
145 676 549 366 183 49 175 16 12 6 0.67 0.56 0.69
522 633 324 162 162 127 38 16 11 4 0.94 0.15 0.83
871 923 378 318 60 59 189 14 13 4 0.58 0.61 1.34
827 76 402 361 41 201 143 10 9 4 0.64 1.1 0.75
464 379 492 384 108 105 164 16 10 6 0.33 0.21 0.74
417 360 408 352 56 204 160 12 12 6 0.61 0.47 0.84
670 609 402 220 182 201 176 14 12 6 0.47 1.04 0.84
8 794 552 461 91 184 76 12 12 4 0.06 0.48 1.15
539 763 468 431 37 66 156 10 11 5 0.69 0.27 0.68
626 356 302 151 151 81 95 19 11 5 0.77 0.97 0.8
999 17 372 303 69 124 77 18 11 5 0.56 0.95 0.71
253 26 507 439 68 73 169 10 12 6 0.02 0.63 1.24
722 136 414 207 207 185 42 13 11 4 0.19 0.96 0.48
444 353 591 394 197 84 45 13 13 5 0.85 1.14 0.59
206 754 567 528 39 189 102 18 9 4 0.63 0.97 0.91
586 921 372 196 176 170 186 13 12 4 0.15 1.21 0.65
814 501 438 292 146 71 115 12 12 6 0.28 0.55 0.89
109 169 528 352 176 45 50 10 12 4 0.48 0.66 0.52
567 910 262 134 128 131 119 10 8 6 0.36 0.72 1.27
```

Raw Dataset: `pirp-20-2-2-3-5.dat`

```
20 2 2 3  1572
738 225 5032 5032 5032 5032 0.93 1.2 0.08
839 564 356 251 105 55 178 10 10 5 0.34 1.14 1.23
617 919 558 372 186 140 120 19 8 5 0.85 0.38 0.92
869 912 408 204 204 126 169 19 12 6 0.95 0.11 1.16
297 665 255 175 80 85 62 12 9 6 0 0.49 0.32
165 903 334 259 75 163 167 16 12 4 0.06 1.21 0.99
254 517 624 545 79 208 165 16 8 5 0.15 0.37 0.65
```

```
814 187 183 130 53 31 61 16 9 4 0.73 0.22 0.61
305 812 609 510 99 74 203 15 10 4 0.75 0.7 0.48
529 334 294 248 46 81 147 12 9 5 0.73 0.4 0.27
596 105 600 422 178 105 200 13 8 6 0.02 0.07 0.83
975 765 456 373 83 152 30 11 10 6 0.77 1.04 1.24
209 105 304 173 131 121 152 12 9 6 0.31 0.64 0.3
466 310 585 506 79 164 195 17 9 5 0.32 1.21 0.61
864 516 609 546 63 117 203 11 13 4 0.67 1.01 0.54
174 760 300 153 147 118 150 11 11 6 0.4 0.29 1.08
211 97 480 320 160 36 83 10 8 6 0 0.26 0.98
581 362 309 206 103 64 52 17 10 6 0.29 0.45 0.55
896 607 236 118 118 114 110 13 12 6 0.37 0.73 0.62
123 276 426 312 114 34 142 19 12 6 0.21 0.47 0.08
358 36 394 197 197 70 156 12 7 4 0.78 0.06 0.83
```

Raw Dataset: `pirp-20-3-2-6-1.dat`

```
20 3 2 6  1617
819 315 5177 5177 5177 5177 5177 5177 5177 0.87 0.92 1.17 0.04
443 579 579 520 59 193 46 102 191 152 18 10 11 4 0.28 0.55 0.7 0.58
820 480 618 412 206 96 157 122 187 134 14 11 10 5 0.94 0.61 0.32 0.89
801 676 585 390 195 125 152 161 65 79 10 9 9 4 0.71 0.83 1.1 1.33
141 342 567 404 163 36 189 160 44 118 13 10 9 5 0.37 0.44 0.42 0.84
158 725 392 317 75 65 170 31 102 196 15 10 9 5 0.52 0.52 0.83 0.81
860 650 621 455 166 180 37 184 143 207 16 12 7 6 0.32 0.63 0.25 1.21
939 763 412 281 131 153 30 182 59 206 13 10 10 6 0.04 0.5 0.5 1.19
919 931 543 414 129 141 137 97 74 181 17 9 9 5 0.28 0.62 1.19 0.94
695 10 376 206 170 148 36 188 82 153 12 10 9 6 0.79 0.39 1.08 1.22
3 35 324 162 162 129 47 110 123 147 18 12 8 5 0.07 0.68 0.33 0.75
408 329 612 542 70 111 204 95 147 170 19 12 7 5 0.13 0.27 1.22 0.17
776 847 366 324 42 119 76 85 165 183 10 11 10 6 0.26 0.62 1.02 0.68
908 853 418 342 76 48 55 104 209 164 16 13 10 4 0.03 0.4 0.98 1.14
861 602 558 423 135 61 186 71 33 147 18 10 9 5 0.6 0.46 0.4 1.01
290 950 408 252 156 81 110 85 197 204 19 10 9 5 0.33 1.1 0.85 0.87
977 535 609 508 101 135 158 31 203 73 19 9 9 4 0.64 0.85 0.5 0.97
883 764 328 278 50 164 121 41 48 66 10 11 9 6 0.97 0.57 0.5 0.99
255 339 576 437 139 179 145 192 170 98 16 9 9 5 0.25 0.67 0.96 0.64
520 563 400 203 197 48 98 59 200 137 13 10 9 5 0.6 0.36 0.35 0.98
887 254 558 470 88 70 98 186 139 63 11 11 10 4 0.57 1.1 0.38 0.59
```

Raw Dataset: `pirp-20-3-2-6-2.dat`

```
20 3 2 6  1623
900 111 5194 5194 5194 5194 5194 5194 5194 0.58 0.38 0.77 0.56
72 876 364 294 70 59 92 97 182 179 16 13 9 6 0.63 0.46 1.03 0.88
532 146 522 442 80 174 126 33 100 142 17 10 10 6 0.36 0.94 0.14 0.99
```

941 821 406 317 89 199 69 198 167 203 15 13 9 5 0.64 1.07 0.93 0.41
820 263 388 229 159 45 182 133 101 194 17 10 9 5 0.7 1.28 1.34 1.09
277 354 576 481 95 81 179 136 192 159 18 14 9 5 0.89 0.22 0.67 1
112 865 612 456 156 107 204 196 111 66 16 10 8 6 0.94 0.38 0.65 0.18
12 543 624 533 91 187 208 61 65 78 11 10 8 4 0.33 1.06 0.85 0.56
688 380 398 325 73 145 163 199 41 40 19 9 8 6 0.95 1.06 0.89 0.77
745 603 534 421 113 178 140 102 140 108 16 12 8 5 0.68 0.4 0.92 0.41
691 369 612 569 43 199 204 190 121 117 19 10 9 4 0.82 0.31 0.48 0.64
950 325 570 430 140 164 151 190 170 109 12 13 9 6 0.93 0.45 0.62 1.01
283 103 360 223 137 84 178 142 59 180 12 12 9 5 0.43 1.1 0.32 0.5
235 662 382 273 109 191 152 127 99 112 12 13 8 5 0.16 0.5 0.63 0.77
981 461 507 451 56 115 84 109 77 169 15 11 9 5 0.82 0.9 0.51 0.8
35 971 386 299 87 193 57 178 180 167 12 14 10 4 0.94 0.77 0.88 0.56
259 385 416 376 40 122 83 45 114 208 14 13 6 5 0.29 0.29 1.02 0.47
264 117 370 273 97 156 185 82 130 102 15 12 9 5 0.29 0.37 0.45 0.64
206 126 603 569 34 39 134 134 198 201 10 11 7 5 0.27 0.58 0.38 0.38
35 243 570 495 75 190 146 109 103 57 14 9 7 6 0.75 0.97 0.65 1.11
121 850 342 171 171 76 50 46 31 111 17 9 7 5 0.07 0.07 0.69 0.54

Raw Dataset: `pirp-20-3-2-6-3.dat`

20 3 2 6 1574
770 294 5038 5038 5038 5038 5038 5038 5038 0.25 1.22 1.1 0.66
610 703 350 225 125 56 146 149 175 65 10 14 10 6 0.23 1.02 0.6 0.59
575 831 537 492 45 153 94 168 179 104 18 12 7 6 0.13 0.43 0.14 0.24
157 452 384 233 151 134 81 169 192 78 19 13 8 6 0.47 0.97 0.99 1.09
680 76 394 319 75 197 115 69 94 163 15 14 8 6 0.63 0.34 0.58 1.3
935 320 603 477 126 131 201 100 178 32 13 9 9 4 0.51 0.41 0.72 0.74
256 527 477 318 159 73 41 32 152 106 12 9 10 4 0.16 0.93 0.1 0.33
737 483 534 415 119 159 178 126 164 62 10 13 9 4 0.12 0.49 0.63 0.48
394 22 390 276 114 50 108 67 195 184 14 9 10 5 0.88 0.98 0.95 0.57
366 854 408 342 66 160 188 204 163 105 18 12 8 6 0.91 1 0.61 0.88
799 780 501 418 83 72 167 101 67 160 15 11 8 5 0.85 0.71 0.6 0.41
77 990 308 156 152 112 154 136 85 103 12 14 8 4 0.46 1.05 0.49 0.65
605 435 600 476 124 156 187 192 200 80 10 9 8 4 0.6 0.56 0.68 1
982 643 332 258 74 111 57 166 34 156 16 14 8 6 0.13 0.58 0.48 0.76
142 585 384 192 192 112 67 151 171 48 13 9 9 4 0.86 0.96 1.25 1.33
375 883 360 321 39 120 83 77 83 96 13 11 6 6 0.56 0.18 1.08 1.2
573 957 486 324 162 38 123 108 93 81 13 15 7 5 0.66 0.79 1.16 1.41
27 733 298 243 55 59 149 51 129 110 17 9 10 6 0.9 1.27 0.56 1.18
812 118 408 311 97 204 182 91 80 149 18 9 7 4 0.63 0.25 1.2 0.87
537 671 603 517 86 201 139 140 93 168 10 14 7 4 0.79 0.61 1.35 0.46
930 941 627 520 107 173 103 35 209 122 10 9 9 6 0.85 0.82 0.61 0.55

Raw Dataset: `pirp-20-3-2-6-4.dat`

```
20 3 2 6  1615
842 797 5169 5169 5169 5169 5169 5169 5169 0.11 1.08 0.2 0.76
825 294 390 349 41 171 77 195 100 117 14 12 9 6 0.08 0.74 1.27 0.51
801 372 406 253 153 135 53 83 129 203 19 14 8 5 0.11 0.75 1.18 0.51
56 749 441 326 115 83 147 105 68 136 14 10 8 4 0.75 0.65 0.36 0.78
301 289 402 211 191 173 44 201 185 129 15 13 7 5 0.31 0.99 0.33 1.08
975 19 546 480 66 63 176 155 182 115 10 10 8 5 0.82 0.91 0.9 0.54
441 709 356 321 35 178 158 130 106 160 14 14 6 4 0.73 1.03 0.56 0.6
462 100 388 254 134 86 194 95 84 190 11 10 10 5 0.51 0.43 1.02 0.72
63 150 429 315 114 103 56 123 97 143 10 14 7 4 0.1 1.17 1.3 0.47
447 188 336 298 38 165 168 72 163 92 14 13 8 6 0.34 0.52 1.17 0.69
428 489 398 269 129 199 177 187 123 61 14 15 8 4 0.54 1.12 0.74 0.5
983 563 480 322 158 160 60 157 104 134 15 12 8 5 0.37 0.99 0.66 0.77
893 473 394 200 194 152 197 110 73 93 19 11 7 6 0.19 0.45 1.04 1.16
259 430 543 444 99 59 152 51 127 181 13 11 8 4 0.82 0.31 0.23 0.86
29 534 394 305 89 197 45 74 169 162 15 12 9 6 0.26 0.4 0.4 1.25
759 494 606 565 41 195 45 67 202 89 18 8 8 6 0.58 0.47 0.51 0.27
547 837 522 348 174 171 78 63 112 59 16 14 10 4 0.39 0.61 0.75 0.41
322 902 390 248 142 48 195 80 99 92 12 9 6 4 0.64 0.95 0.93 0.41
977 417 378 289 89 40 53 87 189 122 12 10 10 4 0.58 0.84 0.63 0.96
943 302 627 535 92 138 157 143 122 209 14 10 8 4 0.14 0.79 0.92 0.61
57 169 576 470 106 70 77 147 119 192 18 12 8 6 0.21 0.42 0.16 0.51
```

Raw Dataset: `pirp-20-3-2-6-5.dat`

```
20 3 2 6  1591
596 515 5093 5093 5093 5093 5093 5093 5093 0.04 0.1 0.48 0.43
487 592 370 300 70 51 185 173 178 63 15 9 8 5 0.75 0.23 0.43 0.5
130 681 380 300 80 82 190 130 79 55 14 13 7 4 0.9 1.14 1.11 0.98
781 179 292 247 45 99 122 92 146 36 14 13 9 5 0.1 0.71 0.67 1.19
348 423 594 448 146 36 100 198 37 161 12 9 8 4 0.36 0.61 0.98 0.47
790 530 456 336 120 152 147 115 101 78 11 12 9 6 0.97 0.84 0.89 0.59
541 779 360 210 150 70 71 94 109 180 17 11 8 6 0.84 0.86 0.31 0.54
982 558 364 277 87 67 54 182 92 146 10 12 7 5 0.41 0.88 0.73 0.33
36 921 314 167 147 144 96 153 157 107 10 14 10 4 0.18 0.6 0.69 1.11
424 364 416 323 93 45 160 201 208 168 13 15 8 5 0.43 0.72 0.63 0.44
82 524 576 442 134 182 63 192 77 112 12 10 7 5 0.12 0.66 0.32 1.04
382 848 591 408 183 59 197 87 80 172 10 11 9 4 0.21 1.16 1.2 0.75
584 696 615 527 88 205 100 50 205 107 18 11 9 6 0.46 0.65 0.94 1.03
180 646 410 292 118 31 132 205 115 54 15 11 10 5 0.75 0.81 0.59 0.73
932 907 525 398 127 175 67 132 109 35 11 13 10 4 0.18 0.7 0.5 1.3
706 526 414 335 79 141 71 159 71 207 11 8 8 6 0.97 0.7 0.67 0.87
461 129 374 222 152 56 153 31 187 118 18 10 8 6 0.62 0.3 1.19 0.45
117 594 468 312 156 87 120 137 68 149 12 12 9 5 0.66 0.65 0.76 0.98
461 960 354 308 46 177 100 130 62 160 11 14 7 4 0.19 1.08 0.77 0.75
```

889 807 418 378 40 44 209 204 200 114 19 13 6 5 0.81 0.81 0.4 0.29
903 68 597 560 37 73 199 133 159 187 12 12 9 5 0.25 0.96 0.62 0.84

Raw Dataset: `pirp-20-5-2-10-1.dat`

```
20 5 2 10  1568
484 755 5018 5018 5018 5018 5018 5018 5018 5018 5018 5018 5018 0.9 0.14 0.42 0.55 1.06 1.03
786 4 408 204 204 163 187 35 178 51 190 139 173 30 16 10 12 7 9 6 0.58 0.78 0.79 0.33 1.25 0.7
569 538 606 531 75 90 112 127 202 98 151 87 157 119 18 9 13 8 7 6 0.39 0.94 0.75 0.57 0.26 0.75
492 930 344 273 71 144 172 160 141 153 50 70 164 168 15 16 11 10 7 4 0.34 1.12 0.66 0.37 1.33 0.43
576 337 402 201 201 142 46 159 104 38 82 118 72 147 19 11 12 9 7 6 0.2 0.26 0.91 1.19 0.81 1.08
147 916 597 503 94 53 51 31 41 199 40 130 120 72 19 13 13 10 8 5 0.81 0.34 0.81 0.93 0.42 0.36
136 435 418 332 86 70 209 180 137 176 36 178 117 207 16 14 11 9 7 4 0.37 0.25 0.37 0.46 0.75 0.63
688 861 410 346 64 179 205 113 165 181 161 90 30 47 11 14 9 9 7 6 0.74 0.47 0.33 0.93 0.67 1.37
984 194 398 326 72 198 59 89 38 199 123 166 113 116 16 16 8 8 7 4 0.36 0.09 0.41 0.76 0.78 0.99
565 595 412 298 114 124 139 201 67 175 87 206 52 64 12 14 9 11 7 4 0.65 0.9 0.22 0.69 0.69 0.97
443 712 546 369 177 85 91 83 57 148 50 79 85 182 13 14 13 9 9 4 0.53 0.34 0.14 1.32 1.09 1.05
723 193 400 255 145 43 84 117 34 87 141 74 200 114 11 14 13 9 8 4 0.26 1.11 0.95 1.18 0.82 1.18
93 555 600 544 56 56 117 193 154 60 78 200 158 191 14 16 11 12 7 5 0.51 0.91 0.52 0.04 0.59 0.98
510 428 410 268 142 205 141 123 152 166 50 66 89 86 15 9 14 8 6 4 0.97 0.78 0.63 0.98 1.11 0.7
730 421 390 230 160 184 95 88 122 38 56 68 195 103 18 15 12 8 8 4 0.07 0.58 0.87 0.28 0.54 1.4
271 150 356 283 73 114 81 147 51 43 100 178 162 139 16 11 14 8 9 6 0.81 0.57 0.6 0.4 0.32 0.94
882 865 624 537 87 48 207 196 208 110 38 116 111 134 18 13 10 10 6 6 0.33 0.3 0.99 0.46 0.33 0.6
554 281 388 322 66 167 192 171 44 194 128 124 159 128 18 14 11 8 8 5 0.16 0.72 1.04 1.15 0.58 1.08
711 114 398 199 199 167 179 117 63 165 70 134 161 49 14 14 9 10 8 5 0.26 0.18 0.43 0.49 0.36 0.88
638 23 615 410 205 123 107 44 68 190 150 31 156 94 12 13 9 8 8 5 0.52 0.32 1.13 1.04 0.63 0.87
488 461 504 392 112 129 158 48 96 168 132 100 32 154 14 12 10 11 8 6 0.96 0.85 0.72 0.02 0.75 0.53
```

Raw Dataset: `pirp-20-5-2-10-2.dat`

```
20 5 2 10  1594
717 967 5102 5102 5102 5102 5102 5102 5102 5102 5102 5102 5102 0.67 0.87 0.58 0.58 1.19 0.93
3 751 597 418 179 36 199 32 44 96 52 86 116 136 18 16 9 12 6 4 0.33 0.29 0.42 1.11 1 0.65
486 701 597 469 128 117 146 55 142 169 138 199 154 96 11 11 8 12 8 6 0.5 0.13 0.98 0.3 0.77 0.63
484 495 398 199 199 197 42 137 126 80 171 175 71 122 10 10 13 11 7 4 0.26 0.83 0.57 0.53 0.66 0.97
352 388 615 509 106 54 194 198 64 70 205 168 176 58 11 13 11 8 8 6 0.14 0.6 0.92 0.83 0.71 1.05
387 535 606 563 43 103 183 71 184 135 131 198 202 82 19 12 8 11 8 4 0.16 0.92 1.03 0.49 0.2 0.83
54 382 609 479 130 64 128 182 63 175 69 159 203 168 18 12 9 8 7 5 0.71 0.91 0.44 0.5 0.25 1.13
240 512 286 233 53 41 88 63 96 143 138 97 74 106 10 16 11 10 8 6 0.05 0.42 1.05 0.14 0.54 0.85
445 336 393 305 88 123 37 36 89 50 61 62 67 131 12 13 9 9 7 4 0.69 0.62 0.34 0.4 0.67 1.07
627 216 406 306 100 170 55 73 203 112 190 45 162 164 14 17 10 10 7 5 0.05 0.4 0.71 0.92 0.87 1.34
114 900 412 292 120 206 91 75 142 78 43 62 64 187 19 14 10 8 8 5 0.52 0.82 0.22 0.53 0.9 0.99
405 706 394 256 138 162 51 115 42 145 128 103 177 197 17 16 12 10 7 5 0.94 0.54 1.16 0.98 0.45 1.04
668 12 513 381 132 71 157 171 77 154 170 49 148 37 13 10 8 9 7 5 0.77 0.73 1.14 0.7 0.8 1.06
223 301 558 372 186 155 121 65 108 129 169 50 167 162 17 14 11 11 7 6 0.01 0.28 0.9 0.85 0.34 0.56
513 995 416 233 183 65 152 187 103 167 208 52 168 155 10 12 12 10 8 6 0.34 1.07 0.58 1.24 0.83 0.76
```

830 138 540 460 80 68 60 78 70 113 153 180 79 173 10 12 13 11 9 5 0.97 0.68 0.57 0.89 1.23 0.76
835 709 627 477 150 158 49 113 119 199 123 82 209 154 13 14 12 10 8 6 0.6 1.24 0.48 0.52 0.68 0.72
672 317 606 539 67 161 202 191 104 190 33 154 82 88 17 10 9 9 6 5 0.23 0.3 0.3 0.68 1.14 0.55
603 895 402 246 156 103 189 35 73 201 124 42 184 104 11 14 9 8 6 6 0.16 1.19 0.02 0.84 0.67 0.61
687 302 603 569 34 117 56 108 201 191 163 49 87 87 14 9 9 10 7 5 0.37 0.15 1.01 1.1 0.32 0.26
268 155 406 358 48 67 138 105 107 125 119 95 195 203 16 16 13 9 8 5 0.23 0.81 1.15 1.03 0.13 0.92

Raw Dataset: `pirp-20-5-2-10-3.dat`

20 5 2 10 1603
950 249 5129 5129 5129 5129 5129 5129 5129 5129 5129 5129 5129 0.92 0.46 0.12 1.03 0.69 0.6
188 712 354 193 161 105 88 177 43 30 126 151 174 118 19 11 9 8 7 4 0.55 0.58 0.88 0.41 0.56 0.28
183 227 378 222 156 93 189 117 67 98 161 110 145 80 11 13 11 7 8 5 0 0.45 0.46 0.41 1.13 0.94
112 725 414 277 137 42 72 60 67 207 99 115 199 130 18 13 12 7 8 6 0.95 0.51 0.94 1.39 0.36 1.18
831 765 627 503 124 159 189 44 121 81 161 130 209 119 12 15 10 8 9 6 0.5 0.91 1.07 1.36 0.31 0.63
975 395 378 311 67 92 163 157 127 95 54 189 157 58 15 12 12 7 9 5 0.85 0.48 1.12 1.19 1.4 0.73
165 861 609 497 112 191 92 141 203 140 108 55 65 116 19 11 13 8 9 4 0.33 0.08 1.3 0.93 0.46 1.11
671 679 603 455 148 52 100 106 143 165 139 201 190 128 18 10 13 9 6 4 0.79 0.58 0.81 0.76 0.76 1.34
94 434 400 242 158 112 124 129 130 35 200 110 194 178 14 11 12 9 8 6 0.12 0.05 1.22 0.59 0.75 0.75
727 640 392 255 137 123 138 157 39 192 31 196 105 45 10 10 13 10 8 4 0.07 0.87 0.69 0.2 0.18 0.65
840 919 348 290 58 174 67 126 173 115 158 171 94 159 16 11 13 10 7 5 0.51 0.69 0.25 1.43 0.67 0.23
975 61 588 512 76 196 128 77 84 61 188 153 112 34 12 14 9 8 8 4 0.59 1.23 0.38 0.66 1.1 1.31
927 123 552 410 142 184 172 147 87 180 40 62 179 82 11 10 11 8 8 5 0.92 0.52 1.23 0.6 0.98 1.3
563 310 328 205 123 164 126 47 89 65 110 109 117 81 13 12 12 7 7 4 0.11 1.09 0.74 0.55 1.51 1.25
774 386 414 223 191 72 160 114 163 75 84 207 166 49 17 13 12 7 7 5 0.11 1 0.98 0.46 1.32 0.69
108 777 594 454 140 125 58 160 108 144 198 156 168 105 10 16 10 9 6 5 0.22 0.34 1.08 0.57 0.37 0.36
269 502 394 214 180 122 34 127 163 74 97 30 197 77 17 12 14 9 8 4 0.62 0.99 0.89 0.49 0.8 0.23
732 725 609 560 49 91 167 148 114 128 203 144 203 90 14 12 12 9 6 6 0.93 0.37 1.24 0.74 1.27 0.73
222 241 591 419 172 182 76 104 197 180 142 56 165 116 10 16 9 12 7 6 0.66 1.09 0.64 1 1.06 0.35
596 808 416 376 40 31 189 127 144 163 208 91 49 161 11 10 11 10 8 5 0.41 1.25 0.98 0.73 1.25 0.56
109 917 368 265 103 152 96 54 184 32 135 68 153 88 17 12 13 7 7 5 0.8 0.77 0.18 1.06 0.27 0.4

Raw Dataset: `pirp-20-5-2-10-4.dat`

20 5 2 10 1556
27 383 4979 4979 4979 4979 4979 4979 4979 4979 4979 4979 4979 0.97 0.45 1.2 0.85 0.61 0.57
794 713 567 537 30 182 90 114 180 77 69 67 46 189 11 15 12 10 8 4 0.14 0.53 0.94 1.11 0.96 0.76
232 173 400 364 36 62 147 67 200 113 120 162 107 124 15 12 14 8 8 6 0.77 0.13 0.25 0.67 1.42 0.56
373 174 410 344 66 187 149 32 69 161 205 199 178 150 14 13 10 10 6 4 0.53 0.46 0.14 0.12 0.51 1.12
362 282 406 203 203 173 131 195 46 65 102 162 30 116 19 16 13 8 8 5 0.98 0.58 0.85 1.03 0.77 0.85
669 651 404 242 162 202 190 120 90 84 142 104 134 74 16 10 9 7 7 4 0.79 1.02 0.15 0.72 0.5 1.01
253 920 408 284 124 44 175 168 108 204 152 70 196 170 14 11 9 11 7 5 0.46 0.23 0.8 0.61 0.61 1.1
99 202 384 278 106 130 167 66 170 192 38 113 110 92 14 16 11 10 8 5 0.54 0.22 1.15 0.93 0.66 0.7
789 983 540 388 152 151 163 86 111 62 180 83 169 124 10 11 10 7 7 6 0.5 0.7 0.57 0.66 0.71 0.84
264 476 368 184 184 134 163 151 111 92 174 59 95 96 15 15 12 8 7 6 0.78 0.46 0.56 1.17 0.52 1.25
451 961 549 366 183 82 43 122 58 48 98 156 38 75 13 13 14 10 9 4 0.91 0.68 0.76 0.43 0.96 1.16

```
476 382 609 509 100 163 112 197 150 203 178 198 186 103 17 13 11 8 6 5 0.3 0.37 0.7 0.87 0.41 0.37
201 709 609 488 121 185 183 194 132 139 169 203 170 186 12 12 12 10 7 6 0.63 0.54 0.47 0.39 0.69 0.72
266 358 618 569 49 163 46 206 139 180 47 151 55 51 16 14 10 9 7 4 0.12 0.58 0.88 0.82 0.83 1.14
885 923 615 584 31 118 205 52 46 32 50 175 156 129 17 9 12 11 6 6 0.09 0.44 0.59 1.12 0.25 0.76
456 827 324 265 59 33 144 158 34 141 54 113 162 31 17 16 11 10 6 6 0.32 1.21 0.46 0.74 0.59 0.05
609 16 396 198 198 65 78 72 135 34 31 48 118 78 13 11 11 7 8 4 0.24 0.13 0.32 0.54 0.16 0.75
686 735 621 489 132 55 182 53 105 51 41 137 207 64 15 13 10 8 9 4 0.69 0.97 0.56 0.42 0.23 0.1
322 18 555 370 185 32 169 91 34 155 99 87 36 114 15 11 12 10 7 5 0.74 0.61 1.11 0.61 1.15 0.79
458 237 352 199 153 75 88 58 97 122 88 33 176 56 10 10 13 7 7 4 0.94 0.6 0.34 0.66 0.61 0.73
30 300 398 243 155 137 183 181 61 142 199 132 188 111 18 13 12 7 9 5 0.68 0.98 0.71 0.95 1.23 0.29
```

Raw Dataset: `pirp-20-5-2-10-5.dat`

```
20 5 2 10  1567
639 618 5016 5016 5016 5016 5016 5016 5016 5016 5016 5016 5016 0.07 0.48 0.58 0.94 0.85 1.28
455 208 406 325 81 157 132 34 52 203 152 90 122 174 17 11 12 7 9 6 0.18 0.87 0.82 1.09 0.59 1.09
193 367 453 334 119 145 74 84 121 70 112 80 108 151 18 15 14 12 7 6 0.86 0.58 1.41 0.27 0.61 1.17
653 371 597 506 91 199 48 32 194 121 51 102 180 89 19 10 14 10 7 5 0.89 0.6 0.92 0.34 1.13 0.43
32 711 416 280 136 101 109 67 176 43 159 169 152 208 11 12 11 11 7 4 0.83 0.75 0.54 0.61 0.61 0.44
710 800 396 215 181 54 66 52 68 198 43 133 93 187 14 13 14 9 7 4 0 1.18 0.87 0.55 0.37 1.03
17 561 358 191 167 179 58 144 106 129 116 155 61 142 17 10 12 8 7 4 0.8 0.48 0.8 0.69 1.31 1.04
36 721 618 466 152 163 206 137 175 183 98 72 84 107 11 9 11 8 8 5 0.83 0.4 0.18 1.15 1.01 1.43
777 45 597 475 122 133 173 199 142 130 52 45 165 196 16 12 9 10 8 4 0.34 0.16 0.35 0.72 0.46 1.17
202 727 384 212 172 192 186 158 160 83 55 177 70 172 16 16 9 9 8 4 0.11 0.53 0.42 0.4 0.86 1.04
507 135 386 335 51 117 38 193 66 140 72 137 183 100 10 14 12 9 6 5 0.29 0.42 0.89 0.75 1.18 0.97
754 812 358 256 102 81 73 44 50 120 179 150 61 171 10 16 10 9 6 4 0.97 0.61 1.13 0.79 0.78 0.92
691 806 374 225 149 90 130 162 144 56 187 96 45 87 12 16 12 10 6 6 0.67 1.31 1.14 0.99 0.74 0.7
554 593 489 383 106 131 62 163 133 85 61 124 72 93 16 11 14 9 8 5 0.26 0.31 0.52 0.88 0.74 1.24
222 314 579 406 173 35 193 109 84 59 162 173 57 70 18 16 13 11 6 5 0.65 0.34 0.49 0.93 0.81 0.62
771 371 579 386 193 49 73 53 152 47 99 117 144 49 14 16 11 9 7 6 0.47 0.77 0.72 0.65 0.75 0.78
503 721 585 390 195 82 96 86 75 59 157 87 106 192 10 14 8 11 6 5 0.64 0.68 0.32 0.45 1 1.3
157 563 332 166 166 39 78 148 134 121 161 39 37 163 18 9 9 8 6 4 0.35 0.76 0.94 1.13 1.11 1.13
173 205 400 245 155 193 182 109 34 51 132 200 166 100 19 16 9 11 8 5 0.95 1.23 0.59 0.41 0.34 0.88
954 185 627 460 167 124 144 110 80 209 35 207 117 125 18 11 13 7 8 5 0.6 0.64 0.9 0.72 0.36 0.26
674 764 621 442 179 207 83 146 108 157 63 207 129 41 18 10 9 10 9 6 0.91 1.08 0.46 0.88 1.35 0.6
```

Raw Dataset: `pirp-30-2-2-3-1.dat`

```
30 2 2 3  2286
850 272 7317 7317 7317 7317 0.86 0.34 1.17
709 709 507 338 169 135 139 12 8 5 0.95 0.32 0.78
744 794 276 138 138 94 40 14 12 4 0.72 0.95 0.51
859 350 600 440 160 78 200 18 11 5 0.31 0.96 0.3
211 469 399 266 133 77 100 10 11 4 0.03 0.95 0.86
765 399 384 216 168 192 169 17 11 6 0.23 1.14 0.6
644 306 364 223 141 182 112 13 12 4 0.22 0.95 1.33
```

```
668 181 416 208 208 108 79 10 10 4 0.28 0.23 0.95
635 507 334 209 125 104 167 13 9 6 0.64 0.48 1.15
621 159 618 412 206 36 39 11 11 6 0.87 0.76 1
824 117 294 231 63 147 111 19 10 5 0.58 0.8 0.79
96 813 370 185 185 52 127 13 10 6 0.74 1.14 0.32
818 442 492 328 164 82 79 14 10 5 0.05 0.18 0.77
54 939 312 156 156 38 97 15 8 6 0.09 1.08 0.93
927 252 312 156 156 111 70 10 7 4 0.71 0.8 0.55
324 342 226 159 67 71 113 14 8 5 0.26 0.73 0.2
290 160 368 184 184 30 45 13 11 6 0 1.03 0.24
587 382 396 352 44 198 181 19 11 5 0.29 0.87 0.58
125 451 597 481 116 180 199 10 9 4 0.73 0.71 0.95
430 967 294 196 98 66 62 14 10 4 0.37 0.92 0.85
157 159 369 272 97 77 123 10 8 5 0.92 0.11 0.58
477 821 402 201 201 82 48 10 12 5 0.71 0.84 0.59
66 759 398 284 114 199 98 18 9 6 0.27 0.99 0.5
503 661 410 335 75 205 32 17 10 5 0.42 0.94 0.37
199 140 314 268 46 157 127 17 8 6 0.72 0.85 0.97
654 355 206 103 103 52 77 16 11 6 0.91 0.69 0.67
996 655 582 415 167 194 177 19 9 6 0.06 1.13 0.75
911 495 573 458 115 191 145 13 12 6 0.39 0.85 0.79
388 958 320 250 70 160 58 11 8 4 0.9 0.88 0.75
152 533 228 175 53 39 114 19 9 4 0.1 0.83 0.93
479 763 444 296 148 101 41 11 11 6 0.19 0.87 0.77
```

Raw Dataset: `pirp-30-2-2-3-2.dat`

```
30 2 2 3  2356
399 444 7541 7541 7541 7541 0.81 0.38 0.49
663 926 486 391 95 65 162 18 11 6 0.49 1.21 0.79
16 683 432 383 49 144 59 15 12 6 0.15 1.23 1.02
335 669 531 354 177 46 177 13 9 4 0.13 0.14 1.11
671 519 244 147 97 122 85 11 10 4 0.99 0.33 0.15
155 727 411 298 113 137 49 17 10 5 0.7 1.18 0.22
589 630 543 362 181 151 96 19 9 6 0.64 0.23 0.39
474 419 489 357 132 66 163 12 9 6 0.91 0.06 0.48
773 818 555 483 72 185 150 12 9 4 0.36 1.19 0.52
230 583 303 256 47 101 50 17 10 6 0.44 0.48 0.55
946 424 585 490 95 195 183 11 8 5 0.5 0.73 1.02
703 606 416 283 133 83 208 17 9 5 0.17 0.82 0.86
538 971 314 212 102 157 114 10 9 5 0.58 0.48 0.4
333 0 362 181 181 165 145 12 11 4 0.47 1.2 0.32
361 380 412 206 206 42 120 18 11 5 0.95 0.71 0.69
468 859 342 290 52 171 34 19 9 4 0.96 0.79 0.48
932 390 363 256 107 121 108 13 12 5 0.79 0.99 0.74
261 123 248 124 124 40 112 10 9 6 0.56 1 0.93
618 720 354 305 49 153 177 14 9 6 0.97 0.23 0.36
```

```
465 217 414 236 178 166 207 17 9 6 0.56 1.13 0.23
108 2 600 497 103 140 200 10 12 4 0.2 0.72 0.98
517 664 246 123 123 62 56 14 11 5 0.11 0.47 0.48
158 216 388 194 194 142 129 12 10 6 0.85 0.31 0.26
514 957 531 354 177 157 43 13 11 5 0.54 0.92 0.35
25 681 474 390 84 140 158 16 10 5 0.29 0.1 0.27
891 733 354 236 118 33 86 13 12 5 0.3 0.15 0.67
796 672 333 222 111 71 89 14 13 5 0.42 0.06 1.21
504 209 380 190 190 57 91 12 9 5 0.36 1.05 0.87
972 352 219 162 57 73 57 15 8 5 0.23 0.05 0.85
839 815 594 529 65 188 198 14 11 6 0.03 1.23 0.71
345 380 618 431 187 206 187 14 11 4 0.18 0.53 0.25
```

Raw Dataset: pirp-30-2-2-3-3.dat

```
30 2 2 3  2246
533 500 7188 7188 7188 7188 0.88 0.49 0.29
810 910 549 366 183 38 33 19 11 5 0.77 0.95 1.08
859 871 248 191 57 85 124 12 11 5 0.75 0.24 0.66
837 594 552 437 115 146 184 15 7 6 0.74 0.88 0.49
335 95 294 256 38 147 55 19 8 6 0.94 0.7 0.49
948 693 483 382 101 74 161 14 8 5 0.31 0.19 0.22
813 403 612 408 204 129 155 18 10 4 0.84 0.55 0.46
586 85 414 342 72 44 207 13 11 5 0.47 0.74 0.8
682 889 567 378 189 119 77 12 12 5 0.28 0.96 0.37
891 983 408 204 204 162 195 15 11 4 0.7 1.15 1.1
950 321 165 112 53 55 54 19 9 6 0.21 1.12 0.78
694 41 423 311 112 141 33 18 9 6 0.41 0.79 0.43
709 927 561 502 59 56 187 12 10 5 0.42 0.62 0.4
994 227 316 193 123 116 158 19 13 6 0.98 0.43 0.88
366 501 152 76 76 53 51 18 12 5 0.63 0.34 0.39
619 148 612 408 204 63 132 17 8 4 0.6 0.59 0.09
240 670 495 330 165 49 145 18 9 5 0.27 1.03 0.33
506 166 324 231 93 162 65 13 7 6 0.58 0.89 0.58
698 509 576 387 189 191 192 10 10 6 0.79 1.04 1.31
682 728 558 451 107 42 186 19 12 4 0.04 0.73 0.81
394 69 410 380 30 204 205 16 12 5 0.9 0.92 0.64
298 869 330 295 35 165 126 11 8 5 0.75 0.66 0.36
656 862 248 152 96 124 87 14 10 6 0.64 0.42 0.98
701 458 324 261 63 54 162 14 12 4 0.02 0.76 1.41
156 981 300 211 89 53 150 19 11 6 0.52 1.18 0.94
543 548 390 260 130 80 195 14 13 5 0.64 1.17 0.96
672 126 382 329 53 103 191 19 10 5 0.81 1 0.49
534 461 334 232 102 167 77 16 8 4 0.63 0.39 0.34
589 473 624 574 50 136 208 18 8 5 0.08 0.9 1.02
505 694 483 322 161 112 67 13 9 5 0.85 0.36 0.12
86 607 495 330 165 149 113 13 7 4 0.28 0.14 1.03
```

Raw Dataset: `pirp-30-2-2-3-4.dat`

```
30 2 2 3  2139
43 963 6847 6847 6847 6847 0.07 0.62 0.37
13 427 240 149 91 120 90 14 12 6 0.54 1.21 0.46
81 763 468 312 156 154 57 18 12 6 0.7 0.22 0.59
643 391 398 230 168 199 43 12 11 4 0.92 0.71 0.91
921 662 411 379 32 40 137 15 10 5 0.48 0.98 0.29
987 756 102 54 48 36 51 16 12 4 0.48 0.9 0.16
790 909 306 165 141 153 132 16 12 4 0.77 1.08 0.81
183 318 456 399 57 101 152 18 9 4 0.65 0.96 0.92
591 720 266 192 74 89 133 15 11 5 0.8 1 0.75
615 760 618 487 131 206 56 17 12 4 0.76 0.67 0.93
330 961 561 527 34 46 187 13 10 5 0.31 0.65 0.11
148 63 492 338 154 164 102 18 12 6 0.28 0.37 1.38
132 360 573 513 60 191 136 15 11 5 0.57 0.76 1.05
317 66 315 268 47 105 103 12 8 5 0.57 0.38 0.79
813 358 310 231 79 42 155 13 8 4 0.42 1.07 0.9
739 921 159 117 42 53 33 19 12 4 0.1 0.33 0.24
859 905 480 376 104 73 160 18 10 6 0.2 0.99 0.31
823 203 198 99 99 61 73 11 9 4 0.55 0.08 0.54
186 542 519 478 41 68 173 16 8 5 0.39 0.92 0.31
833 494 220 110 110 47 40 14 11 6 0.37 1.02 0.22
88 999 218 112 106 101 109 19 8 5 0.5 0.54 0.89
624 991 594 505 89 198 66 17 11 5 0.1 0.99 0.94
453 548 274 137 137 48 110 18 12 4 0.56 0.38 0.21
298 252 594 407 187 139 198 13 10 6 0.46 0.61 0.81
483 294 609 544 65 54 203 14 9 6 0.74 0.09 0.57
979 841 591 545 46 83 197 15 12 4 0.86 0.57 1.06
802 944 402 254 148 126 201 14 11 4 0.13 0.65 0.87
71 38 350 192 158 127 175 18 8 6 0.02 0.81 0.73
868 666 489 450 39 163 159 19 11 4 0.36 0.99 0.25
742 994 396 244 152 108 198 16 10 4 0.95 1.14 0.58
761 427 404 202 202 92 134 17 12 5 0.59 0.49 0.46
```

Raw Dataset: `pirp-30-2-2-3-5.dat`

```
30 2 2 3  2173
769 313 6956 6956 6956 6956 0.07 0.87 0.59
318 743 346 227 119 111 173 11 12 4 0.67 0.94 0.1
361 761 366 183 183 53 71 12 11 5 0.1 1.05 0.4
532 216 624 580 44 208 193 10 11 5 0.01 0.45 0.17
220 360 224 156 68 112 33 16 11 4 0 0.89 0.49
738 720 212 106 106 55 89 16 12 5 0.53 0.97 0.63
221 92 174 99 75 31 87 12 12 5 0.38 0.43 1.1
```

```
330 906 519 479 40 142 173 10 9 6 0.68 1.02 0.76
464 199 357 242 115 81 119 16 9 4 0.84 1.15 0.86
871 810 292 229 63 56 146 11 12 6 0.94 0.69 0.32
931 935 534 377 157 39 178 12 11 4 0.03 0.78 1.05
48 881 297 202 95 99 32 17 9 4 0.86 0.26 0.41
398 709 338 300 38 68 169 15 8 4 0.73 0.93 1.19
145 799 549 371 178 183 163 13 8 5 0.9 0.34 1.09
151 463 408 307 101 195 204 16 11 6 0.24 0.78 1.2
666 43 423 282 141 129 38 16 11 4 0.96 0.57 1.06
328 922 330 204 126 165 80 14 10 5 0.87 1.06 0.94
66 468 213 182 31 71 68 11 12 5 0.24 0.6 0.59
15 608 489 326 163 138 47 11 12 4 0.12 0.66 0.92
674 956 218 139 79 37 109 19 12 6 0.43 0.68 0.58
503 685 531 457 74 177 33 17 10 4 0.13 0.92 0.09
822 885 418 209 209 104 188 12 8 5 0.33 0.37 0.7
549 96 166 83 83 69 72 10 9 6 0.53 0.6 0.93
554 662 537 430 107 163 179 10 10 6 0.39 0.9 0.84
329 59 240 123 117 32 120 18 11 6 0.22 0.68 1.37
901 863 388 238 150 136 194 17 11 4 0.78 0.97 1.12
652 628 396 198 198 163 111 13 8 4 0.6 0.94 0.8
356 196 392 291 101 165 196 12 13 5 0.74 1.03 0.33
839 105 340 170 170 33 85 17 8 5 0.39 1.02 1.14
652 905 204 148 56 102 60 17 11 5 0.63 0.59 0.62
851 992 546 364 182 38 162 11 8 4 0.14 0.41 0.19
```

Raw Dataset: `pirp-30-3-2-6-1.dat`

```
30 3 2 6  2351
138 929 7526 7526 7526 7526 7526 7526 7526 0.18 1.16 0.47 1.03
881 707 534 356 178 175 87 52 135 67 16 13 9 6 0.99 0.42 0.71 1.02
212 508 338 184 154 169 146 76 85 149 15 10 10 6 0.97 0.97 0.37 1.24
123 784 404 270 134 59 202 160 181 78 15 15 9 6 0.3 1.11 0.55 0.32
943 815 588 426 162 196 70 111 124 81 13 13 9 4 0.47 0.86 1.14 0.95
572 259 394 322 72 197 140 126 84 157 13 12 9 6 0.46 0.39 0.64 0.94
325 591 390 195 195 55 154 96 88 31 11 15 7 5 0.79 0.9 0.87 0.81
338 977 552 407 145 170 135 184 143 131 18 12 10 6 0.96 0.78 0.53 0.39
591 777 366 228 138 43 183 51 109 169 10 8 9 5 0.64 0.2 0.79 0.84
23 770 338 219 119 139 169 156 160 46 11 12 9 4 0.14 0.65 1.15 1.31
502 249 588 481 107 106 196 48 51 128 16 13 10 5 0.24 0.29 0.55 0.91
669 466 618 452 166 76 199 206 91 178 17 10 10 6 0.51 0.58 0.39 0.52
289 696 382 191 191 96 156 31 53 64 16 9 8 4 0.62 0.64 0.73 0.37
387 304 394 240 154 173 60 197 131 108 11 10 6 6 0.62 0.72 0.41 0.73
847 878 292 173 119 99 48 134 42 146 18 13 8 4 0.49 0.77 0.32 0.44
440 189 603 443 160 118 31 197 201 189 17 14 7 6 0.04 0.52 0.26 1.37
184 710 627 531 96 84 96 209 146 59 11 10 9 6 0.55 0.45 1.09 0.3
736 565 603 441 162 201 54 46 40 177 14 11 9 5 0.52 1.3 1.32 1.05
977 61 376 188 188 137 75 52 136 87 10 9 10 6 0.08 0.99 0.61 0.49
```

```
214 851 412 252 160 100 206 172 156 175 10 12 9 6 0.52 0.83 0.46 1.11
310 992 350 175 175 31 79 110 170 46 19 11 9 5 0.09 0.87 0.64 1.42
398 371 624 416 208 182 142 75 46 32 17 11 9 5 0.7 0.97 0.17 1.32
836 258 528 373 155 62 173 127 162 176 12 14 9 4 0.12 0.75 0.63 1.04
911 146 400 363 37 83 105 173 189 200 12 12 10 6 0.95 0.87 0.44 0.94
875 413 624 454 170 31 31 80 191 208 16 14 10 4 0.86 0.11 0.52 0.38
690 947 320 275 45 32 109 160 87 36 17 11 7 6 0.32 0.69 0.54 0.93
197 417 416 268 148 201 47 65 93 208 16 14 9 6 0.74 0.37 1.07 0.11
202 855 392 265 127 106 46 108 81 196 13 14 9 4 0.77 0.38 0.17 1.07
694 446 374 321 53 153 57 187 168 39 14 13 9 5 0.05 1.04 0.87 0.99
260 520 561 507 54 139 85 62 187 51 10 13 9 6 0.31 0.9 0.78 0.76
981 1 579 472 107 134 151 193 141 84 12 13 7 5 0.9 0.91 1.13 0.74
```

Raw Dataset: `pirp-30-3-2-6-2.dat`

```
30 3 2 6  2341
627 461 7491 7491 7491 7491 7491 7491 7491 0.92 1.06 0.24 0.02
277 15 507 428 79 146 156 145 169 79 11 14 9 4 0.27 1 1.23 1.29
504 758 360 180 180 41 154 75 66 41 17 12 7 4 0.64 1.16 1.15 0.51
452 256 374 247 127 161 187 57 151 70 10 13 9 4 0.8 0.53 1.13 1.01
298 85 378 189 189 64 123 161 36 66 17 13 7 6 0.71 1.06 0.11 0.52
187 280 250 147 103 40 59 122 43 125 19 10 7 5 0.45 0.71 0.33 1.05
567 293 380 345 35 190 160 121 95 141 10 13 7 6 0.4 1.1 0.51 0.48
122 978 534 442 92 36 116 164 100 178 19 9 10 5 0.48 0.36 0.44 0.58
841 729 570 471 99 124 103 190 105 53 17 11 7 5 0.04 1.15 0.95 0.91
38 673 435 296 139 84 145 56 134 57 16 11 7 6 0.45 1.01 1.11 0.45
96 99 366 254 112 122 63 34 112 101 16 9 10 5 0.32 0.85 0.48 0.08
597 134 302 216 86 141 123 66 63 151 17 15 8 5 0.6 0.9 0.63 0.74
156 33 388 194 194 164 194 128 175 177 16 11 8 6 0.81 0.52 1.04 1.46
532 914 624 502 122 165 132 39 87 208 11 14 8 5 0.17 0.88 0.85 0.78
168 491 606 480 126 202 188 143 163 107 19 9 8 5 0.46 1.03 1.02 0.63
310 202 486 395 91 162 104 116 128 33 11 10 11 6 0.83 0.39 0.82 1.06
333 825 358 285 73 71 179 144 31 121 19 12 10 5 0.11 0.93 0.55 0.18
505 753 382 272 110 115 191 169 161 94 15 11 9 5 0.46 0.5 1.19 0.45
24 139 376 244 132 122 126 161 169 188 16 11 8 6 0.88 0.6 0.67 0.34
456 80 378 325 53 189 169 96 61 102 11 15 9 5 0.75 0.81 0.54 0.88
927 957 618 578 40 185 206 128 118 116 10 10 10 4 0.78 0.45 0.73 0.45
84 444 531 490 41 152 166 169 39 177 12 10 8 4 0.52 1.14 0.42 0.59
190 178 609 503 106 203 182 104 58 120 18 12 7 5 0.51 0.36 1.38 0.54
436 641 597 485 112 131 78 35 120 199 14 12 10 5 0.84 0.57 0.92 0.62
528 942 606 434 172 128 202 178 137 144 11 11 11 6 0.5 0.78 0.78 0.54
99 125 410 375 35 96 106 205 119 171 19 10 8 5 0.66 0.49 1.29 0.12
336 525 398 214 184 60 70 83 160 199 18 12 7 4 0.77 0.26 0.89 0.66
334 913 262 212 50 131 119 87 74 102 14 10 8 4 0.96 0.52 0.84 1.25
209 23 330 235 95 45 84 112 165 112 16 11 8 4 0.45 0.11 0.4 1.05
41 796 388 194 194 56 68 119 76 140 11 15 8 5 0.69 0.78 0.76 0.48
807 705 382 248 134 191 124 88 91 137 18 10 10 6 0.45 1.14 1.16 0.38
```

Raw Dataset: `pirp-30-3-2-6-3.dat`

```
30 3 2 6  2357
699 495 7544 7544 7544 7544 7544 7544 7544 0.61 0.89 0.6 1.19
782 954 398 243 155 123 79 94 173 199 11 9 10 4 0.96 0.34 0.1 0.66
966 708 378 238 140 168 55 55 111 189 17 15 8 4 0.22 0.96 0.52 0.53
347 584 501 364 137 110 98 167 67 129 13 13 9 4 0.68 0.35 0.99 1.12
85 442 552 437 115 184 75 176 183 64 13 14 11 6 0.82 1.22 0.87 1.01
678 824 404 223 181 102 153 118 202 109 18 15 9 4 0.64 1.14 1.01 0.25
104 813 624 506 118 63 180 208 30 120 12 14 8 4 0.28 0.36 0.38 0.47
110 400 358 302 56 138 103 87 47 179 10 14 9 6 0.02 0.19 0.9 1.08
432 675 408 365 43 184 204 204 121 99 14 10 7 4 0.69 1.04 1.34 1.22
106 92 374 259 115 154 76 184 90 187 13 11 7 4 0.18 0.28 1.06 1.27
143 295 374 231 143 153 73 82 69 187 15 14 8 6 0.63 0.98 0.57 0.64
509 234 528 431 97 35 176 126 164 101 13 10 11 4 0.88 0.26 0.18 0.66
39 400 376 231 145 188 61 170 124 72 11 11 9 5 0.25 0.59 0.9 0.17
148 356 564 406 158 181 111 152 188 155 11 14 8 4 0.22 0.86 0.63 0.94
917 405 252 133 119 46 47 126 104 122 10 14 7 6 0.27 1.01 0.76 0.77
226 759 406 320 86 203 176 55 48 120 13 14 9 5 0.8 0.14 0.25 0.72
955 621 612 437 175 60 159 177 160 204 13 8 8 6 0.73 1.01 0.65 0.41
895 248 396 198 198 179 133 33 115 57 15 10 6 6 0.58 0.39 1.07 0.98
718 649 374 236 138 88 135 42 187 143 18 11 8 6 0.43 0.21 0.3 0.12
630 26 597 499 98 58 44 72 49 199 12 9 9 5 0.99 0.89 0.86 0.86
415 824 386 193 193 142 88 58 77 40 15 9 9 6 0.26 0.85 0.58 1.33
173 690 326 280 46 105 111 163 38 110 11 14 7 5 0.52 0.28 0.96 0.5
785 227 564 380 184 30 125 145 188 155 19 9 6 6 0.86 0.74 1.04 0.81
281 641 627 508 119 188 209 169 111 184 17 9 7 5 0.39 0.97 0.46 0.48
558 700 585 397 188 135 195 176 98 119 17 11 9 5 0.59 0.53 0.7 0.66
595 70 252 175 77 51 35 126 48 102 19 12 8 4 0.83 1.07 0.92 0.63
124 92 352 176 176 166 69 170 73 57 16 13 9 5 0.02 0.39 0.53 0.85
600 221 398 307 91 58 91 138 53 199 18 12 8 6 0.63 0.26 0.83 0.84
820 805 522 393 129 69 95 78 150 174 17 12 9 6 0.24 0.41 1.31 1.14
535 315 370 327 43 185 44 97 34 168 19 14 6 6 0.07 1.11 0.84 0.5
200 124 504 345 159 118 138 130 94 168 12 14 10 5 0.04 0.42 1.34 0.63
```

Raw Dataset: `pirp-30-3-2-6-4.dat`

```
30 3 2 6  2226
448 425 7125 7125 7125 7125 7125 7125 7125 0.26 0.84 1.31 0.42
19 214 327 276 51 109 93 82 58 81 19 9 7 4 0.11 1.15 1.13 0.32
398 567 358 263 95 179 31 177 49 133 10 12 7 6 0.78 0.23 0.92 1.02
342 944 621 414 207 182 66 116 83 81 18 12 8 6 0.53 0.19 0.36 0.76
158 881 543 362 181 68 155 85 96 35 14 14 9 6 0.83 0.03 0.87 0.65
878 204 507 379 128 111 75 146 30 169 11 15 10 4 0.77 1.07 0.45 0.34
324 597 310 270 40 72 155 42 61 109 16 9 8 5 0.04 0.59 0.5 1.25
```

157 85 516 471 45 89 170 116 172 138 16 11 8 4 0.28 1.25 0.5 1.05
14 900 543 362 181 35 41 128 32 118 10 14 10 5 0.96 0.31 0.84 1.34
974 653 314 157 157 52 129 137 78 100 11 10 10 4 0.28 0.44 0.83 1.21
81 308 374 292 82 49 47 101 149 187 10 14 11 5 0.3 1.17 0.53 1.09
170 827 416 208 208 45 89 170 129 188 14 10 11 4 0.29 0.82 0.58 0.92
379 149 468 314 154 37 84 156 134 80 17 14 10 5 0.58 0.76 1.29 1.03
338 219 344 212 132 172 71 118 48 43 19 13 8 5 0.82 1.11 0.97 0.6
101 930 525 474 51 106 175 84 129 147 15 11 8 6 0.91 0.48 0.87 0.65
491 380 386 318 68 173 68 61 193 84 19 8 10 4 0.42 0.66 0.52 1.23
977 737 372 186 186 64 71 166 91 148 13 13 8 4 0.32 0.95 1.07 0.92
608 144 382 323 59 154 46 191 91 121 13 10 10 6 0.61 0.66 0.55 0.31
699 321 408 307 101 121 197 134 204 195 15 13 7 4 0.32 0.84 0.69 0.33
510 139 627 495 132 209 107 190 96 62 14 12 8 4 0.56 0.39 0.95 1.26
476 607 570 421 149 79 190 116 175 68 19 12 6 6 0.74 0.53 1.06 0.85
783 520 402 367 35 44 191 201 104 78 10 9 10 6 0 0.85 0.65 1.32
288 859 414 379 35 134 188 207 52 55 17 13 9 4 0.42 0.67 1.05 0.41
583 515 558 507 51 40 156 56 69 186 12 11 9 5 0.97 0.98 0.66 1.01
770 265 406 333 73 109 195 203 109 37 11 10 9 4 0.49 1.23 0.91 0.84
196 680 326 285 41 163 70 117 35 93 17 13 9 6 0.28 0.98 0.83 0.34
395 318 376 204 172 117 70 97 120 188 13 13 9 4 0.6 0.87 0.69 1.35
282 366 597 486 111 198 199 179 173 75 16 11 8 6 0.33 1.05 0.06 1.18
60 559 588 464 124 196 108 62 50 100 16 15 7 5 0.43 0.38 0.84 0.76
223 252 573 409 164 164 179 191 134 32 14 10 9 4 0.75 0.48 0.4 0.5
831 233 594 520 74 106 76 198 175 161 15 10 8 4 0.16 1.19 0.28 0.67

Raw Dataset: `pirp-30-3-2-6-5.dat`

30 3 2 6 2413
830 852 7724 7724 7724 7724 7724 7724 7724 0.37 0.56 0.39 0.91
406 609 621 558 63 98 113 207 112 151 15 9 10 4 0.29 0.88 1.16 0.62
891 140 348 182 166 174 133 137 81 135 11 9 8 6 0.46 0.99 0.75 1.36
536 294 621 487 134 207 167 45 169 149 11 15 8 6 0.39 0.85 0.92 0.27
508 803 402 201 201 89 161 128 180 64 15 10 11 4 0.79 0.71 1.06 0.35
567 735 540 360 180 137 90 166 58 54 10 9 8 4 0.69 0.53 0.39 0.67
937 181 582 552 30 194 127 127 148 119 16 12 7 6 0.85 0.58 0.18 0.9
402 478 334 167 167 141 34 138 48 59 19 11 7 6 0.73 1.06 0.55 1.29
286 39 576 524 52 43 64 124 192 172 18 12 9 4 0.16 0.87 0.58 0.27
444 273 603 522 81 197 200 139 201 116 15 10 10 4 0.18 1.12 0.68 1.34
877 486 376 236 140 70 152 147 188 134 12 12 9 6 0.88 0.27 0.28 0.66
305 357 606 472 134 202 161 146 75 85 13 13 8 5 0.15 0.3 0.04 0.69
584 497 627 589 38 199 209 87 70 163 14 11 10 6 0.69 0.16 0.13 0.63
285 840 400 200 200 111 60 177 125 118 15 14 11 5 0.05 0.74 0.95 0.98
244 525 483 363 120 88 160 161 133 73 16 13 9 6 0.2 0.43 0.46 0.66
256 330 396 286 110 182 115 173 35 198 13 10 8 6 0.59 0.6 0.47 0.61
949 379 404 292 112 166 42 202 115 44 10 10 8 6 0.94 0.95 1.09 1.42
670 223 573 398 175 145 114 173 191 101 19 8 9 6 0.15 0.94 0.04 0.52
529 675 579 386 193 112 108 86 64 141 18 12 10 5 0.63 1.04 0.58 0.38

322 512 489 352 137 70 163 64 138 132 13 13 10 5 0.77 0.8 0.99 0.35
675 495 370 186 184 176 134 147 185 112 19 10 9 4 0.15 0.95 0.54 0.92
312 441 352 249 103 86 135 82 176 166 15 9 8 5 0.87 0.42 1.12 0.87
809 844 531 377 154 62 101 113 91 177 12 14 8 6 0.15 1.01 0.64 0.65
582 167 412 304 108 187 46 87 200 206 16 11 8 4 0.15 0.22 1.01 0.94
742 222 483 357 126 161 44 73 94 116 18 14 9 4 0.32 0.19 1.19 0.77
31 397 390 258 132 190 195 48 190 40 13 13 10 5 0.76 0.41 0.79 0.73
735 116 288 144 144 121 37 100 53 80 18 14 9 4 0.55 0.44 0.6 0.84
208 793 368 319 49 93 41 158 107 184 13 8 7 4 0.83 0.45 0.74 0.91
962 834 314 248 66 59 134 37 157 80 10 13 7 4 0.39 1.07 1.22 0.74
745 27 386 338 48 173 111 160 86 193 10 10 6 6 0.64 0.84 0.87 0.34
543 589 579 404 175 151 193 73 157 166 14 9 6 5 0.19 0.14 0.66 1.13

Raw Dataset: pirp-30-5-2-10-1.dat

30 5 2 10 2350
797 537 7522 7522 7522 7522 7522 7522 7522 7522 7522 7522 7522 0.99 1.02 0.39 0.74 1.39 0.65
941 952 573 457 116 44 69 173 33 158 110 63 177 191 13 13 14 10 7 5 0.21 0.62 0.68 0.46 1.23 0.69
975 917 603 402 201 95 32 54 153 125 187 45 86 62 13 13 14 10 8 5 0.45 0.81 0.4 0.62 0.75 1.23
424 539 416 385 31 195 56 63 142 131 80 208 68 75 12 16 9 12 7 4 0.83 0.33 0.92 0.33 0.72 0.11
301 811 558 449 109 57 146 154 185 43 145 137 186 149 19 11 13 9 7 5 0.95 0.64 0.97 0.11 0.75 1.12
974 873 522 348 174 65 30 114 170 103 117 137 98 47 10 16 13 8 6 6 0.83 0.77 0.7 0.95 1.13 0.39
861 509 624 507 117 32 208 134 182 155 187 163 198 129 10 11 12 9 7 4 0.57 0.69 0.73 1.19 0.44 0.89
206 828 402 233 169 94 79 140 35 141 201 197 118 192 18 10 12 8 7 4 0.85 0.75 1.09 0.38 0.59 0.9
179 60 531 501 30 126 122 64 165 80 92 177 85 52 10 12 13 8 8 5 0 0.46 0.84 1.17 0.59 1.03
10 614 332 174 158 64 99 53 149 158 133 166 50 45 14 9 13 9 8 4 0.64 0.99 0.68 0.88 1.1 0.59
429 497 627 526 101 196 179 168 70 189 122 129 193 209 13 16 12 9 6 6 0.16 0.39 1.37 0.52 0.07 0.11
633 581 304 212 92 134 88 143 55 109 152 76 97 115 15 11 11 7 7 5 0.69 1.33 0.68 1.2 0.61 0.89
789 18 606 415 191 114 152 148 132 138 202 129 159 89 13 16 10 10 7 6 0.27 0.51 1.02 1.25 0.73 1.4
480 467 368 313 55 183 156 114 127 166 184 142 133 107 16 12 13 9 7 6 0.66 1.15 0.18 0.6 0.4 0.91
258 837 398 329 69 84 41 198 44 101 177 107 199 104 10 9 9 10 9 6 0.04 0.84 0.99 0.92 0.91 1.09
606 16 386 253 133 118 179 79 69 109 48 146 193 188 12 12 13 9 7 6 0.58 0.33 1 1.08 1 0.9
957 58 386 327 59 83 117 37 181 155 146 79 193 108 15 15 11 9 8 5 0.75 0.96 1.07 1.17 0.7 0.81
878 111 603 432 171 71 109 121 133 106 199 201 193 164 13 14 10 10 8 4 0.59 0.58 0.91 1.15 0.97 0.93
510 734 350 232 118 124 125 73 65 175 84 62 115 49 13 12 10 10 9 4 0.15 0.82 1.09 0.57 0.6 0.8
645 156 382 311 71 170 136 142 36 167 136 99 174 191 16 17 9 10 9 5 0.91 0.83 1.06 0.91 0.76 0.66
325 388 414 254 160 38 110 141 174 207 197 63 119 85 18 10 10 10 9 5 0.12 0.77 1.07 1.2 0.39 1.06
806 260 546 364 182 57 169 110 36 46 98 75 150 49 19 15 9 9 7 4 0.1 0.5 0.7 0.58 0.76 0.49
719 166 567 421 146 189 166 37 86 184 57 154 94 186 10 10 11 7 7 6 0.63 0.84 0.67 0.56 0.34 0.5
337 603 414 323 91 95 85 120 201 156 206 135 159 207 18 15 9 11 6 4 0.16 0.38 0.58 0.86 0.51 0.15
243 36 380 341 39 92 52 36 141 190 151 90 138 92 13 16 10 8 8 5 0.29 0.96 1.16 0.61 1.23 0.63
467 946 579 475 104 79 193 38 165 88 86 140 177 189 12 14 12 11 6 6 0.83 0.66 0.22 0.71 0.9 1.01
497 121 382 191 191 186 65 170 71 145 188 46 140 41 13 13 9 8 8 5 0.5 0.3 0.87 0.46 0.12 0.39
749 770 402 275 127 33 102 138 155 99 191 153 201 34 17 13 10 9 6 5 0.81 0.33 0.99 0.95 0.67 1.35
202 689 585 437 148 81 75 152 195 164 75 85 97 142 19 13 12 10 7 6 0.17 0.43 0.8 1.22 0.82 0.91
583 907 362 270 92 111 39 76 161 181 117 98 90 36 12 15 12 8 8 6 0.13 0.39 0.36 0.61 0.5 0.49
604 770 558 457 101 156 94 159 122 57 186 105 42 131 17 12 10 10 6 5 0.84 0.62 0.49 1.17 1.24 0.4

Raw Dataset: `pirp-30-5-2-10-2.dat`

```
30 5 2 10  2218
282 748 7100 7100 7100 7100 7100 7100 7100 7100 7100 7100 7100 0.39 1.15 0.27 0.84 0.27 1.38
74 123 516 419 97 150 131 172 139 145 160 139 124 76 14 14 13 11 7 4 0.1 0.15 0.72 1.45 0.44 0.47
591 506 546 462 84 108 72 182 43 146 97 52 56 72 11 13 10 8 7 6 0.42 0.34 0.29 1.15 0.39 0.59
554 736 573 476 97 141 134 191 125 38 157 157 180 30 11 11 12 10 6 6 0.4 0.26 0.13 0.49 0.64 0.26
584 703 390 332 58 79 61 110 42 195 86 70 167 87 19 13 12 9 8 5 0.76 0.33 0.36 0.94 1.14 0.55
126 881 316 268 48 40 78 158 66 74 153 126 110 134 17 12 9 11 7 6 0.42 0.57 0.31 0.1 0.7 0.39
20 675 375 263 112 109 47 88 41 125 81 46 108 88 15 9 8 12 8 4 0.24 1.11 0.67 1.04 1.05 0.4
502 117 406 261 145 70 70 203 123 110 179 60 47 86 15 15 12 11 8 5 0.18 1.14 1.1 0.57 1.29 0.62
472 944 406 290 116 144 30 44 80 44 142 157 203 109 11 13 12 9 7 4 0.78 0.95 1.09 1.02 1.53 0.67
121 470 400 311 89 75 200 169 179 124 185 121 134 76 13 13 14 10 8 5 0.27 0.24 0.69 0.58 0.71 1.06
196 384 350 207 143 111 93 61 33 175 31 91 162 56 10 13 13 9 7 4 0.16 0.79 0.7 0.76 0.36 0.69
940 98 570 513 57 126 139 83 158 115 180 42 92 190 12 12 11 8 7 4 0.15 0.24 0.6 0.41 0.88 0.87
964 11 324 222 102 154 162 134 33 82 124 154 97 79 19 11 12 8 7 4 0.19 0.61 0.16 0.9 0.78 0.34
823 932 314 241 73 102 104 122 92 128 146 76 147 157 12 13 11 10 7 5 0.67 0.25 1.2 0.54 0.75 0.89
402 950 396 296 100 111 35 99 195 118 123 81 198 145 15 11 14 8 7 6 0.87 0.31 0.96 0.23 0.52 0.95
947 635 410 321 89 91 191 76 86 165 87 205 144 54 13 10 13 7 6 5 0.28 0.85 1.32 0.26 0.99 0.6
313 971 394 197 197 79 79 41 141 127 68 164 135 114 11 12 14 10 9 5 0.51 0.8 0.99 1.05 0.91 1.02
705 647 474 335 139 96 106 43 136 131 86 158 114 47 11 10 13 9 9 4 0.12 0.49 0.32 0.7 1.19 0.78
482 659 624 556 68 124 112 138 185 157 37 190 89 208 18 14 10 10 8 5 0.43 0.27 0.39 1.02 0.99 1.11
169 905 402 268 134 67 37 132 130 32 84 58 115 82 11 14 11 8 7 5 0.62 0.59 0.46 0.72 0.47 0.62
116 229 612 522 90 107 197 194 204 47 39 158 189 142 16 16 11 8 7 5 0.74 0.92 0.51 0.23 0.81 1.19
575 987 627 592 35 45 143 148 126 171 209 100 165 166 10 15 13 12 7 4 0.89 0.06 0.5 1.01 0.69 0.52
616 269 388 244 144 126 74 152 66 81 59 194 70 41 18 17 14 9 7 5 0.54 0.64 1.29 0.68 0.41 1.01
934 986 594 413 181 82 198 64 54 174 153 164 108 83 10 11 10 10 7 5 0.12 0.48 1.28 0.94 0.73 0.74
479 929 402 356 46 93 47 100 193 141 78 201 45 40 19 13 9 11 9 5 0.01 0.73 1.17 0.72 1.09 1.01
323 293 414 215 199 194 74 81 95 154 51 162 207 180 13 12 9 9 7 4 0.82 0.38 0.84 0.89 0.6 0.78
880 698 600 521 79 196 99 102 110 82 87 188 196 200 13 16 12 8 6 6 0.19 0.5 0.33 0.21 0.09 0.56
217 252 615 562 53 205 171 43 81 151 82 72 142 77 13 9 13 8 9 6 0.61 0.46 0.34 0.75 0.11 0.77
768 339 408 331 77 96 67 124 175 204 48 54 177 31 17 15 13 8 9 5 0.15 0.32 0.97 0.69 1.21 1.51
764 407 418 314 104 50 32 158 205 101 209 201 188 168 11 12 9 7 6 6 0.78 1.1 1.12 0.93 1.37 0.58
726 25 582 543 39 194 91 177 177 128 36 167 78 47 17 12 11 11 6 6 0.45 0.88 0.89 0.93 0.39 0.74
```

Raw Dataset: `pirp-30-5-2-10-3.dat`

```
30 5 2 10  2319
390 740 7422 7422 7422 7422 7422 7422 7422 7422 7422 7422 7422 0.14 0.83 0.48 0.93 0.82 1.17
821 406 555 386 169 155 125 184 114 95 185 164 142 109 10 16 12 9 8 4 0.59 0.91 0.88 1.04 0.73 1.44
829 419 410 365 45 75 187 177 176 148 195 205 68 147 18 17 12 8 7 5 0.65 0.83 0.7 1.2 0.6 0.81
900 732 412 252 160 73 142 97 123 131 89 206 189 199 13 12 13 10 8 6 0.07 0.87 0.15 1.27 0.77 0.78
736 703 573 536 37 45 111 78 83 191 130 70 151 175 12 15 10 8 6 4 0.54 0.14 1.14 1.05 0.48 0.68
336 447 402 201 201 153 49 39 108 146 54 48 60 77 16 11 9 9 7 5 0.62 0.95 0.28 0.65 0.83 0.6
722 946 498 359 139 31 143 58 85 71 165 36 166 94 12 13 13 10 8 4 0.78 0.51 1.14 0.46 0.22 0.4
```

629 620 540 488 52 180 133 116 145 128 74 85 158 148 19 14 12 10 8 6 0.91 0.12 1.39 0.66 0.28 0.5
322 349 597 483 114 109 109 53 42 138 145 199 149 105 10 17 9 10 7 6 0.13 0.3 0.84 0.58 0.81 1.27
890 124 410 245 165 205 188 112 170 31 141 84 136 161 14 9 12 11 8 6 0.04 0.42 0.8 0.52 0.61 0.84
150 236 561 499 62 119 37 65 41 187 149 55 123 44 16 10 14 11 7 4 0.24 0.81 0.47 0.56 0.52 0.77
121 462 624 446 178 54 181 192 191 63 201 208 187 77 18 10 9 9 7 4 0.82 0.53 0.6 0.3 1 0.63
277 347 326 163 163 107 68 82 147 69 84 116 64 105 10 9 13 8 7 6 0.64 0.38 0.35 0.9 0.44 0.92
126 605 621 425 196 155 84 91 180 81 98 207 138 80 17 14 9 11 6 4 0.13 0.87 1.28 0.45 1 0.8
689 316 609 434 175 110 54 46 47 72 203 163 45 182 10 13 14 8 7 6 0.89 0.48 1.2 0.42 0.19 1.35
626 714 388 262 126 148 183 98 150 124 134 188 194 166 13 13 10 9 8 6 0.32 0.46 0.3 0.14 1.04 0.41
938 465 316 229 87 39 131 44 96 158 150 97 122 93 17 16 9 7 7 5 0.05 1.1 0.96 1.07 1.07 0.6
692 875 340 295 45 46 155 161 91 33 46 104 170 113 14 14 10 8 8 5 0.55 0.9 0.98 0.3 0.64 0.75
285 528 585 432 153 96 46 108 195 58 76 55 185 120 18 14 12 10 7 5 0.46 0.88 0.86 1.1 0.88 1.04
776 760 340 260 80 54 33 42 105 170 70 157 157 31 15 13 13 8 9 6 0.5 0.74 0.59 0.47 1.1 0.03
519 933 543 371 172 122 43 173 73 111 125 40 161 181 14 16 11 10 7 4 0.7 0.38 0.72 0.71 1.44 1.19
460 472 342 171 171 132 78 142 138 157 148 167 140 64 13 9 9 10 7 5 0.24 0.97 1.29 0.23 1.32 0.55
229 235 412 264 148 189 82 54 105 102 206 92 78 140 15 15 9 7 6 4 0.14 0.9 0.95 1.09 0.86 1.49
74 823 378 265 113 148 139 43 126 189 150 65 155 35 18 14 11 7 8 6 0.98 0.58 1.15 1.12 0.47 0.83
603 656 603 564 39 113 55 96 168 201 180 70 111 138 17 16 14 10 7 4 0.24 0.66 0.49 0.98 0.88 0.45
849 49 412 352 60 93 66 41 41 122 109 97 206 156 11 16 14 10 7 5 0.37 0.89 0.61 0.62 0.5 0.35
428 699 609 447 162 78 121 160 203 102 70 37 179 53 19 17 10 7 7 5 0.56 0.52 1.19 0.09 0.16 0.61
252 936 280 234 46 43 80 69 55 108 140 115 76 89 10 16 9 10 6 6 0.69 1.11 0.95 0.33 0.36 0.98
468 522 400 219 181 150 171 112 200 183 168 192 172 181 14 16 8 10 8 5 0.65 0.84 0.3 0.47 0.46 0.2
677 193 418 259 159 209 150 182 160 91 36 150 196 160 10 14 13 10 9 4 0.83 0.52 0.56 0.75 0.38 0.89
163 807 612 414 198 52 204 200 44 93 153 174 156 175 16 10 9 9 8 4 0.16 1.04 0.97 1.28 0.44 0.4

Raw Dataset: `pirp-30-5-2-10-4.dat`

30 5 2 10 2320
674 163 7425 7425 7425 7425 7425 7425 7425 7425 7425 7425 7425 0.07 0.51 0.37 0.2 1.2 0.31
177 355 418 345 73 75 58 53 69 53 209 162 200 109 14 15 9 7 9 6 0.31 1.09 0.42 1 0.12 0.29
695 904 591 547 44 49 62 175 95 99 130 197 162 96 10 16 12 10 9 6 0.62 0.52 0.64 0.69 0.91 0.56
410 898 621 445 176 62 45 62 103 193 207 191 135 47 19 9 12 12 7 5 0.58 0.83 0.88 1 0.28 0.86
553 152 382 211 171 183 85 61 71 188 191 70 46 50 12 17 8 10 7 6 0.72 0.75 0.31 1.28 0.49 0.58
801 760 408 239 169 103 173 62 100 146 126 204 99 48 19 16 11 10 7 5 0.48 0.34 0.46 1.34 0.79 0.53
313 917 392 318 74 40 71 144 82 32 85 195 112 196 16 12 13 10 7 4 0.89 0.37 0.84 1.24 0.54 0.66
645 437 519 450 69 130 88 56 86 101 173 163 71 151 19 13 9 8 8 6 0.65 0.35 0.62 0.99 0.8 1.2
914 504 561 432 129 135 125 122 144 110 71 106 187 51 16 13 13 8 8 4 0.55 0.99 0.93 1.1 0.97 0.51
405 474 624 532 92 101 208 113 50 174 89 133 190 55 15 13 11 10 6 5 0.11 0.43 1.24 0.71 1.02 1.02
351 224 408 230 178 175 32 204 91 77 170 33 121 126 14 10 11 10 7 6 0.24 1.15 0.32 1.02 0.73 1.15
142 60 567 448 119 123 145 87 189 116 104 115 80 88 16 13 11 10 7 6 0.19 1.01 0.57 0.95 0.28 0.85
443 259 618 580 38 142 105 149 98 67 109 103 206 138 19 14 14 8 7 6 0.07 0.96 0.96 1.09 1.07 1.03
72 931 400 308 92 48 65 200 121 148 52 40 107 111 18 10 12 9 8 4 0.59 1.05 0.9 0.4 0.85 0.37
964 381 609 460 149 184 151 50 176 203 194 64 94 94 11 14 12 7 7 6 0.3 0.55 0.2 0.9 0.47 1.1
389 199 398 279 119 165 153 56 184 157 89 184 199 120 14 13 13 8 7 6 0.86 1 0.72 0.47 0.5 0.36
56 947 549 514 35 48 176 177 40 85 96 110 183 182 13 13 13 10 8 5 0.95 0.44 0.33 1.17 0.5 0.79
106 338 606 424 182 38 179 154 80 87 61 155 202 164 15 14 8 10 8 5 0.23 0.57 0.7 0.48 1.49 1.23
672 237 483 393 90 114 35 96 135 73 115 161 68 120 11 11 10 7 7 5 0.63 0.47 1.06 0.57 0.47 1.27

800 263 615 555 60 197 205 202 61 129 139 80 104 153 13 12 9 10 7 5 0.06 0.33 1.04 0.41 0.63 1.39
386 2 606 527 79 112 178 202 142 178 158 125 76 193 13 16 9 8 7 4 0.74 0.74 0.98 0.98 0.1 0.91
130 372 346 190 156 150 70 139 63 68 173 72 163 49 13 13 11 10 6 4 0.4 0.29 1.18 1.34 0.38 0.19
491 247 594 466 128 53 194 147 198 184 99 133 136 83 11 15 9 8 9 5 0.02 0.99 1.17 0.91 0.79 0.67
655 18 576 408 168 96 139 93 152 122 192 123 165 114 18 9 14 9 8 5 0.25 0.98 0.55 0.5 1.09 0.53
729 758 350 298 52 123 175 136 136 62 126 174 119 57 11 13 9 12 8 4 0.46 0.92 0.87 1.03 0.44 0.2
272 535 404 229 175 152 47 202 79 36 181 98 75 124 10 15 11 11 8 6 0.96 0.1 0.6 1.04 0.79 0.75
978 232 340 204 136 170 149 50 151 53 98 69 49 108 15 16 11 12 7 6 0.92 0.45 0.22 0.63 0.43 0.43
422 228 418 228 190 124 191 141 165 109 53 163 193 209 14 12 8 10 7 6 0.99 1.23 1.14 0.93 0.29 0.55
282 978 398 203 195 123 66 66 131 80 34 39 199 170 16 16 11 8 7 6 0.25 0.04 0.13 0.59 0.59 1.34
883 305 392 338 54 74 196 66 196 130 44 81 115 93 16 11 12 11 6 6 0.91 0.68 0.64 0.75 0.38 0.46
418 162 396 363 33 197 43 96 148 86 173 107 198 191 18 11 14 9 7 5 0.77 0.68 0.52 1.16 1.21 0.67

Raw Dataset: `pirp-30-5-2-10-5.dat`

30 5 2 10 2311
842 918 7397 7397 7397 7397 7397 7397 7397 7397 7397 7397 7397 0.32 1.29 0.45 0.31 0.75 0.5
979 124 558 449 109 186 114 146 47 116 64 180 80 98 10 14 10 8 6 5 0.59 1.07 0.89 0.98 0.54 0.84
197 524 606 423 183 202 138 72 67 97 96 61 49 149 19 14 12 11 8 5 0.35 0.92 0.35 1.18 0.78 1.09
580 520 480 347 133 100 105 124 58 34 160 83 49 41 13 12 12 9 9 4 0.11 0.84 0.33 1.07 1.26 0.33
168 683 624 530 94 123 196 157 32 208 77 148 99 192 15 15 9 10 8 5 0.66 0.48 0.84 1.09 0.87 0.71
412 313 540 432 108 133 33 90 86 81 113 33 147 180 19 14 9 8 8 6 0.74 0.97 0.59 0.61 0.6 0.64
316 974 543 512 31 41 78 181 56 110 166 169 36 178 17 15 8 8 8 4 0.09 0.29 0.72 1.12 0.5 1.03
251 803 392 296 96 190 92 64 147 40 138 161 109 196 12 12 9 9 6 5 0.86 0.85 1.01 0.42 1.11 1.18
94 381 378 189 189 76 156 175 118 59 150 179 86 134 13 13 13 9 7 6 0.44 0.5 0.25 0.76 0.62 0.82
99 173 504 461 43 83 52 147 168 158 121 48 83 36 18 12 8 10 7 4 0.41 0.35 0.79 0.57 0.74 0.27
909 184 621 466 155 103 107 33 190 118 207 133 139 55 13 14 9 10 8 5 0.81 0.4 0.47 0.82 0.95 0.72
982 569 615 496 119 197 205 197 50 34 81 166 108 126 10 14 11 12 8 5 0.93 0.38 0.87 1.09 0.63 0.68
478 352 627 431 196 198 142 113 123 76 174 156 209 185 19 17 12 9 7 4 0.57 0.68 0.88 0.88 0.72 0.91
324 887 465 429 36 52 99 63 119 89 155 56 127 84 19 11 8 9 6 4 0.08 0.29 0.42 0.9 0.78 0.87
404 336 543 510 33 180 161 139 181 45 39 179 165 60 18 17 13 9 7 4 0.32 0.77 1.13 0.15 0.84 0.65
243 751 400 259 141 112 88 172 39 192 200 193 177 129 10 16 11 9 7 5 0.03 0.41 1.14 0.3 0.64 1.04
109 512 414 249 165 155 56 136 207 140 80 148 95 140 10 12 13 8 6 4 0.27 0.86 1.03 0.59 0.79 0.61
136 354 585 529 56 63 195 38 83 124 51 141 143 143 10 13 12 9 7 5 0.57 1.07 1.2 1.09 1.38 0.29
710 159 388 213 175 167 30 160 56 86 194 128 76 116 15 15 11 9 8 6 0.66 0.08 0.21 0.64 0.9 0.81
439 774 621 491 130 129 207 36 194 69 207 174 67 82 13 10 13 9 7 6 0.27 0.74 0.35 0.81 0.77 0.54
398 535 402 340 62 48 43 166 184 134 121 139 201 46 10 12 8 9 9 6 0.81 0.01 0.46 0.83 1.03 0.85
625 312 606 518 88 137 189 104 58 87 131 122 140 202 16 12 9 9 8 4 0.16 0.45 1.3 0.33 1 1.26
467 16 609 406 203 161 53 67 196 30 171 168 99 39 16 16 10 7 6 6 0.14 1 1.15 0.59 0.95 0.98
808 472 352 251 101 74 90 110 176 57 126 133 131 44 15 12 11 8 8 4 0.19 0.42 0.88 0.84 0.97 1.4
839 218 609 448 161 87 187 175 161 115 187 203 186 34 11 12 10 9 9 6 0.19 0.58 0.31 0.56 1.2 0.87
874 557 531 408 123 109 177 127 103 168 177 53 127 119 18 14 14 8 7 5 0.77 0.67 0.87 0.26 0.47 0.7
802 53 612 564 48 47 57 137 82 51 154 31 160 204 13 14 13 12 9 5 0.24 0.72 1 1.13 0.7 1.11
643 50 564 422 142 177 102 188 156 64 181 121 108 46 15 14 14 11 7 4 0.7 1.08 0.73 0.42 1.54 0.67
101 893 404 202 202 87 158 38 202 133 80 85 143 58 12 10 8 9 7 6 0.58 0.94 0.81 0.81 0.84 0.34
411 54 378 290 88 117 109 116 172 162 189 62 81 92 15 13 9 9 7 5 0.42 0.66 0.71 0.75 1.2 0.29
826 998 597 398 199 191 41 81 122 132 128 95 194 133 18 10 9 10 7 6 0.48 0.77 0.42 1.01 1.22 1.39

Raw Dataset: `pirp-40-2-3-3-1.dat`

```
40 2 3 3  1894
80 240 9095 9095 9095 9095 0.23 0.5 0.72
38 401 609 531 78 147 203 15 9 5 0.31 0.74 1.1
316 984 270 190 80 135 32 16 11 5 0.73 0.31 0.56
39 701 276 194 82 98 138 14 10 6 0.53 0.74 0.2
619 842 477 325 152 159 87 15 8 5 0.56 0.4 0.48
70 841 483 322 161 135 60 16 11 6 0.06 0.73 1.02
347 953 248 151 97 124 56 17 10 6 0.77 1.12 0.43
512 91 296 148 148 47 105 12 12 4 0.4 0.79 0.89
614 745 416 237 179 34 208 16 11 5 0.81 0.3 0.13
797 654 561 525 36 187 38 11 12 4 0.67 0.27 0.31
401 484 344 310 34 172 84 12 9 5 0.37 1.27 0.37
67 693 394 197 197 97 120 18 11 4 0.28 0.27 0.45
448 366 368 232 136 93 184 17 9 4 0.41 0.94 1.31
383 231 386 296 90 112 193 13 9 4 0.98 0.49 0.35
264 487 423 387 36 141 134 18 11 6 0.89 0.88 1.15
147 336 207 173 34 69 66 14 9 4 0.52 0.34 0.97
227 504 316 218 98 86 158 12 9 6 0.65 1.08 0.83
43 994 603 515 88 39 201 14 12 5 0.39 0.61 0.94
553 759 450 411 39 128 150 12 11 4 0.27 0.43 0.97
79 501 384 192 192 30 50 19 11 6 0.76 0.31 1
997 202 242 194 48 121 43 13 8 5 0.02 1.09 0.52
733 740 600 489 111 200 96 13 9 6 0.4 0.3 1.2
947 196 418 209 209 46 64 15 7 6 0.27 0.79 1.36
911 168 412 366 46 143 206 18 12 4 0.23 0.73 0.58
487 843 248 195 53 124 61 16 11 5 0.38 0.53 0.41
467 877 292 220 72 129 146 16 7 4 0.28 0.41 0.75
558 959 330 166 164 165 134 14 11 4 0.84 0.73 0.93
574 495 408 276 132 136 50 13 11 6 0.66 0.78 1.13
613 172 278 176 102 139 52 14 8 4 0.7 0.35 0.78
627 568 308 211 97 154 89 14 8 5 0.36 0.67 0.89
480 898 390 355 35 130 61 18 8 4 0.92 0.31 0.96
249 674 618 487 131 206 163 18 9 5 0.72 0.98 1.24
605 261 561 416 145 187 107 14 11 6 0.59 0.87 0.57
827 307 234 117 117 100 60 12 12 5 0.72 0.61 0.64
95 94 393 262 131 42 81 19 12 5 0.75 0.53 0.27
979 812 603 466 137 195 201 16 11 6 0.5 1.17 1.01
861 403 260 227 33 130 113 11 10 6 0.19 1.16 0.49
580 363 194 104 90 97 83 12 13 5 0.46 0.9 0.88
681 242 432 325 107 144 61 12 9 4 0.18 0.41 0.22
385 884 206 131 75 103 80 12 8 4 0.76 1.03 1.17
786 141 444 296 148 143 41 11 12 6 0.82 0.68 0.99
```

Raw Dataset: `pirp-40-2-3-3-2.dat`

```
40 2 3 3  2181
807 991 10472 10472 10472 10472 0.44 1.18 0.4
727 279 558 372 186 51 175 10 9 5 0.81 0.89 1.18
524 248 543 374 169 181 147 12 8 5 0.18 0.93 1.23
140 339 416 208 208 94 94 16 11 5 0.52 0.48 0.62
480 98 399 288 111 133 99 15 9 5 0.02 0.61 0.68
782 152 507 458 49 158 169 14 12 4 0.69 0.91 0.98
785 343 516 350 166 91 172 15 9 5 0.8 0.84 1.16
327 973 570 456 114 190 148 10 12 4 0.05 1.06 1.05
755 143 318 212 106 98 53 13 8 4 0.69 0.38 0.96
306 454 260 197 63 130 48 16 9 5 0.84 1.06 1.31
586 432 549 395 154 183 140 18 8 5 0.68 0.74 0.72
642 888 399 266 133 82 89 12 10 5 0.67 0.26 1.1
682 449 396 218 178 75 198 14 11 5 0.52 0.42 0.68
988 838 412 206 206 146 172 11 7 4 0.82 0.92 0.1
78 742 350 288 62 175 166 18 12 5 0.15 0.99 0.43
318 758 618 516 102 206 97 17 9 5 0.8 1.09 0.98
412 673 411 377 34 137 80 14 8 6 0.83 1.24 0.56
134 720 296 158 138 94 148 15 12 6 0.28 0.97 0.62
144 189 310 206 104 155 62 16 9 4 0.47 0.89 0.72
236 530 386 193 193 92 98 17 8 6 0.46 0.22 0.4
252 818 528 405 123 176 58 14 13 5 0.05 0.44 1.02
828 529 498 466 32 166 120 12 12 5 0.8 0.47 0.36
783 840 262 146 116 53 131 11 10 5 0.54 0.58 0.74
186 393 438 383 55 88 146 11 10 4 0.26 0.26 1.43
152 92 398 199 199 92 168 18 11 5 0.38 0.55 0.59
491 848 534 356 178 133 132 12 7 4 0.87 1.07 0.42
793 58 609 406 203 192 122 18 10 6 0.4 0.84 1.05
934 337 278 201 77 58 139 13 12 6 0.36 0.46 0.04
316 168 382 292 90 146 191 18 8 6 0.53 0.98 0.86
218 837 398 329 69 96 199 17 9 5 0.08 1.23 0.98
96 388 352 258 94 176 154 11 8 5 0.56 0.16 0.48
878 101 342 274 68 114 62 13 11 6 0.21 0.59 0.8
4 63 192 162 30 96 75 15 11 5 0.76 0.94 0.22
24 671 528 484 44 108 176 13 9 4 0.2 0.69 0.86
397 435 392 209 183 130 196 13 9 6 0.65 0.55 0.96
692 353 356 226 130 178 138 18 12 4 0.57 0.43 0.45
253 425 606 404 202 124 105 11 12 5 0.36 0.28 1.05
877 294 621 417 204 207 106 16 10 4 0.56 0.99 0.58
331 868 226 181 45 47 113 16 12 4 0.72 0.33 0.57
356 181 416 208 208 48 186 10 12 6 0.11 0.78 0.85
770 515 320 160 160 152 151 14 8 6 0.18 0.1 1.09
```

Raw Dataset: `pirp-40-2-3-3-3.dat`

```
40 2 3 3  1973
414 373 9470 9470 9470 9470 0.19 1.01 0.72
193 267 246 168 78 123 71 14 10 5 0.93 0.29 0.67
94 925 324 258 66 78 162 19 11 4 0.09 0.77 0.41
178 183 330 204 126 165 157 13 8 5 0.12 0.32 0.97
379 139 570 380 190 104 40 17 8 4 0.86 0.35 1.05
423 345 230 127 103 44 115 11 8 6 0.06 0.89 0.38
468 358 540 436 104 180 81 11 8 4 0.31 1 0.78
743 372 410 205 205 53 201 14 11 5 0.36 0.31 0.8
616 984 561 433 128 187 120 13 9 5 0.69 0.61 1.04
132 430 338 290 48 169 77 10 12 6 0.69 0.32 0.99
698 648 312 208 104 31 78 13 12 6 0.12 0.81 1.04
23 93 396 345 51 132 82 10 11 5 0.91 0.48 0.86
95 132 288 144 144 98 83 10 11 4 0.26 0.3 0.17
165 646 350 320 30 175 102 13 9 6 0.91 0.99 0.38
428 617 156 122 34 78 62 15 11 6 0.64 0.85 0.45
956 850 334 167 167 61 110 16 12 4 0.31 0.23 0.56
737 981 627 418 209 101 115 17 9 4 0.23 0.74 0.98
686 611 410 205 205 181 110 18 8 4 0.36 0.58 0.67
687 532 525 355 170 32 175 17 11 4 0.32 0.79 0.38
586 621 483 382 101 56 161 10 11 6 0.68 0.43 0.9
561 922 416 379 37 208 154 18 10 6 0.49 0.47 0.43
95 711 314 157 157 98 142 12 11 6 0.33 0.31 0.52
522 417 573 478 95 191 66 12 10 4 0.57 0.97 0.58
384 808 504 403 101 168 70 15 11 5 0.9 0.87 0.95
630 489 393 330 63 89 131 15 8 4 0.77 0.25 0.6
414 901 102 51 51 51 38 11 8 4 0.93 0.8 1.07
917 49 350 175 175 49 162 18 9 6 0.1 1.02 0.32
227 135 498 332 166 31 64 11 12 6 0.1 1.17 0.47
645 401 274 192 82 137 95 17 9 6 0.48 0.69 0.61
168 42 561 417 144 187 34 16 10 6 0.27 0.5 0.49
13 388 426 312 114 142 114 11 10 6 0.58 0.26 0.55
145 128 250 168 82 125 88 12 9 4 0.83 1.11 1.31
149 233 498 350 148 149 166 16 12 5 0.82 1.19 1.09
577 963 411 274 137 66 95 13 10 6 0.3 1.23 0.87
899 936 304 152 152 58 62 12 11 5 0.6 1.13 0.77
938 836 412 206 206 173 175 16 7 4 0.51 0.75 1.12
161 650 372 214 158 186 60 10 9 6 0.08 0.52 0.72
658 575 531 416 115 177 45 19 11 4 0.58 1.11 1.17
347 616 387 258 129 96 32 18 8 6 0.18 1.15 0.43
717 332 426 284 142 110 119 16 11 4 0.03 0.05 0.81
708 387 316 158 158 148 70 13 8 4 0.51 1 0.49
```

Raw Dataset: `pirp-40-2-3-3-4.dat`

```
40 2 3 3  2140
844 369 10272 10272 10272 10272 0.81 0.99 0.25
157 840 346 173 173 52 107 10 9 6 0.75 0.21 1.11
413 128 200 115 85 100 35 14 9 4 0.19 0.58 0.36
622 209 240 150 90 120 35 11 11 6 0.37 0.52 0.88
810 769 308 154 154 107 82 14 10 5 0.41 0.49 1.16
11 933 621 542 79 207 167 14 12 5 0.29 0.08 0.4
206 842 435 290 145 123 91 13 9 4 0.81 0.22 0.66
735 509 388 194 194 97 54 11 10 4 0.05 0.13 0.79
354 921 336 224 112 50 58 16 10 5 0.28 0.24 0.38
494 923 606 545 61 180 202 10 9 6 0.01 1.01 0.29
765 673 486 324 162 156 91 10 10 4 0.59 0.29 0.95
475 959 411 308 103 137 127 13 10 6 0.78 0.42 0.72
65 430 594 513 81 198 126 15 8 5 0.1 0.19 0.91
384 396 591 452 139 103 197 19 12 5 0.49 0.17 0.68
914 64 396 269 127 198 182 11 11 6 0.76 1.02 1.3
865 270 459 356 103 153 153 11 9 6 0.24 0.98 0.68
943 130 606 576 30 71 202 10 12 6 0.21 0.32 1.33
689 777 166 111 55 76 83 18 12 5 0.62 0.32 0.44
275 645 519 346 173 49 44 18 10 5 0.06 0.85 0.49
599 82 615 487 128 173 205 13 10 4 0 0.49 1.2
830 331 416 218 198 40 208 19 8 5 0.66 1.12 0.45
796 188 388 227 161 103 194 14 11 4 0.53 0.28 1.02
535 535 531 445 86 177 85 16 8 6 0.76 0.94 1
404 96 348 174 174 160 130 10 10 5 0.42 0.76 0.49
546 951 392 238 154 49 196 18 8 5 0.98 0.91 0.67
282 307 297 198 99 48 98 11 10 4 0.55 0.88 1.05
35 966 382 198 184 59 191 18 9 6 0.28 0.69 0.97
684 766 540 431 109 155 180 18 11 5 0.29 0.79 1.06
498 131 597 410 187 170 199 11 12 4 0.42 1.05 0.93
172 401 585 390 195 127 146 12 9 6 0.3 1.02 0.69
282 912 314 250 64 157 148 18 12 6 0.12 1.07 0.51
701 783 360 234 126 130 180 16 8 4 0.43 0.6 0.04
186 484 576 400 176 192 151 11 13 5 0.65 0.25 0.41
856 148 492 328 164 150 112 11 10 6 0.8 0.58 0.66
169 94 340 237 103 170 151 15 9 5 0.58 0.26 0.15
875 359 537 503 34 179 147 10 9 6 0.43 0.35 0.96
338 615 567 378 189 93 95 11 8 6 0.91 0.71 1.01
161 311 300 150 150 42 57 17 7 6 0.46 1 1.25
472 766 346 173 173 36 77 19 12 6 0.16 0.65 0.29
555 89 570 518 52 190 96 10 10 6 0.06 0.65 1.19
408 446 570 380 190 51 139 16 9 6 0.07 1.02 1.12
```

Raw Dataset: `pirp-40-2-3-3-5.dat`

```
40 2 3 3  1880
434 454 9024 9024 9024 9024 0.46 0.89 0.75
793 861 369 279 90 77 123 12 12 4 0.81 1.06 0.69
239 139 382 191 191 37 167 10 8 4 0.26 0.25 1.02
76 200 441 294 147 98 66 13 9 4 0.95 0.69 0.84
715 275 380 311 69 190 52 18 10 5 0.18 0.44 0.8
623 780 546 404 142 182 56 17 9 4 0.38 0.35 1.09
810 475 297 216 81 98 99 18 12 6 0.46 0.22 0.76
61 729 558 442 116 186 88 19 8 6 0.62 0.29 1.16
567 584 435 290 145 68 143 19 10 6 0.55 0.3 1.29
458 273 561 427 134 187 94 14 9 5 0.49 1.24 0.51
498 871 402 349 53 134 40 18 11 5 0.23 1.02 0.67
789 261 396 198 198 51 129 11 9 5 0.03 0.58 0.33
321 165 330 204 126 115 165 19 8 6 0.8 0.66 0.76
60 57 340 207 133 170 124 12 8 5 0.95 0.78 0.44
711 370 228 122 106 97 114 15 8 6 0.94 0.96 0.33
325 882 392 348 44 196 132 11 10 6 0.09 0.87 0.83
108 594 450 300 150 39 108 17 11 6 0.7 1.15 0.99
116 752 312 278 34 104 42 17 12 5 0.42 0.72 0.29
226 281 342 171 171 67 152 16 11 4 0.54 1.09 0.55
180 507 291 249 42 97 64 14 11 4 0.09 1 1.23
897 76 406 272 134 203 50 17 11 6 0.85 0.97 0.63
412 258 396 198 198 76 92 15 13 4 0.61 0.91 1.19
86 287 603 495 108 201 48 17 11 4 0.21 0.38 0.29
966 148 226 187 39 113 105 10 10 6 0.75 0.53 1.17
617 448 456 304 152 34 43 12 10 6 0.46 1.06 0.89
990 490 567 446 121 189 62 17 13 6 0.74 0.91 0.52
660 820 339 226 113 77 32 18 10 4 0.88 1.26 0.81
436 257 531 492 39 177 165 11 10 5 0.25 0.76 0.57
643 535 591 394 197 83 194 17 9 4 0.38 0.24 0.79
248 347 315 237 78 49 105 12 12 5 0.84 0.22 0.45
112 951 396 286 110 132 124 18 9 5 0.56 0.84 0.72
518 376 309 224 85 103 30 19 8 5 0.87 0.81 0.56
693 591 388 210 178 179 194 18 8 5 0.78 0.64 0.43
484 374 414 365 49 207 39 12 8 4 0.26 0.24 0.67
895 200 182 114 68 70 91 14 8 4 0.46 0.59 0.39
551 265 412 295 117 206 100 10 9 6 0.83 0.44 0.64
926 122 356 219 137 166 178 16 9 5 0.58 0.29 0.37
947 625 351 269 82 117 32 16 9 5 0.5 0.98 0.52
352 339 202 146 56 101 97 16 8 4 0.76 0.41 1.17
445 461 369 246 123 102 82 18 7 5 0.61 0.29 0.91
755 605 318 270 48 142 159 15 12 4 0.49 0.4 0.12
```

Raw Dataset: `pirp-40-3-3-6-1.dat`

```
40 3 3 6  1976
679 877 9487 9487 9487 9487 9487 9487 9487 0.16 1.17 0.54 1.23
444 643 549 476 73 183 122 162 93 74 15 14 9 4 0.94 0.86 0.77 0.24
198 567 477 405 72 139 159 128 63 45 13 14 11 4 0.94 1.17 0.56 0.62
919 161 627 550 77 209 46 90 168 62 18 10 11 4 0.92 0.21 0.79 0.63
681 876 354 260 94 122 136 177 59 58 10 11 7 6 0.31 0.93 1.3 0.82
112 998 543 363 180 108 100 55 110 181 18 11 8 6 0.53 0.35 1.2 0.31
741 602 318 203 115 73 159 126 53 102 15 14 10 6 0.73 0.36 0.93 0.64
843 136 552 495 57 103 142 184 90 136 10 10 7 6 0.67 0.54 0.86 0.51
340 646 408 374 34 204 132 41 64 152 15 11 8 4 0.8 0.85 0.93 1.36
580 947 570 380 190 43 155 177 176 154 11 14 8 5 0.75 0.58 0.26 0.38
246 396 609 547 62 112 65 203 190 68 10 14 9 5 0.72 0.38 0.61 0.75
341 320 489 339 150 86 163 119 89 75 11 13 9 6 0.81 0.76 0.63 0.95
543 750 398 352 46 199 170 84 137 47 18 13 10 6 0.82 1.19 0.47 0.82
894 393 222 155 67 35 100 88 63 111 10 8 8 6 0.21 0.95 0.54 0.5
446 427 414 219 195 121 206 207 39 207 10 9 8 5 0.31 0.7 0.91 0.57
380 336 390 195 195 193 189 145 66 129 13 11 9 5 0.61 0.96 0.23 1.18
896 233 408 204 204 160 48 56 102 192 13 14 10 4 0.44 0.16 0.28 1.19
867 594 296 148 148 93 86 136 47 93 16 12 11 6 0.12 1.03 1.09 1.03
489 882 552 417 135 65 57 184 143 116 18 15 10 4 0.66 0.44 0.17 0.76
44 537 483 322 161 129 31 60 139 87 15 10 8 6 0.1 1.03 1.22 0.46
656 975 326 283 43 163 41 45 67 64 14 12 7 4 0.05 0.62 0.51 0.89
313 897 358 182 176 179 85 120 110 135 11 10 10 5 0.02 0.77 0.59 0.47
657 160 390 327 63 92 85 135 98 195 16 13 8 4 0.49 0.87 0.45 0.54
333 261 603 438 165 136 113 168 201 196 18 9 10 6 0.01 0.59 0.58 0.66
867 950 600 437 163 60 184 200 170 65 16 8 9 5 0.18 0.3 0.97 1.06
912 921 288 160 128 38 144 113 32 96 16 9 7 4 0.13 0.88 0.53 0.36
314 532 410 294 116 47 205 195 143 48 19 15 8 6 0.36 1.16 0.97 0.47
549 162 352 277 75 32 37 154 142 176 10 11 10 5 0.34 0.63 0.76 0.98
666 783 348 232 116 76 44 112 41 54 10 11 8 4 0.58 1.26 0.32 0.39
181 116 543 384 159 153 181 163 73 140 10 13 11 4 0.84 0.34 0.37 1.05
994 653 576 507 69 192 124 192 148 160 13 9 9 5 0.97 0.39 0.86 0.31
997 225 510 403 107 170 46 52 124 89 18 14 7 5 0.67 0.51 0.61 0.08
801 160 340 170 170 116 80 107 38 42 10 8 9 6 0.95 0.19 1.18 0.58
508 986 612 526 86 91 204 121 100 74 18 8 6 6 0.69 0.93 0.65 0.41
249 185 298 149 149 142 111 57 38 120 11 13 7 5 0.92 0.68 0.86 0.9
568 972 378 261 117 188 49 51 53 189 15 12 8 4 0.56 0.54 1.32 1.09
840 1 480 403 77 82 47 106 132 160 13 9 8 4 0.16 0.72 0.7 0.29
27 201 402 353 49 155 159 37 152 201 13 13 8 4 0.41 0.76 0.86 0.93
603 339 352 221 131 50 124 87 176 59 12 12 8 4 0.58 0.37 0.09 0.11
138 828 406 260 146 87 53 57 195 203 19 14 8 4 0.96 0.77 0.79 1.07
537 780 406 243 163 203 164 166 137 67 14 13 6 4 0.94 0.45 0.45 1.22
```

Raw Dataset: `pirp-40-3-3-6-2.dat`

```
40 3 3 6  2083
384 64 10003 10003 10003 10003 10003 10003 10003 0.97 0.97 1.03 0.3
530 951 492 328 164 73 94 134 65 150 15 9 7 5 0.68 0.93 0.44 0.31
667 589 362 194 168 54 171 181 94 175 11 14 10 6 0.82 1.01 1.08 0.92
787 4 406 203 203 76 63 92 193 61 19 10 8 6 0.63 1.05 0.49 0.74
155 845 444 296 148 82 61 40 147 102 18 11 9 5 0.51 0.27 0.84 0.39
783 202 543 376 167 30 62 115 140 181 16 12 7 5 0.52 0.98 0.39 0.55
604 118 364 182 182 130 122 65 62 176 19 14 8 6 0.15 0.43 0.11 0.49
351 257 606 537 69 46 202 44 69 114 13 13 9 5 0.63 0.41 0.37 1.06
777 135 384 336 48 52 111 185 31 192 19 10 8 4 0.96 0.65 0.8 0.58
367 745 410 289 121 205 84 184 103 173 17 11 10 6 0.49 0.5 1.13 0.58
24 8 612 426 186 48 42 160 167 204 14 14 9 4 0.98 1.02 0.75 0.91
612 861 394 206 188 197 73 130 183 67 18 8 9 4 0.61 0.7 1.22 0.85
881 204 573 395 178 35 61 122 32 191 13 11 9 6 0.35 0.9 0.83 0.87
240 221 398 242 156 143 144 199 85 48 12 9 10 5 0.02 0.61 0.98 0.87
479 151 410 205 205 56 195 98 56 107 12 9 9 6 0.27 1.01 1.23 0.72
565 371 334 225 109 87 31 167 117 96 11 12 7 4 0.23 0.26 0.7 0.78
19 634 516 373 143 127 132 172 132 31 10 8 9 5 0.59 0.51 0.62 0.42
19 673 540 472 68 180 56 144 160 60 16 14 10 4 0.21 0.21 0.71 0.46
805 382 459 306 153 153 73 102 153 54 13 10 8 6 0.27 0.29 0.71 1.11
637 158 501 342 159 151 148 167 164 164 14 14 8 4 0.12 0.4 0.25 0.42
933 641 418 318 100 105 88 209 182 201 16 13 8 5 0.59 0.35 0.24 0.73
404 737 350 186 164 175 98 170 47 49 11 13 7 6 0.56 0.52 1.29 0.66
840 464 388 284 104 95 194 64 153 34 13 9 8 5 0.29 0.83 0.17 1.07
49 945 615 418 197 205 97 60 34 159 11 14 6 5 0.04 0.68 0.81 0.32
919 105 374 198 176 115 185 61 34 187 16 14 8 4 0.43 0.59 0.56 0.54
509 140 370 229 141 185 160 43 134 135 18 12 9 5 0.53 1.17 0.8 0.44
439 319 398 210 188 140 119 199 73 159 14 9 7 6 0.95 1.29 0.45 0.62
130 920 597 429 168 199 39 113 198 41 11 13 10 5 0.46 0.93 0.89 1.09
728 571 410 350 60 205 185 186 89 152 12 11 7 5 0.28 0.68 0.81 0.91
701 748 588 517 71 62 38 148 196 103 12 11 10 5 0.92 0.38 0.09 0.85
848 48 396 309 87 95 115 120 113 198 14 10 8 6 0.46 0.75 0.51 0.76
606 465 378 208 170 109 189 145 138 37 15 10 9 5 0.81 0.69 1.15 1.06
71 773 268 207 61 131 134 42 89 84 11 9 6 5 0.91 1.09 0.5 1.16
974 72 492 367 125 132 164 44 103 117 18 14 7 4 0.66 0.75 0.89 0.89
664 388 384 293 91 152 143 111 112 192 16 14 10 4 0.57 0.05 0.69 1.03
504 374 513 342 171 86 126 152 92 31 16 8 8 5 0.18 0.33 0.76 0.58
75 652 404 252 152 202 95 95 188 53 13 13 8 4 0.37 1.14 0.51 1.03
331 620 579 531 48 193 42 132 136 45 16 10 10 6 0.61 0.16 0.11 0.87
369 730 588 472 116 185 141 152 176 196 15 11 10 4 0.88 0.15 0.06 1.2
210 970 588 533 55 51 75 196 173 128 18 12 9 6 0.56 1.06 0.2 0.23
390 453 356 188 168 112 171 163 139 178 14 10 8 4 0.85 0.49 0.31 0.85
```

Raw Dataset: `pirp-40-3-3-6-3.dat`

```
40 3 3 6  2007
514 731 9638 9638 9638 9638 9638 9638 9638 0.46 0.49 0.8 1.04
807 459 388 221 167 94 154 148 104 194 16 11 10 6 0.12 0.83 0.93 0.7
551 244 410 214 196 114 136 133 205 50 10 15 9 5 0.97 1.23 0.79 1
134 723 624 545 79 175 161 193 208 175 15 10 9 4 0.09 0.61 0.13 0.74
957 129 486 337 149 83 162 152 62 128 14 9 8 4 0.28 0.35 1.17 1.3
834 751 328 241 87 73 164 111 118 77 19 10 10 4 0.46 0.43 0.27 0.52
883 403 507 338 169 126 120 43 138 87 12 11 8 6 0.11 0.97 0.82 0.63
6 251 404 328 76 127 202 151 40 191 10 9 10 6 0.66 0.64 1.08 0.72
265 678 612 436 176 134 57 204 86 56 11 13 7 6 0.15 1.25 0.81 1.02
696 506 324 209 115 162 70 69 142 49 14 15 7 5 0.04 1.04 0.37 0.92
931 537 591 546 45 118 180 40 197 155 18 15 6 5 0.04 0.22 1.27 0.67
391 75 386 323 63 193 110 49 172 135 12 10 9 6 0.1 1.15 0.39 0.12
275 408 618 419 199 206 38 90 129 157 13 15 7 6 0.37 0.26 0.37 0.71
963 245 338 169 169 65 53 88 76 107 12 14 10 6 0.02 0.81 0.51 1.28
225 7 492 328 164 30 67 105 128 42 14 11 9 5 0.51 0.63 1.09 0.45
80 90 561 374 187 125 175 129 170 63 14 10 9 4 0.5 0.74 0.31 0.66
216 568 492 346 146 34 81 164 111 133 13 13 9 4 0.36 0.57 1.01 1.25
244 886 573 382 191 92 73 177 138 125 11 13 8 5 0.85 0.56 0.89 0.9
642 421 378 189 189 68 134 165 110 116 17 10 9 4 0.02 0.66 0.79 0.36
508 793 374 228 146 80 51 187 79 59 12 10 8 6 0.2 0.34 1.11 0.51
125 954 302 221 81 151 50 54 124 31 14 11 8 5 0.34 0.71 0.71 1
604 392 294 168 126 77 136 147 80 81 15 12 10 4 0.18 0.66 0.57 1.02
578 828 549 442 107 119 183 99 41 32 12 12 7 5 0.41 1.03 0.68 0.87
105 229 406 203 203 123 192 31 45 34 12 14 8 6 0.56 0.74 0.9 0.94
835 255 543 362 181 144 68 106 132 150 19 10 7 6 0.1 0.33 1.31 0.87
913 196 372 272 100 124 67 60 117 88 19 12 7 6 0.75 1.05 0.94 0.25
196 336 600 432 168 179 49 185 200 117 15 11 9 4 0.84 1.16 0.37 0.62
136 468 597 402 195 125 75 163 117 199 15 12 10 5 0.98 1.04 0.54 0.7
262 227 418 267 151 209 204 163 97 199 16 10 6 6 0.01 0.52 1.37 0.85
379 454 370 258 112 159 176 185 58 57 15 10 7 4 0.66 0.57 0.99 0.11
481 595 406 268 138 203 47 132 110 179 13 14 11 4 0.01 0.34 0.27 0.5
431 990 412 319 93 206 86 51 56 111 11 15 10 6 0.51 0.24 0.61 0.83
884 244 462 308 154 56 48 47 126 37 17 9 7 6 0.1 0.45 0.68 1.04
612 591 286 143 143 116 95 60 44 91 19 11 10 4 0.68 0.44 0.14 0.05
245 345 390 214 176 73 191 195 128 170 18 10 10 6 0.11 1.06 0.66 0.8
787 490 308 195 113 69 126 70 154 87 10 11 11 5 0.26 0.22 1.14 0.68
272 900 334 302 32 123 46 167 31 62 17 10 11 5 0.17 1.32 1.16 1.26
947 424 364 309 55 182 113 40 152 166 18 11 8 4 0.61 0.55 1.08 1.4
684 536 627 550 77 173 209 32 149 51 14 11 8 4 0.46 0.47 0.49 0.61
445 552 150 83 67 42 75 65 40 43 16 13 8 5 0.65 0.22 1.26 1.03
759 349 621 540 81 149 127 207 157 94 12 12 8 6 0.41 0.8 0.72 0.73
```

Raw Dataset: `pirp-40-3-3-6-4.dat`

```
40 3 3 6  2083
518 818 9999 9999 9999 9999 9999 9999 9999 0.63 0.33 0.84 1.2
793 644 350 316 34 175 69 126 129 62 11 11 9 5 0.89 1.09 0.56 0.82
26 911 364 219 145 126 89 176 151 182 14 15 8 4 0.25 0.95 1.25 1.15
886 526 576 384 192 77 36 51 119 124 18 11 8 6 0.47 0.69 0.47 0.57
411 382 418 243 175 199 209 179 42 54 18 10 9 4 0.92 1.1 0.65 0.08
131 611 394 272 122 197 33 169 120 41 17 10 7 6 0.95 0.9 0.77 0.62
340 330 348 313 35 174 80 84 83 105 12 13 10 5 0.42 0.67 0.94 1.18
347 452 468 326 142 156 101 113 61 80 17 12 11 6 0.4 0.25 0.49 0.7
326 566 336 168 168 51 73 79 90 45 16 11 7 6 0.7 0.18 1.38 0.29
923 831 564 376 188 183 165 179 179 146 16 13 11 5 0.03 0.79 1.11 0.91
891 965 519 356 163 104 136 173 116 168 11 10 7 5 0.01 1.01 0.95 0.73
152 771 552 417 135 123 184 146 68 123 10 10 7 4 0.71 0.38 0.66 0.36
732 521 416 331 85 185 208 161 157 165 15 8 9 6 0.51 0.52 1.25 0.95
381 466 534 356 178 164 30 100 104 98 13 14 10 6 0.88 0.35 0.67 0.4
92 64 570 445 125 119 190 141 36 81 12 14 7 5 0.27 0.62 1.04 1.2
291 707 286 143 143 111 89 49 52 137 19 11 7 4 0.49 0.69 0.53 0.41
380 238 567 517 50 77 86 84 189 169 15 11 7 5 0.34 0.83 0.89 1.37
542 514 579 484 95 153 64 45 193 176 14 8 10 5 0.22 1.16 0.73 1.2
747 12 609 450 159 164 148 203 122 148 18 12 7 6 0.22 1.05 0.82 0.7
477 267 600 497 103 86 109 200 61 167 15 10 9 4 0.01 0.53 1.08 0.72
974 305 370 320 50 118 130 185 167 36 14 15 9 4 0.57 0.94 0.84 0.56
796 499 528 466 62 41 176 129 106 168 17 14 9 5 0.93 0.44 1.07 0.13
806 924 567 524 43 162 189 147 132 136 13 13 9 5 0.22 0.71 0.72 0.67
579 173 362 244 118 181 132 162 64 112 19 12 7 4 0.21 0.51 0.63 0.38
650 287 416 316 100 140 96 204 208 175 11 11 9 5 0.36 0.66 0.32 1.03
158 223 364 313 51 182 146 98 86 167 11 11 9 5 0.37 0.37 1.22 1.17
510 221 404 202 202 37 31 192 56 195 10 12 8 6 0.86 0.88 1.14 0.91
934 181 402 265 137 119 32 201 45 78 16 11 10 4 0.61 0.99 0.41 1.07
747 93 414 274 140 74 64 164 207 109 11 9 8 5 0.14 0.37 0.72 1.09
651 779 615 571 44 59 123 169 205 34 10 11 8 4 0.49 0.57 0.49 0.8
162 549 573 480 93 80 191 140 190 166 16 10 11 5 0.09 0.37 0.11 1
449 738 366 185 181 128 183 71 109 167 16 14 8 4 0.01 0.09 1.02 0.97
872 869 414 276 138 134 73 114 132 94 16 10 10 6 0.51 0.61 0.61 1.43
54 16 603 402 201 78 110 99 180 30 10 15 9 5 0.76 0.83 0.9 0.79
903 627 456 306 150 68 152 44 125 64 17 14 10 5 0.13 0.92 0.81 0.8
703 713 368 184 184 47 77 75 55 121 19 14 8 5 0.31 0.34 0.78 0.57
756 593 376 330 46 124 85 188 117 75 16 10 8 4 0.01 0.99 1.27 0.56
497 738 386 218 168 156 86 187 193 101 13 10 7 4 0.96 0.22 1.03 0.86
596 86 416 348 68 143 103 166 40 208 17 14 8 6 0.8 0.19 1.38 0.61
856 769 332 241 91 115 92 114 41 166 17 10 9 4 0.66 0.51 0.43 0.19
738 727 406 203 203 39 67 81 203 154 13 12 9 4 0.42 1.14 0.97 0.93
```

Raw Dataset: `pirp-40-3-3-6-5.dat`

```
40 3 3 6  2055
300 921 9865 9865 9865 9865 9865 9865 9865 0.59 0.5 0.4 0.38
376 847 624 494 130 178 189 134 208 96 14 15 9 4 0.76 0.98 0.53 1.2
923 315 412 244 168 188 57 112 45 206 13 9 7 6 0.01 0.39 0.51 0.27
963 47 336 168 168 157 50 100 115 150 13 9 10 4 0.78 0.75 0.67 1.32
942 99 510 413 97 66 50 170 165 77 10 9 8 5 0.27 0.75 0.89 0.6
123 896 330 282 48 64 114 142 57 165 15 14 9 4 0.7 0.95 0.45 0.67
890 98 368 235 133 184 102 35 174 163 15 10 10 6 0.69 0.15 0.6 0.49
195 692 411 274 137 89 82 73 30 70 18 12 8 6 0.71 0.08 0.87 0.94
747 797 402 201 201 104 78 193 138 55 19 15 9 6 0.88 0.76 0.63 0.13
306 754 486 387 99 62 132 162 102 123 19 12 11 5 0.74 0.85 0.88 0.3
565 53 262 214 48 65 97 61 131 61 17 14 8 4 0.17 0.35 0.1 0.49
828 175 392 243 149 75 138 196 170 178 16 12 8 5 0.89 0.6 0.91 0.9
886 403 591 394 197 170 148 147 31 185 14 9 8 5 0.19 0.64 0.6 1.18
161 150 398 218 180 71 126 63 199 49 15 10 9 4 0.74 0.42 0.18 0.68
510 42 388 245 143 162 194 94 99 76 13 14 8 6 0.59 0.79 1.02 1.27
754 332 534 461 73 129 119 84 60 178 18 9 9 4 0.24 0.29 0.43 0.33
478 404 384 297 87 146 169 171 137 192 12 12 7 5 0.8 0.53 0.84 0.97
986 644 480 388 92 66 86 149 160 155 17 9 7 5 0.65 0.36 0.81 0.99
175 495 603 437 166 201 115 197 96 189 11 10 9 6 0.85 0.38 0.52 0.73
481 251 368 285 83 119 107 66 80 184 11 11 9 5 0.68 0.5 0.83 1.37
581 75 525 396 129 175 39 63 141 47 11 14 6 6 0.23 0.96 1.22 0.41
53 887 362 195 167 148 112 181 46 56 14 14 9 4 0.64 0.54 1.21 0.36
134 500 408 295 113 204 134 145 174 108 18 12 10 6 0.3 0.26 1.16 0.54
853 315 416 330 86 200 121 69 129 208 13 10 10 4 0.17 0.51 0.7 0.88
234 781 394 197 197 120 164 108 122 140 12 11 8 4 0.73 1.27 0.3 0.74
156 202 372 257 115 58 111 45 83 186 14 13 10 6 0.48 0.71 1.15 0.95
401 180 418 344 74 115 74 121 163 209 18 9 10 6 0.87 0.73 0.53 0.97
595 368 366 324 42 183 105 178 160 74 19 11 8 6 0.49 0.52 1.31 0.5
493 523 399 312 87 133 110 92 78 38 10 10 8 4 0.83 0.77 0.58 0.45
663 539 594 504 90 198 106 78 30 48 19 9 7 6 0.23 0.92 0.42 1.03
442 281 350 175 175 88 160 151 43 143 19 14 6 4 0.54 0.59 0.43 0.33
611 279 414 269 145 55 87 168 50 207 14 9 8 6 0.24 0.19 0.24 1.06
41 467 398 322 76 175 156 88 125 199 16 14 9 4 0.61 1.22 0.58 1.07
380 809 609 406 203 124 112 49 73 180 10 14 9 4 0.55 0.65 0.41 0.89
7 515 408 375 33 204 179 105 71 42 17 14 8 6 0.7 0.64 0.59 0.18
380 569 588 448 140 179 172 196 124 70 12 10 7 6 0.81 0.83 0.82 0.46
13 938 372 186 186 118 171 94 42 105 18 11 8 5 0.19 0.85 0.76 0.96
81 934 537 358 179 72 125 101 82 103 10 11 10 4 0.85 0.49 0.72 0.21
679 202 564 376 188 121 75 64 47 77 17 10 11 4 0.92 0.45 1.11 0.71
997 212 376 188 188 107 50 92 123 137 10 10 7 5 0.74 1.01 0.78 0.66
307 109 564 472 92 42 59 52 188 138 18 13 9 5 0.73 0.38 0.37 1.32
```

Raw Dataset: pirp-40-5-3-10-1.dat

```
40 5 3 10  2032
200 335 9753 9753 9753 9753 9753 9753 9753 9753 9753 9753 9753 0.8 0.71 0.67 1.01 0.29 0.42
29 719 414 207 207 30 128 38 62 60 173 79 53 151 16 15 12 10 6 6 0.1 0.56 0.37 0.43 1.22 0.51
757 345 416 301 115 208 58 56 92 127 128 73 129 126 10 10 13 8 7 6 0.55 0.29 0.71 1.12 0.85 0.22
936 383 576 394 182 106 164 99 50 74 104 192 189 104 17 15 10 10 7 6 0.7 0.9 1.08 0.86 1.26 0.65
19 233 404 328 76 71 82 202 114 78 146 108 60 195 15 16 12 11 6 4 0.2 0.5 0.87 0.87 0.53 0.33
339 685 576 403 173 178 192 30 136 131 175 52 183 100 14 17 13 11 8 5 0.1 0.46 0.67 0.7 0.91 1.09
995 974 408 204 204 35 183 94 182 62 191 150 85 146 10 12 10 9 6 4 0.71 0.56 1.29 0.5 0.62 1.11
197 259 390 350 40 31 157 156 179 184 30 139 195 162 14 12 8 9 8 5 0.55 0.52 1.32 0.71 0.47 0.12
551 88 621 537 84 169 207 37 165 184 76 162 172 112 18 14 12 8 6 6 0.71 0.4 1 0.75 0.53 0.38
712 832 356 261 95 54 117 178 173 60 106 65 111 126 12 16 10 8 6 6 0.81 0.62 1.04 0.8 0.17 1.44
86 59 366 290 76 79 90 44 58 183 36 124 156 70 11 16 12 10 9 6 0.23 0.5 0.97 1.16 0.77 0.7
953 512 582 388 194 160 144 54 40 183 105 99 106 77 10 10 9 9 7 4 0.18 1.19 0.47 0.6 0.97 0.93
503 699 416 307 109 121 182 208 154 96 120 120 134 71 11 13 12 9 8 4 0.86 0.95 1.33 0.96 0.75 1.11
216 202 612 535 77 204 144 170 153 80 61 35 46 34 16 11 8 10 7 4 0.26 0.6 0.4 0.57 0.87 0.4
509 811 358 259 99 141 179 103 134 76 65 82 134 113 14 12 13 7 8 6 0.32 0.93 0.44 0.46 0.48 0.48
81 186 384 199 185 87 65 89 36 166 192 169 59 107 19 9 10 10 8 6 0.26 0.84 0.89 0.71 0.62 1.14
405 628 528 364 164 72 160 61 176 154 119 35 40 88 18 16 12 12 7 6 0.72 0.83 1.1 0.92 0.9 0.96
405 530 412 332 80 142 69 191 101 206 99 31 178 127 19 15 13 10 7 6 0.64 0.81 0.85 0.27 0.54 0.33
27 958 364 332 32 99 44 130 107 149 112 67 46 182 17 11 10 9 8 5 0.61 0.93 1.16 0.22 0.85 0.86
836 782 406 205 201 201 203 45 163 130 155 55 164 152 18 15 13 9 7 6 0.76 0.05 0.15 0.62 0.86 0.77
171 238 386 193 193 126 116 135 129 152 150 73 101 188 17 10 9 10 7 6 0.84 0.34 0.53 0.6 0.89 1.47
72 218 366 183 183 89 151 33 101 42 32 30 138 81 14 11 9 9 6 6 0.33 0.39 0.71 1.17 0.14 0.75
160 22 318 159 159 148 117 30 32 101 49 128 54 95 18 9 8 11 7 4 0.45 1.13 0.72 0.42 0.5 0.79
480 731 618 412 206 136 73 143 34 145 165 126 91 85 11 13 14 10 8 4 0.17 0.83 1.03 0.51 0.56 0.96
726 465 621 531 90 70 169 145 37 49 116 92 207 158 17 10 13 9 6 4 0.22 0.03 0.81 0.96 1.42 1.05
838 290 549 455 94 56 183 94 53 61 179 169 155 178 14 12 12 12 8 4 0.16 0.82 1.14 1.05 1.09 0.62
712 173 621 440 181 142 149 201 207 188 72 164 196 158 15 13 12 10 9 6 0.75 0.91 1.06 0.38 0.3 0.03
863 184 627 482 145 98 99 93 75 151 158 209 138 104 16 14 9 9 6 6 0.45 1 0.22 0.71 0.99 0.83
816 879 412 356 56 130 50 130 169 73 206 144 151 195 15 10 10 8 8 4 0.87 0.75 0.9 0.67 0.99 0.48
522 674 398 352 46 54 77 83 31 73 162 54 181 199 13 14 11 8 7 5 0.81 0.21 0.76 0.93 1.28 0.6
954 591 384 313 71 165 120 61 189 134 107 192 88 180 17 14 9 10 7 6 0.4 0.81 0.8 0.77 0.77 1.03
269 144 392 251 141 196 160 163 162 46 134 186 126 184 19 16 13 11 7 4 0.06 0.43 0.68 1.35 0.74 0.43
776 492 372 188 184 81 144 158 107 186 42 183 64 43 19 16 13 10 8 4 0.71 0.87 0.97 0.63 0.87 1.19
116 963 362 261 101 69 176 115 83 64 119 86 95 181 17 10 9 8 8 5 0.99 0.56 0.41 0.62 0.69 0.71
306 789 408 355 53 93 201 204 101 97 119 89 188 136 11 12 9 10 7 4 0.56 1.06 1.02 0.58 1.04 0.26
367 352 609 513 96 81 143 203 117 81 44 89 97 188 19 16 13 8 8 4 0.74 0.96 0.38 1.11 0.35 0.77
105 530 418 275 143 30 182 173 209 49 206 121 155 55 11 17 14 7 6 4 0 0.72 0.76 0.72 0.95 0.38
767 501 609 517 92 63 178 170 118 203 72 162 56 153 14 16 8 9 7 4 0.35 0.75 0.72 0.64 1.3 0.52
65 346 404 215 189 123 104 184 146 51 158 199 38 202 11 12 10 10 8 4 0.04 1.02 0.96 0.95 0.49 0.12
807 881 561 499 62 59 42 106 41 187 132 163 111 35 10 17 13 11 7 6 0.26 0.9 0.4 0.48 0.79 0.88
256 611 624 528 96 190 147 153 86 55 174 208 173 95 14 14 9 7 7 6 0.07 0.45 0.51 0.81 0.28 1.12
```

Raw Dataset: `pirp-40-5-3-10-2.dat`

```
40 5 3 10  1979
314 124 9500 9500 9500 9500 9500 9500 9500 9500 9500 9500 9500 0.19 0.72 0.45 0.5 0.7 0.79
494 850 384 207 177 180 55 192 130 129 108 30 88 41 11 9 14 7 8 5 0.95 1.21 0.88 0.36 1.16 0.11
657 844 398 306 92 120 199 156 91 125 38 115 112 179 11 9 13 11 8 6 0 0.08 0.29 0.53 0.84 1.32
119 584 326 185 141 109 67 163 58 76 79 66 77 52 10 16 13 8 8 4 0.69 0.6 1.12 0.22 1 1.28
30 174 609 477 132 100 72 154 134 203 131 191 152 153 17 14 13 11 9 6 0.67 1.16 1.24 0.3 0.83 1.03
984 503 603 456 147 173 110 90 36 201 165 149 140 54 17 10 8 9 7 4 0.9 0.74 0.75 0.78 1.26 0.69
562 639 585 414 171 167 44 195 151 40 51 64 162 78 16 10 11 10 7 6 0.38 0.25 1.11 0.93 0.64 0.55
317 567 404 282 122 90 54 42 33 128 202 56 46 40 10 14 8 9 6 4 0.13 0.51 0.95 0.9 0.39 0.77
347 87 531 413 118 42 177 128 140 174 67 71 39 118 16 14 9 7 8 5 0.74 0.41 0.71 0.56 0.57 0.48
572 505 621 433 188 35 172 148 104 91 207 140 105 43 19 11 13 9 7 6 0.32 0.72 0.31 0.49 0.61 0.67
675 575 549 516 33 126 172 98 108 176 183 85 80 44 18 13 14 8 6 4 0.44 0.8 0.3 1.18 0.81 0.94
623 906 344 274 70 145 119 84 36 74 52 89 99 172 15 11 10 10 6 5 0.37 0.81 0.67 1.15 0.93 0.88
842 431 618 536 82 138 203 44 92 206 71 112 35 146 11 15 10 8 7 5 0.51 1.13 0.44 0.9 0.51 0.78
664 886 380 325 55 84 56 172 185 58 95 190 189 126 13 14 9 9 6 6 0.93 0.39 0.87 0.91 1.29 0.89
259 699 597 416 181 113 73 150 74 197 136 191 51 199 15 13 13 10 7 6 0.66 0.53 0.94 0.9 1.27 0.56
120 12 603 500 103 169 123 92 104 142 64 86 40 201 10 15 11 9 6 4 0.58 0.43 0.53 0.28 0.21 0.42
10 93 561 381 180 77 187 43 79 107 135 164 38 138 15 13 8 11 8 5 0.87 0.47 0.94 0.37 0.55 0.11
536 566 489 434 55 141 103 163 54 73 89 76 60 66 13 10 12 8 7 5 0.39 0.14 0.34 0.35 0.86 0.47
824 669 594 513 81 144 155 117 198 92 43 39 43 89 19 13 12 10 6 4 0.53 0.97 0.82 0.91 0.14 0.72
791 844 600 406 194 95 91 125 200 156 135 67 109 86 17 9 12 8 8 5 0.69 0.85 1.04 0.25 0.53 0.99
551 655 410 351 59 201 42 168 36 205 204 94 174 81 18 14 10 11 8 5 0.08 0.73 1.24 0.58 1.21 0.52
11 586 585 439 146 121 104 69 44 187 124 48 195 53 10 17 11 10 6 5 0.27 0.85 0.75 1.05 1.09 1.24
614 246 627 561 66 124 200 141 189 123 59 70 83 209 12 14 10 12 8 5 0.81 0.73 1.2 1.07 1.12 0.56
310 579 378 301 77 186 42 128 128 169 75 180 162 189 19 11 11 9 9 4 0.22 0.88 0.3 0.4 0.73 1.02
497 326 483 433 50 153 138 82 61 108 161 135 142 132 19 16 12 8 7 5 0.7 0.74 0.94 0.41 0.69 0.32
480 1 412 206 206 34 51 128 113 180 46 149 63 35 12 14 10 8 7 5 0.05 0.88 0.76 0.85 1.15 0.75
550 729 388 290 98 124 70 155 130 142 97 194 187 71 12 11 12 11 6 5 0.41 0.16 0.74 0.32 0.66 1.16
186 426 340 244 96 66 77 138 54 99 139 170 140 51 15 11 9 10 6 6 0.59 0.46 0.69 0.54 0.69 0.73
738 102 394 288 106 50 51 179 174 197 158 38 188 173 19 11 13 10 8 5 0.35 0.34 0.7 0.85 0.9 0.47
297 467 372 234 138 91 186 153 74 144 56 169 91 115 18 14 11 10 8 6 0.74 0.76 0.54 0.78 1.49 0.6
659 156 597 398 199 134 162 157 106 39 196 193 146 116 16 13 13 10 6 5 0.2 0.98 0.77 0.56 0.98 0.57
217 404 543 448 95 127 90 181 126 181 117 163 101 36 10 10 11 7 7 5 0.17 0.64 0.71 0.82 1.2 0.54
746 953 552 450 102 174 142 108 84 31 184 61 160 106 19 13 10 8 7 6 0.71 0.2 1.07 0.81 0.75 0.52
38 958 316 286 30 158 120 106 93 118 59 111 30 108 16 16 12 7 6 6 0.56 0.25 0.93 0.22 1 0.24
461 323 382 220 162 139 173 113 52 111 191 49 179 49 12 10 9 10 9 5 0.6 0.43 0.83 0.34 1.2 1.17
633 716 627 554 73 158 93 93 209 206 196 77 66 190 14 9 10 9 6 5 0.91 0.82 0.79 0.38 0.93 0.56
519 25 396 310 86 74 77 66 44 83 162 64 54 198 16 13 9 10 7 4 0.59 1.29 0.64 0.75 0.96 0.56
489 512 624 514 110 101 175 150 105 154 155 208 114 32 14 13 9 10 7 4 0.14 0.54 0.98 0.88 1.19 0.74
20 565 603 408 195 186 49 69 155 178 101 201 165 98 11 13 11 8 7 5 0.47 0.18 0.5 0.83 1.12 0.57
245 104 392 240 152 97 52 92 196 105 97 62 184 49 11 9 13 10 7 6 0.12 0.54 0.8 0.82 0.22 0.12
169 198 606 493 113 39 172 132 97 177 68 202 61 160 11 15 9 8 6 6 0.12 0.18 0.95 0.46 0.98 0.55
```

Raw Dataset: `pirp-40-5-3-10-3.dat`

```
40 5 3 10  2050
174 426 9840 9840 9840 9840 9840 9840 9840 9840 9840 9840 9840 0.76 0.62 0.72 0.43 0.81 1.04
791 196 609 406 203 40 196 83 159 83 101 108 79 114 17 13 10 7 9 5 0.09 0.96 0.36 0.51 1.28 0.77
745 227 612 408 204 112 159 160 33 70 76 151 31 66 18 12 11 9 7 6 0.18 0.14 0.53 0.75 0.48 0.57
451 767 573 429 144 179 65 180 191 170 39 38 188 189 19 12 11 7 7 5 0.76 1.03 0.86 0.35 0.94 0.92
14 142 588 450 138 120 130 117 151 81 196 97 30 96 13 13 13 10 7 5 0.28 1.15 0.45 1.42 0.79 0.53
319 793 408 204 204 51 130 90 165 144 44 61 164 159 12 14 10 9 8 4 0.56 0.38 0.43 0.28 1.03 1.12
460 18 618 565 53 169 206 183 183 206 168 153 174 50 10 16 13 10 7 5 0.85 1.32 0.5 1.33 0.9 1.16
232 927 603 428 175 190 164 67 201 196 45 68 161 167 14 13 10 9 6 6 0.7 0.25 0.38 0.47 0.43 0.43
490 413 362 227 135 68 150 93 181 102 160 32 53 66 12 11 10 10 7 5 0.27 1.13 1.01 0.62 0.95 1.12
146 749 306 275 31 143 153 67 153 75 61 145 75 43 13 12 10 7 7 6 0.94 0.44 0.88 0.29 1.25 0.7
553 75 603 427 176 201 69 61 45 116 42 134 102 125 14 16 14 9 8 5 0.25 0.65 1.02 0.67 0.63 0.9
615 75 412 330 82 197 128 50 78 101 197 196 206 84 10 14 12 8 9 5 0.5 1.24 0.36 1.25 0.84 0.99
653 104 627 471 156 131 154 82 69 182 209 37 152 159 13 10 9 9 6 6 0.25 0.49 1.07 0.48 0.33 0.63
736 893 388 243 145 31 194 94 112 47 79 40 44 132 16 14 14 10 7 4 0.93 0.34 0.68 1.04 1.15 0.31
794 39 312 255 57 148 45 32 156 153 105 32 86 31 11 12 8 10 6 4 0.59 0.38 0.4 0.48 0.52 0.57
61 669 603 560 43 33 115 96 77 189 196 90 201 159 16 14 10 10 8 5 0.3 0.4 1.13 0.96 0.92 0.64
149 442 549 462 87 161 181 88 34 154 117 124 36 183 19 9 14 7 8 4 0.29 1.06 0.62 1.18 0.39 0.36
772 68 525 412 113 106 118 87 73 119 161 175 148 123 12 10 13 8 9 5 0.22 0.26 0.66 0.96 0.62 0.89
960 148 368 277 91 138 123 184 119 55 144 42 129 166 11 16 10 9 8 5 0.16 1.01 0.59 0.98 0.4 0.89
492 386 579 522 57 179 187 193 176 187 73 147 95 87 17 15 13 7 7 4 0.75 0.55 0.32 0.99 0.19 0.66
929 342 621 435 186 207 191 115 175 123 73 42 90 161 10 12 11 12 7 6 0.44 1.05 0.54 1.04 0.95 1.18
385 728 600 429 171 115 135 122 121 116 36 194 200 59 10 16 12 10 7 4 0.96 1.02 0.74 0.14 1.2 1.11
531 761 346 213 133 47 108 162 48 173 83 152 69 105 14 14 11 8 8 4 0.68 0.37 1.25 0.66 0.68 0.23
441 440 582 529 53 174 43 129 194 114 110 162 163 126 16 13 9 10 8 5 0.62 1.17 0.36 1.29 1.14 1.11
608 761 549 444 105 168 183 73 73 145 86 57 79 122 12 14 14 10 7 4 0.36 0.46 0.91 1.26 0.58 0.37
115 777 408 294 114 96 67 79 123 136 52 97 124 134 10 13 10 8 6 6 0.48 0.35 0.53 1.5 0.53 1.19
202 924 414 329 85 207 178 62 132 113 59 125 53 181 15 17 11 7 8 4 0.2 0.2 0.71 0.73 0.15 0.95
853 927 609 547 62 109 200 33 140 174 197 95 155 203 10 13 13 9 9 6 0.89 1.06 0.99 0.81 0.85 1.08
197 490 376 346 30 143 188 75 178 82 123 55 143 95 17 10 9 7 6 6 0.04 0.46 0.81 1.25 0.96 0.98
442 669 627 486 141 38 181 207 94 191 209 163 127 188 15 16 9 7 9 6 0.2 0.79 1.1 1.3 1.14 0.58
359 580 579 544 35 114 50 193 115 152 42 36 184 130 11 13 12 10 6 5 0.62 0.94 0.55 0.98 0.87 0.48
168 169 453 375 78 139 69 50 120 69 91 59 151 122 18 15 14 9 6 6 0.18 0.52 1.29 1.04 0.67 1.17
998 233 412 269 143 130 42 107 81 103 48 89 201 206 18 17 8 8 7 5 0.95 0.51 0.35 0.49 1.02 1.2
505 624 402 334 68 173 185 116 144 115 201 194 170 39 17 16 9 11 8 6 0.67 0.23 0.89 0.78 1.14 0.27
113 3 615 537 78 172 179 140 153 124 204 205 183 123 18 16 12 10 9 6 0.13 1.31 0.26 1.33 0.48 0.85
112 474 627 512 115 169 58 209 39 151 92 177 96 133 15 16 11 11 8 6 0.71 0.36 0.96 0.77 1.05 0.97
184 842 388 307 81 110 30 184 186 83 99 51 194 46 15 16 12 7 7 5 0.72 0.21 0.99 1.11 0.83 0.46
651 159 302 241 61 114 34 129 85 90 151 83 142 109 17 10 13 10 7 4 0.07 0.78 0.63 1.29 1.05 1.41
370 547 576 436 140 128 166 91 192 130 182 105 97 40 16 9 13 8 7 4 0.87 1 0.32 0.97 0.84 0.18
345 235 418 219 199 93 79 209 142 82 168 113 169 185 15 10 12 8 8 6 0.21 0.52 0.64 0.4 0.28 0.92
791 477 406 230 176 76 181 203 39 86 38 109 139 33 10 10 9 10 9 5 0.83 0.65 0.49 1.14 0.74 0.52
```

Raw Dataset: `pirp-40-5-3-10-4.dat`

```
40 5 3 10  2032
215 538 9756 9756 9756 9756 9756 9756 9756 9756 9756 9756 9756 0.94 1.05 0.42 1.27 1.01 0.44
611 199 356 181 175 88 90 30 158 117 100 178 152 111 13 15 12 8 9 4 0.57 0.46 1.36 0.97 0.9 0.27
44 451 406 336 70 180 44 203 182 87 103 48 96 66 15 11 12 11 6 4 0.7 1.08 0.7 0.08 0.89 1.12
54 24 564 465 99 145 40 188 143 76 159 139 66 166 13 12 13 8 8 5 0.57 0.84 0.68 0.64 0.51 0.7
619 722 348 262 86 39 130 95 123 76 99 98 73 174 19 16 12 11 7 4 0.75 0.68 0.09 0.51 0.71 0.97
436 825 618 538 80 75 98 44 195 57 206 128 32 187 15 12 12 8 7 5 0.84 0.86 0.85 0.47 1.34 0.85
640 941 410 296 114 182 205 92 169 173 49 185 117 126 14 12 14 9 6 4 0.27 1.11 0.12 1.31 1.3 0.71
495 421 346 173 173 46 170 89 124 82 82 134 49 118 17 15 10 10 7 5 0.85 1.26 0.06 0.72 1.43 0.27
655 83 552 368 184 177 174 144 57 141 85 141 127 163 12 13 8 12 7 4 0.77 0.78 0.42 0.41 0.67 0.45
157 953 588 460 128 92 149 133 103 144 196 83 93 60 13 10 9 9 7 5 0.58 0.31 0.5 0.28 0.68 1.04
504 543 531 489 42 31 124 73 86 74 66 177 132 31 16 15 10 9 6 5 0.04 0.27 0.67 0.56 1.03 0.07
58 503 344 301 43 144 92 44 137 36 119 31 172 37 14 10 14 11 6 4 0.48 0.87 0.43 0.9 1.17 1.19
464 533 555 377 178 143 161 185 73 71 80 150 151 127 17 9 11 11 8 5 0.85 1.22 0.73 1.15 0.9 0.38
684 73 618 484 134 41 45 51 30 49 144 91 206 151 12 11 13 8 9 4 0.7 0.48 0.87 0.32 0.84 0.24
80 850 320 275 45 97 146 38 160 130 83 123 152 88 11 9 10 10 7 5 0.77 1.24 0.69 0.69 1 0.78
549 974 456 362 94 100 73 152 37 93 42 48 122 113 10 10 11 7 7 5 0.5 0.53 0.2 0.88 0.85 0.65
843 949 394 287 107 166 42 190 147 164 197 71 186 139 10 17 13 8 6 5 0.11 0.53 0.98 1.03 0.81 0.36
807 667 402 320 82 201 70 191 192 93 160 166 117 113 13 13 13 8 8 4 0.78 1.2 0.38 0.74 0.74 1.1
384 812 585 452 133 93 190 88 122 157 195 39 195 90 18 10 10 8 6 6 0.57 0.33 0.6 0.43 0.65 0.31
51 728 398 304 94 33 100 155 36 184 199 156 73 197 10 11 9 7 8 6 0.43 1.2 0.77 0.49 1.01 0.67
620 87 627 458 169 148 55 209 106 158 117 205 41 160 19 13 11 9 8 4 0.47 1.11 0.8 0.19 0.5 0.9
82 331 408 363 45 204 63 175 72 103 115 191 31 204 11 11 9 8 8 4 0.4 0.9 0.67 0.87 1.24 0.86
926 575 378 302 76 47 122 71 85 136 154 189 176 76 17 9 11 9 8 4 0.94 1.14 0.39 0.75 1.25 0.66
675 313 398 322 76 88 133 122 94 199 149 74 125 196 19 13 13 9 8 4 0.32 0.91 0.74 0.76 1 0.63
515 801 382 202 180 68 149 38 164 145 191 80 169 62 14 16 9 10 7 6 0.01 0.38 1.25 1.28 0.76 0.39
527 976 350 260 90 73 60 175 148 147 36 67 48 112 18 15 10 10 8 6 0.59 0.42 0.48 0.7 0.51 0.94
257 330 615 560 55 162 134 190 82 53 166 60 205 116 12 15 8 8 7 5 0.64 0.53 1.21 0.87 0.5 0.91
231 44 414 229 185 59 155 143 198 45 85 156 41 207 19 13 10 10 8 4 0.7 0.43 0.99 1.08 0.59 0.99
569 954 618 440 178 97 195 47 101 206 131 155 156 170 11 13 11 11 7 4 0.21 0.38 1.36 0.87 0.71 0.4
460 932 408 360 48 140 202 61 78 204 135 181 185 58 12 16 9 9 7 6 0.56 0.2 1.22 0.6 0.82 1.08
36 153 376 303 73 144 142 102 166 75 34 44 143 188 16 13 14 12 8 5 0.66 1.08 0.5 0.52 0.95 1.11
216 755 354 252 102 72 169 80 80 177 165 177 63 112 12 10 14 9 8 5 0.93 0.34 1.09 0.44 1.04 0.82
544 467 597 514 83 92 91 37 49 199 44 43 172 156 14 16 10 11 8 4 0.7 0.27 0.57 0.61 0.8 0.86
425 57 406 293 113 134 203 112 195 40 119 87 182 45 15 12 9 8 6 5 0.9 0.96 1.15 0.43 0.37 1.21
714 407 621 488 133 114 189 149 207 154 186 189 37 142 12 16 11 11 7 4 0.91 0.2 1.11 0.91 0.29 0.67
14 204 358 302 56 113 169 40 68 55 179 38 66 141 19 10 12 8 6 5 0.34 0.49 0.78 1.39 0.77 1.01
371 730 412 331 81 206 161 192 30 35 196 193 81 118 19 10 10 10 7 6 0.37 0.56 1.4 0.99 0.68 0.89
727 389 543 450 93 101 51 181 179 154 111 137 71 162 19 17 10 10 7 5 0.24 0.66 0.91 0.25 0.86 1.08
1 239 618 568 50 72 179 182 127 206 51 203 111 122 14 10 11 7 7 6 0.94 1.07 0.83 0.53 1.09 0.65
884 264 618 529 89 69 48 181 206 189 141 162 135 65 14 17 12 8 8 6 0.46 0.82 0.21 1.33 0.75 1.11
218 883 585 451 134 180 195 169 131 40 105 165 46 139 18 17 11 9 6 4 0.5 0.64 0.52 0.08 1.07 0.36
```

Raw Dataset: `pirp-40-5-3-10-5.dat`

```
40 5 3 10  2068
994 896 9930 9930 9930 9930 9930 9930 9930 9930 9930 9930 9930 0.55 1.16 0.86 0.75 0.94 1
577 832 594 396 198 41 69 193 193 195 62 145 91 46 15 12 8 9 9 6 0.86 1.12 0.77 0.79 0.22 0.82
124 765 561 397 164 111 187 52 70 124 184 132 70 151 11 12 10 8 7 4 0.21 0.82 0.71 0.51 0.89 0.36
745 219 382 233 149 60 191 90 147 135 147 171 129 139 15 9 9 7 7 5 0.72 0.43 0.42 0.4 0.04 1.21
470 796 570 403 167 175 53 96 67 190 187 82 162 154 12 9 9 10 7 4 0.57 0.1 1.2 1.04 0.54 0.3
477 468 400 243 157 104 110 101 117 200 89 181 37 151 16 14 9 9 6 6 0.64 1.11 1.02 0.91 0.55 1.08
434 394 615 410 205 119 163 147 87 101 147 160 77 125 13 16 11 12 8 4 0.11 0.3 1.24 1.16 0.46 0.86
100 507 609 501 108 151 111 203 194 105 117 154 188 153 10 14 8 9 6 4 0.98 0.56 0.4 1.12 0.22 0.47
40 485 591 535 56 177 126 179 124 138 67 150 197 59 12 14 14 9 7 4 0.48 0.36 1.26 0.76 0.61 0.46
544 537 504 365 139 126 114 168 35 86 65 135 154 150 11 10 8 9 7 6 0.98 0.31 0.36 0.54 0.41 1.21
73 387 372 198 174 48 130 114 135 186 52 59 125 43 16 10 14 10 6 5 0.41 0.78 0.29 0.5 0.56 0.52
159 274 603 434 169 96 195 54 113 80 201 150 133 78 18 14 11 8 8 6 0.07 0.59 0.76 0.65 0.62 0.92
589 111 348 308 40 122 72 140 70 132 174 69 111 164 14 10 13 10 9 5 0.52 0.9 0.42 0.92 0.79 0.31
362 293 414 238 176 51 173 130 130 42 174 207 186 40 18 15 14 7 7 4 0.12 0.63 0.98 1.06 1.42 0.81
447 720 400 200 200 87 197 83 99 119 136 70 183 195 18 13 13 8 9 6 0.58 0.96 0.71 0.35 0.51 0.19
782 369 588 429 159 107 134 196 89 33 97 78 172 147 14 13 12 9 7 6 0.74 0.46 1.13 1.36 0.55 0.3
221 548 624 419 205 89 70 194 194 132 144 186 146 208 12 14 13 11 8 4 0.72 0.92 1.32 0.99 1.03 0.48
361 70 555 376 179 113 157 49 185 178 157 72 30 60 15 9 14 7 7 6 0.68 0.53 0.9 0.52 0.65 1.44
519 337 374 196 178 112 147 80 41 101 170 187 49 56 14 14 8 7 7 5 0.48 1.09 1.29 0.83 0.78 1.29
438 874 404 252 152 107 69 50 184 188 88 202 48 54 14 10 10 9 8 5 0.71 1.22 0.75 0.71 0.99 0.43
554 607 537 402 135 178 89 159 134 79 125 179 170 69 16 16 14 8 7 4 0.23 1.17 0.87 0.44 1.07 0.53
382 950 410 331 79 88 55 118 119 189 78 205 105 184 17 14 12 12 6 5 0.61 0.4 0.72 0.7 1.16 0.7
974 534 372 212 160 53 85 186 126 67 116 69 140 185 17 11 9 10 6 6 0.66 1.06 1.02 1.19 0.25 1.33
201 839 564 531 33 36 116 188 102 30 35 124 96 52 15 14 12 8 8 6 0.05 0.68 0.78 0.33 0.58 0.63
58 766 576 384 192 126 60 34 47 54 74 40 99 169 13 10 10 8 7 4 0.27 1.21 0.7 0.68 0.74 0.91
606 406 615 583 32 194 70 43 87 168 130 205 168 195 16 11 11 10 8 6 0.21 0.91 0.41 0.36 1.26 0.96
599 835 504 336 168 83 66 154 156 132 92 102 54 140 13 11 9 10 7 4 0.74 0.94 0.61 0.57 1.08 0.53
588 611 404 301 103 202 79 33 36 111 181 113 137 86 15 15 11 10 7 5 0.56 0.75 0.61 0.81 0.99 0.4
534 904 410 277 133 103 205 189 196 193 132 182 182 147 15 12 12 9 7 6 0.98 0.43 0.7 1.3 0.89 1.16
142 398 579 386 193 62 56 131 66 110 55 67 109 83 11 12 11 10 8 4 0.21 0.2 0.86 0.63 0.65 0.38
495 523 416 272 144 153 131 69 118 73 139 208 154 162 11 12 12 8 6 6 0.72 0.8 1.07 1.18 0.89 0.94
172 94 356 312 44 178 101 176 86 76 172 57 41 113 14 13 11 11 7 4 0.12 0.89 0.66 0.27 0.87 0.94
756 518 594 427 167 117 198 123 30 111 117 78 115 191 14 16 9 9 8 6 0.66 0.56 0.94 0.55 0.21 0.58
883 539 416 386 30 63 208 64 144 124 62 101 82 36 10 11 14 9 6 6 0.4 1.16 0.76 0.69 0.39 1.08
343 870 390 258 132 160 195 190 72 159 130 167 99 172 12 10 10 10 8 5 0.09 0.57 1.08 1.03 0.44 0.61
984 482 591 486 105 195 197 67 161 92 58 132 161 122 14 14 9 8 6 6 0.09 0.51 0.8 0.96 0.75 0.55
143 178 380 249 131 129 116 95 92 81 117 39 190 73 15 13 11 12 7 5 0.53 0.35 0.25 0.82 0.76 1.17
603 196 627 462 165 81 154 209 107 69 59 50 75 75 14 14 13 7 6 4 0.22 0.98 0.53 0.62 0.82 1.06
460 236 390 269 121 110 174 166 63 117 195 189 171 91 11 11 11 10 7 4 0.9 0.8 0.91 0.67 1.1 0.42
441 911 480 411 69 83 81 131 65 62 119 62 72 160 14 17 11 10 7 6 0.3 0.58 0.87 0.4 0.48 0.29
575 207 408 363 45 73 204 176 180 38 99 61 168 44 18 11 11 11 8 5 0.02 0.18 0.44 0.6 0.74 0.87
```

Raw Dataset: `pirp-50-2-3-3-1.dat`

```
50 2 3 3  2594
308 798 12452 12452 12452 12452 0.46 0.96 0.68
17 921 388 212 176 194 86 19 9 5 0.8 1.25 0.16
835 859 398 311 87 199 105 12 10 5 0.15 0.39 0.62
528 672 386 353 33 193 83 14 10 4 0.92 0.24 1.08
325 64 394 314 80 197 67 18 10 4 0.11 0.49 0.93
89 907 350 177 173 44 175 17 8 5 0.64 0.77 0.53
828 605 582 517 65 194 142 16 12 6 0.46 0.34 0.89
257 767 546 442 104 147 182 14 10 4 0.59 0.56 0.96
119 715 603 520 83 201 96 19 10 6 0.01 0.4 0.2
698 610 330 165 165 94 78 10 8 6 0.54 1.01 0.6
627 187 591 465 126 197 149 10 11 5 0.82 0.82 1.07
332 910 356 239 117 79 178 15 11 5 0.15 0.78 0.98
38 124 414 332 82 207 191 12 10 6 0.35 0.84 0.83
734 730 314 201 113 157 63 12 8 6 0 1.11 0.82
808 309 261 174 87 59 87 10 12 6 0.01 0.63 1.1
583 283 492 328 164 40 156 12 8 5 0.75 1.11 0.48
578 173 378 189 189 35 117 12 10 6 0.57 0.35 1.19
932 506 326 190 136 163 95 15 9 5 0.14 1.12 0.28
847 974 368 184 184 126 170 13 8 5 0.65 0.36 1.29
464 768 334 239 95 167 154 14 9 5 0.17 0.31 0.37
627 21 292 195 97 146 71 18 9 6 0.2 0.82 0.68
664 486 471 314 157 113 66 19 10 4 0.77 0.53 0.65
427 21 603 402 201 85 192 17 11 4 0.5 1.13 0.49
255 209 402 201 201 185 149 19 13 6 0.92 1.19 0.93
142 616 465 391 74 155 125 15 10 6 0.31 0.19 0.92
865 982 528 352 176 147 51 17 10 6 0.07 0.47 1.04
795 642 232 143 89 43 116 11 11 5 0.12 1.06 0.28
178 905 146 73 73 66 64 10 9 6 0.93 0.71 1.25
45 630 426 284 142 77 71 15 12 6 0.73 0.87 0.76
841 17 537 376 161 173 179 15 8 4 0.33 1 0.48
604 642 588 392 196 182 38 18 8 5 0.23 0.76 0.45
160 391 591 453 138 117 197 17 11 6 0.54 0.79 0.56
574 774 294 224 70 98 95 19 10 6 0.96 1.12 0.61
952 477 504 390 114 168 37 12 9 6 0.22 0.84 0.69
489 730 344 251 93 118 172 16 10 5 0.43 0.72 0.42
55 605 186 128 58 62 54 17 7 5 0.87 0.61 0.7
233 540 304 152 152 81 54 12 9 6 0.97 0.54 1.24
411 50 250 219 31 125 104 11 12 5 0.01 0.66 1.05
254 662 366 251 115 122 39 12 11 4 0.45 0.66 0.55
319 771 315 210 105 97 95 11 9 5 0.28 0.82 0.28
820 309 615 558 57 170 205 16 11 6 0.8 1 0.93
233 656 558 372 186 80 101 19 11 6 0.08 0.71 0.22
615 500 585 390 195 82 125 13 8 4 0.55 0.38 0.7
964 213 358 179 179 55 98 15 10 4 0.64 0.75 0.33
602 987 315 273 42 105 77 13 10 6 0.52 1.1 1.29
752 996 418 209 209 108 206 14 9 5 0.08 1.12 0.12
```

```
949 244 272 143 129 72 136 13 13 6 0.08 0.69 0.75
32 13 579 386 193 149 63 17 11 6 0.57 0.25 1.16
821 629 579 499 80 44 193 15 11 6 0.72 0.1 0.89
404 987 372 186 186 148 48 15 11 5 0.71 1.2 0.66
764 708 522 370 152 174 159 15 10 5 0.42 0.94 1.11
```

Raw Dataset: `pirp-50-2-3-3-2.dat`

```
50 2 3 3  2473
412 524 11872 11872 11872 11872 0.04 1.16 0.5
179 467 594 432 162 145 198 16 10 6 0.05 0.42 0.76
708 998 292 146 146 55 62 11 9 4 0.45 0.46 0.64
268 809 549 440 109 183 133 16 11 4 0.65 0.35 1.05
621 180 399 278 121 68 133 19 7 6 0.05 0.53 0.65
107 244 312 156 156 117 64 19 8 6 0.36 0.12 1
414 676 387 259 128 111 129 13 12 4 0.16 0.7 0.79
460 421 402 201 201 137 142 13 8 6 0.83 0.94 1.04
324 777 350 253 97 175 154 16 10 6 0.85 0.74 1.1
96 796 378 289 89 189 164 17 8 5 0.39 0.86 1.19
906 376 618 502 116 206 54 19 10 6 0.52 0.8 1.02
723 824 408 204 204 117 163 16 11 6 0.35 0.72 1.15
485 268 363 242 121 30 48 17 12 4 0.89 0.25 0.89
895 285 474 437 37 158 98 16 9 5 0.74 0.7 0.4
765 949 597 475 122 199 159 14 10 4 0.23 0.2 0.86
944 731 624 453 171 208 64 10 12 6 0.77 0.73 0.54
321 141 378 300 78 189 44 17 9 5 0.17 0.18 0.28
803 152 220 110 110 36 41 15 8 6 0.33 0.43 1.17
668 806 248 188 60 124 63 12 13 6 0.1 0.61 0.55
693 534 246 123 123 90 100 16 8 6 0.25 0.89 1.07
967 719 260 148 112 110 130 11 11 5 0.96 0.64 0.83
96 181 447 305 142 149 57 16 10 4 0.78 0.28 0.74
580 287 230 115 115 50 88 19 10 5 0.48 0.79 0.23
5 385 238 181 57 119 61 15 9 6 0.38 0.54 0.55
863 104 585 435 150 40 195 17 10 6 0.7 0.19 0.33
278 810 334 227 107 167 56 19 9 4 0.01 0.47 0.72
197 88 284 170 114 124 142 13 11 5 0.85 0.6 0.71
757 960 624 500 124 208 84 15 8 6 0.13 0.48 0.72
89 175 540 435 105 50 180 18 10 4 0.86 0.41 0.6
633 831 294 171 123 93 147 11 11 5 0.36 1.02 0.61
736 483 416 208 208 132 112 19 7 5 0.55 1.14 0.3
766 109 390 329 61 141 195 18 9 5 0.94 0.35 1.28
667 976 310 181 129 119 155 11 8 5 0.57 0.95 0.93
349 110 609 503 106 33 203 10 12 4 0.43 0.51 1.28
226 99 342 171 171 82 91 19 8 4 0.28 0.37 0.54
915 936 374 218 156 187 54 19 9 4 0.22 0.4 0.43
497 787 549 366 183 43 101 11 10 4 0.28 0.75 0.51
678 59 444 296 148 87 70 17 8 5 0.51 0.97 0.31
```

```
222 751 380 268 112 35 190 11 10 5 0.79 0.11 0.99
124 336 252 188 64 84 48 17 11 6 0.08 0.38 0.34
613 268 582 388 194 57 37 12 12 5 0.76 0.8 0.33
580 787 282 188 94 74 73 15 12 6 0.21 0.72 0.41
169 205 292 146 146 136 120 12 12 4 0.47 0.87 0.7
75 355 603 402 201 84 132 11 12 4 0.04 0.63 0.49
895 678 555 370 185 70 100 11 12 6 0.04 0.45 0.95
849 698 198 99 99 86 84 15 11 6 0.28 1.27 0.02
814 793 268 220 48 106 134 16 9 4 0.94 1.02 0.45
875 58 294 178 116 86 147 17 9 6 0.25 0.62 0.68
732 721 356 274 82 178 43 11 11 4 0.34 0.94 0.69
956 977 570 406 164 84 190 13 12 6 0.3 1.21 0.85
757 174 310 155 155 90 90 17 11 4 0.44 0.78 0.74
```

Raw Dataset: `pirp-50-2-3-3-3.dat`

```
50 2 3 3  2680
625 659 12864 12864 12864 12864 0.75 0.32 0.97
637 125 388 194 194 144 157 12 10 6 0.06 0.77 1
95 295 621 515 106 118 207 17 11 6 0.77 0.83 1.36
594 769 352 242 110 176 38 14 7 6 0.1 0.88 0.53
621 202 314 199 115 157 139 18 12 4 0.89 0.53 1.43
331 845 376 188 188 123 96 10 12 6 0.44 1.08 0.49
275 624 396 226 170 46 198 10 8 5 0.63 1.02 0.54
623 757 394 229 165 197 114 18 9 6 0.84 0.73 0.83
734 834 591 394 197 88 171 16 12 4 0.85 0.48 0.31
481 438 585 390 195 87 34 12 10 4 0.76 0.6 0.24
228 338 294 212 82 147 80 11 7 6 0.68 0.46 0.73
287 203 388 194 194 131 101 19 9 5 0.24 0.9 0.56
630 28 356 221 135 178 103 11 9 6 0.92 0.63 1.3
506 161 378 331 47 72 189 13 10 6 0.02 0.79 1.03
82 397 338 299 39 116 169 19 8 6 0.84 0.99 0.92
438 574 364 223 141 86 182 18 12 5 0.54 0.7 1.07
882 500 621 414 207 176 140 12 10 4 0.93 1.09 1.34
220 341 627 494 133 209 64 16 9 4 0.29 1.1 1.12
980 330 392 198 194 196 73 18 11 6 0.45 0.99 0.66
81 878 348 174 174 51 139 16 10 6 0.94 0.28 0.99
416 653 342 243 99 114 77 14 9 6 0.64 0.93 0.51
937 789 360 210 150 180 69 15 12 6 0.53 1.05 0.27
2 349 358 238 120 179 68 15 9 6 0.35 1.06 0.84
105 299 588 533 55 160 196 11 9 5 0.14 0.95 0.54
276 474 390 195 195 86 127 14 9 4 0.92 0.76 1.11
765 626 450 300 150 43 85 18 13 4 0.51 0.77 0.46
939 925 339 226 113 98 86 13 8 5 0.94 0.29 0.82
77 914 618 472 146 89 206 18 12 5 0.69 0.54 0.41
414 92 582 388 194 154 187 17 9 6 0.05 0.98 0.25
820 703 372 186 186 155 115 13 10 4 0.38 0.34 0.93
```

818 778 390 195 195 39 112 10 11 4 0.23 0.49 0.75
450 310 174 128 46 58 43 14 12 5 0.86 0.82 0.64
929 192 192 122 70 96 77 17 8 6 0.36 0.08 0.69
105 805 591 394 197 93 115 15 10 5 0.05 0.83 1.11
617 898 522 354 168 122 174 17 8 4 0.17 0.71 0.51
99 797 274 137 137 119 128 18 10 5 0.45 1.1 0.32
581 355 236 198 38 118 90 17 12 6 0.33 0.97 0.22
105 756 334 190 144 145 167 15 10 6 0.31 1.07 0.54
415 480 624 450 174 208 35 12 11 6 0.33 0.55 0.52
39 754 564 422 142 188 91 18 10 5 0.84 0.63 1.21
937 398 513 374 139 171 59 16 11 6 0.44 0.98 0.93
164 82 394 249 145 197 159 19 12 4 0.88 0.93 0.35
880 496 558 509 49 104 186 10 11 4 0.88 0.86 0.58
454 973 268 158 110 41 134 13 10 6 0.14 0.87 0.61
82 59 402 364 38 201 40 12 8 5 0.39 0.63 0.82
839 162 300 150 150 125 70 14 11 4 0.04 0.25 1.02
993 236 507 338 169 49 157 18 10 4 0.55 0.69 0.49
694 758 396 198 198 69 172 15 9 6 0.72 0.43 0.98
786 923 603 504 99 201 122 16 9 5 0.8 0.72 0.27
764 767 339 246 93 90 113 10 8 6 0.09 1.05 0.13
657 648 282 244 38 82 141 14 11 5 0 0.82 1.01

Raw Dataset: `pirp-50-2-3-3-4.dat`

50 2 3 3 2707
622 949 12996 12996 12996 12996 0.65 0.36 1.24
733 198 561 374 187 86 72 14 8 4 0.93 0.79 0.59
343 474 370 189 181 112 185 15 11 4 0.68 0.42 0.62
645 18 414 207 207 149 151 12 9 4 0.95 0.68 0.57
801 609 600 565 35 130 200 10 9 6 0.19 0.85 0.28
638 37 316 158 158 94 118 17 10 4 0.22 0.88 1.04
828 171 324 174 150 101 162 19 12 6 0.84 1.16 0.71
687 812 585 390 195 163 128 11 11 4 0.16 0.88 0.82
798 443 522 376 146 174 119 16 8 4 0.86 0.47 0.24
348 319 486 452 34 131 162 15 11 4 0.09 0.28 0.36
998 169 406 267 139 203 173 12 11 6 0.2 0.72 1.04
643 728 242 191 51 121 104 18 10 5 0.32 0.69 0.85
225 574 540 490 50 154 180 12 13 6 0.34 0.18 0.67
988 155 519 346 173 159 34 15 13 4 0.65 1.03 0.48
78 731 412 206 206 72 112 10 10 5 0.28 0.81 0.87
417 123 594 396 198 107 57 12 13 4 0.76 0.32 0.97
225 662 552 368 184 130 149 11 13 5 0.33 0.45 1.05
636 823 390 279 111 113 195 19 8 6 0.37 0.7 0.55
639 143 438 383 55 40 146 19 7 4 0.9 0.93 0.94
705 673 510 348 162 146 170 19 8 5 0.77 0.82 0.64
125 906 543 362 181 43 116 10 10 6 0.98 0.51 1.09
197 161 402 201 201 50 91 17 11 6 0.97 0.49 0.67

```
149 816 528 407 121 176 30 16 11 5 0.06 0.39 0.46
218 815 372 309 63 186 39 12 9 6 0.16 0.44 0.19
955 93 382 252 130 191 107 11 11 5 0.21 0.73 1.16
544 961 459 306 153 113 66 14 9 5 0.68 0.79 0.53
237 38 134 87 47 67 54 17 9 6 0.76 0.2 1.01
501 68 549 366 183 127 106 12 12 5 0.15 0.38 1.06
382 723 627 423 204 89 209 12 11 5 0.77 0.65 0.4
357 985 612 529 83 126 204 13 9 4 0.68 0.68 0.35
820 263 609 530 79 203 32 16 9 6 0.56 0.3 0.54
1 956 336 224 112 111 82 17 12 6 0.64 0.3 0.82
927 515 432 387 45 120 144 13 11 4 0.7 0.2 0.82
990 511 540 360 180 119 110 10 9 6 0.48 0.78 1.31
999 272 386 193 193 95 82 15 11 4 0.76 0.72 0.77
141 685 378 189 189 96 143 13 8 4 0.54 0.41 0.7
959 829 370 271 99 185 49 19 12 6 0.47 0.6 1.16
602 719 621 581 40 202 207 16 12 4 0.74 0.23 0.97
499 922 388 320 68 194 136 17 11 4 0.07 0.46 0.2
22 888 352 296 56 57 176 10 11 6 0.99 0.66 0.34
93 342 420 322 98 75 140 15 11 5 0.43 0.56 0.03
445 442 363 242 121 67 103 11 10 4 0.45 0.23 0.79
528 663 366 193 173 125 183 19 11 5 0.05 1.01 1.01
413 980 624 490 134 208 167 11 12 6 0.71 0.54 0.81
292 143 386 338 48 67 193 17 11 5 0.89 0.74 1.18
518 945 398 199 199 97 150 12 10 4 0.59 0.8 0.52
713 612 570 456 114 148 190 10 8 6 0.32 0.68 0.63
276 128 280 163 117 140 112 11 11 6 0.89 0.34 0.54
235 384 404 372 32 92 202 16 9 4 0.25 0.61 0.85
847 602 358 315 43 179 142 18 11 4 0.37 0.36 0.33
278 718 418 262 156 188 209 17 8 5 0.01 0.98 1.29
```

Raw Dataset: `pirp-50-2-3-3-5.dat`

```
50 2 3 3  2506
917 253 12030 12030 12030 12030 0.1 0.98 0.53
764 944 312 263 49 70 104 17 12 6 0.75 0.46 0.55
849 463 564 384 180 99 188 19 10 5 0.77 1 0.81
931 316 266 173 93 49 133 18 8 4 0.9 0.23 0.28
127 128 224 112 112 80 62 15 8 4 0.4 0.82 0.82
661 690 148 74 74 59 72 19 7 6 0.62 0.33 0.58
672 521 222 111 111 90 71 16 10 5 0.44 0.82 0.78
3 503 414 276 138 128 59 12 12 4 0.23 0.66 0.52
459 246 232 161 71 97 116 12 13 4 0.34 0.91 0.95
189 594 280 238 42 140 129 15 8 5 0.08 0.25 0.49
903 537 495 330 165 149 35 10 11 5 0.54 0.98 0.57
744 50 555 463 92 185 143 13 8 4 0.87 0.73 0.49
832 84 585 390 195 110 111 10 11 4 0.61 1.06 1.05
369 888 612 408 204 118 142 10 9 6 0.12 0.88 0.5
```

```
292 366 588 492 96 196 88 17 8 4 0.9 0.36 0.76
255 90 519 346 173 119 108 19 8 5 0.36 0.89 0.58
566 912 350 223 127 102 175 13 8 5 0.08 0.22 1.3
84 856 306 258 48 102 36 15 9 6 0.77 0.69 0.68
859 477 168 89 79 33 84 15 8 4 0.29 0.58 0.4
636 535 327 250 77 109 56 11 11 6 0.68 0.13 1.37
284 755 384 354 30 71 128 13 10 4 0.77 0.63 0.39
573 216 627 571 56 183 209 17 10 6 0.51 1.08 1.08
238 25 528 398 130 176 66 11 12 5 0.03 0.43 0.79
191 350 188 134 54 55 94 17 8 5 0.26 0.49 0.55
606 209 294 240 54 98 85 10 13 5 0.35 1.02 0.88
484 260 624 540 84 183 208 15 8 5 0.35 0.23 0.58
112 14 178 90 88 64 89 16 7 6 0.72 0.15 0.86
166 73 576 384 192 74 109 13 10 6 0.79 0.74 0.62
586 748 352 262 90 176 150 11 9 6 0.98 0.43 1.33
937 656 558 372 186 96 158 14 11 4 0.71 0.24 1.02
733 535 416 208 208 82 125 17 9 4 0.65 0.88 0.59
576 625 376 275 101 188 106 16 10 5 0.74 0.63 0.7
859 41 324 209 115 123 162 19 11 4 0.33 0.6 0.48
227 961 597 426 171 199 126 14 10 6 0.82 0.65 0.94
131 617 358 237 121 89 179 19 12 6 0.79 0.5 0.21
282 93 573 494 79 133 191 14 10 5 0.79 0.82 0.91
551 874 362 330 32 104 181 12 9 6 0.3 1.31 1.19
21 276 474 374 100 158 56 19 12 5 0.97 0.9 1.12
540 830 171 114 57 34 42 10 11 5 0.35 0.52 0.16
715 147 390 319 71 69 195 13 12 6 0.56 0.97 0.49
696 640 582 487 95 194 157 15 13 5 0.35 0.44 0.58
733 391 384 201 183 186 192 17 9 5 0.84 1.17 0.71
307 354 582 388 194 124 91 18 10 6 0.68 0.57 0.73
153 491 600 400 200 170 161 14 7 6 0.69 0.37 0.95
350 805 360 243 117 180 81 13 10 5 0.36 0.03 0.77
568 901 206 148 58 103 46 11 11 5 0.81 0.39 0.37
146 56 370 185 185 77 178 14 9 4 0.2 0.93 1
36 287 594 482 112 198 110 13 8 6 0.06 0.8 1.36
234 895 356 178 178 138 175 16 12 5 0.99 0.16 0.58
668 591 226 159 67 47 113 16 13 6 0.8 0.03 0.41
584 148 280 140 140 135 65 15 8 5 0.22 0.78 0.24
```

Raw Dataset: `pirp-50-3-3-6-1.dat`

```
50 3 3 6  2580
808 775 12385 12385 12385 12385 12385 12385 12385 0.93 0.32 0.71 0.49
968 190 390 206 184 42 195 87 50 182 17 11 8 6 0.27 0.75 0.43 0.53
921 81 621 495 126 207 163 35 146 106 13 13 10 6 0.53 0.75 0.18 0.36
526 720 609 493 116 35 203 100 138 137 16 12 7 4 0.54 1.03 0.67 0.9
968 800 376 346 30 95 161 188 181 116 19 15 7 4 0.08 0.48 0.54 0.34
354 181 414 321 93 179 32 36 207 180 10 9 8 4 0.45 0.42 0.82 0.1
```

829 32 336 168 168 112 100 129 30 140 12 14 9 4 0.86 0.35 0.32 0.91
729 966 360 304 56 60 180 42 124 126 16 13 10 4 0.69 0.64 1.06 0.87
206 132 573 438 135 54 191 77 73 72 10 10 8 4 0.72 0.56 0.63 0.62
703 137 338 250 88 39 48 169 116 45 11 14 10 6 0.86 0.62 0.72 0.44
918 290 579 506 73 131 38 193 179 141 17 9 7 5 0.97 0.44 0.75 0.52
908 910 531 411 120 90 167 134 177 160 12 14 11 5 0.09 0.14 1.14 0.97
322 195 555 423 132 92 185 144 51 148 16 10 9 5 0.21 0.97 0.9 0.68
71 53 621 510 111 150 54 191 207 88 12 14 7 4 0.13 0.45 0.63 1.1
171 113 594 463 131 69 198 184 109 139 11 12 7 4 0.2 0.68 0.4 0.75
559 819 380 223 157 126 55 135 190 161 18 14 9 6 0.5 0.44 0.23 1.42
538 599 364 279 85 46 182 109 160 144 12 10 10 5 0.38 0.71 0.82 0.35
603 738 294 238 56 109 64 147 137 115 12 14 9 4 0.53 1.04 0.37 1.18
175 297 308 184 124 109 105 116 154 93 14 9 8 5 0.42 0.4 0.16 0.41
777 425 366 290 76 124 183 84 96 128 18 10 7 4 0.01 0.96 0.82 0.59
863 208 362 212 150 50 141 181 47 105 18 12 7 5 0.41 0.33 0.14 0.29
852 518 627 582 45 168 69 180 209 196 13 15 8 5 0.81 0.45 0.72 0.75
327 610 384 274 110 192 151 165 86 149 16 8 10 5 0.86 0.73 0.81 0.96
864 52 378 298 80 187 189 120 99 161 13 9 9 4 0.92 0.52 0.17 0.73
378 28 372 278 94 102 40 160 31 186 19 9 10 6 0 0.9 0.64 1.31
224 293 322 230 92 142 46 112 90 161 12 10 8 4 0.98 0.53 0.71 0.59
574 277 573 502 71 47 181 137 191 30 10 11 10 6 0.26 0.76 0.78 0.84
209 765 408 236 172 156 204 185 62 63 17 13 9 4 0.91 0.82 0.55 1.01
14 125 394 197 197 183 156 74 37 81 11 10 8 4 0.58 1.22 0.56 1.16
103 974 594 396 198 164 48 136 88 58 16 11 8 5 0.5 0.91 1.41 0.93
797 21 345 293 52 62 48 115 92 113 10 13 9 6 0.07 0.86 0.64 0.65
91 165 507 338 169 57 95 75 77 124 18 15 8 5 0.53 0.47 0.89 0.48
92 107 372 277 95 50 186 63 175 180 14 9 7 4 0.51 0.35 0.47 0.49
471 419 376 271 105 114 126 81 188 161 11 13 7 4 0.16 0.99 0.56 0.19
969 317 534 374 160 31 148 72 95 178 18 10 11 5 0 1.09 0.65 0.58
165 950 402 209 193 161 74 133 194 201 18 15 10 4 0.03 0.97 0.84 1.02
514 30 390 195 195 172 106 165 121 96 11 10 9 6 0.98 0.13 0.09 0.2
866 605 621 564 57 194 207 43 94 39 11 12 10 6 0.49 0.14 1.04 1.5
34 6 408 232 176 123 204 155 180 99 15 15 9 5 0.38 0.65 1.04 0.51
246 991 441 317 124 78 123 55 70 147 10 9 10 4 0.16 0.68 1 0.5
843 439 615 541 74 166 189 147 205 104 17 14 8 4 0.76 0.86 0.43 0.74
299 27 402 299 103 196 201 158 93 45 13 11 7 5 0.26 0.77 0.85 0.34
454 306 312 238 74 68 156 49 85 64 13 15 10 5 0.57 0.69 0.79 0.1
979 882 609 516 93 203 99 35 110 74 19 12 7 5 0.26 0.67 1.3 0.43
613 761 412 208 204 206 106 59 178 122 17 14 8 5 0.46 0.44 0.46 0.45
932 781 404 279 125 175 70 202 134 95 15 11 10 4 0.72 1.02 1.16 0.87
467 423 597 567 30 199 94 36 32 113 11 12 9 4 0.63 0.45 0.8 1.2
871 788 362 181 181 158 138 166 179 33 13 12 8 4 0.73 0.75 0.62 0.37
841 243 525 392 133 143 68 175 63 93 16 14 7 6 0.5 0.76 0.29 0.8
35 407 394 281 113 165 89 197 140 47 12 10 8 6 0.68 0.9 0.91 1.32
674 89 588 423 165 35 119 124 196 120 18 12 9 6 0.76 0.46 0.78 1.06

Raw Dataset: `pirp-50-3-3-6-2.dat`

```
50 3 3 6  2573
246 385 12351 12351 12351 12351 12351 12351 12351 0.1 0.54 0.2 0.72
717 322 406 244 162 184 157 203 71 35 19 12 8 4 0.85 0.34 0.21 1.03
799 459 306 175 131 33 153 74 94 50 14 9 9 4 0.92 0.42 0.52 0.61
44 152 618 454 164 157 155 206 111 198 14 12 8 4 0.09 1.1 1.27 0.56
539 370 326 271 55 63 37 138 162 163 18 13 9 5 0.2 0.3 0.95 1.17
728 48 322 201 121 33 85 161 92 119 11 12 7 6 0.12 0.21 0.37 0.2
164 154 618 414 204 206 86 54 179 177 13 12 9 5 0.86 0.88 1.14 0.36
595 894 558 372 186 114 110 35 109 136 11 11 9 6 0.56 0.41 0.83 0.16
81 476 378 263 115 94 121 71 34 126 14 12 9 4 0.6 0.76 0.72 1.46
660 981 582 470 112 157 159 68 194 47 19 10 9 4 0.77 0.3 0.36 1.41
541 365 618 437 181 157 174 78 171 206 15 11 8 6 0.97 1.02 0.33 0.48
946 878 498 356 142 107 103 166 149 83 16 11 10 5 0.6 0.58 0.56 1.37
96 900 603 501 102 201 135 197 169 85 14 12 9 5 0.96 0.9 0.89 0.45
182 899 202 166 36 52 101 44 100 52 14 13 7 4 0.53 0.55 0.55 0.7
911 209 525 413 112 90 132 110 166 175 11 11 8 4 0.41 0.32 0.94 0.88
929 285 573 390 183 80 191 50 67 101 12 14 8 4 0.58 1.1 0.93 0.96
921 488 394 350 44 96 109 145 169 197 19 12 10 4 0.58 0.45 1.07 0.83
389 216 398 285 113 39 199 164 193 46 15 14 7 5 0.6 0.93 0.78 0.76
776 365 558 421 137 60 121 150 185 186 13 12 9 4 0.2 0.53 0.35 0.77
658 654 498 350 148 125 82 148 166 132 12 14 8 6 0.53 0.38 0.58 0.62
643 3 296 153 143 140 40 50 85 148 15 10 9 6 0.71 1.05 0.58 0.74
975 350 588 392 196 117 32 186 115 70 11 14 10 6 0.63 0.57 0.45 0.93
795 565 316 284 32 113 144 83 158 132 15 14 7 6 0.4 0.82 0.28 0.85
465 74 402 364 38 201 129 112 152 138 17 11 7 6 0.53 1.07 0.95 1.04
859 383 498 332 166 51 104 56 38 82 11 14 8 5 0.33 0.91 0.64 0.81
934 744 374 204 170 74 53 106 82 187 16 10 11 6 0.82 0.73 1.11 0.64
430 623 591 549 42 175 127 70 64 197 12 14 9 6 0.22 0.44 0.66 1.05
700 232 392 334 58 156 196 95 64 165 12 12 9 5 0.34 0.42 0.86 1.2
656 722 618 431 187 128 104 94 100 206 10 9 8 4 0.91 0.85 0.18 0.92
60 747 510 410 100 139 137 170 140 142 15 15 9 6 0.1 0.59 0.36 1.1
612 387 603 402 201 40 132 156 193 169 19 12 9 4 0.54 0.8 0.2 0.43
502 706 394 197 197 104 50 195 81 41 15 10 10 5 0.97 0.44 0.67 0.68
555 119 522 348 174 138 70 44 38 37 10 9 7 5 0.86 0.93 0.86 0.59
210 66 591 394 197 75 161 73 159 136 15 14 8 6 0.38 1.15 1.18 1.12
519 670 354 190 164 53 133 41 52 177 16 10 10 4 0.2 0.34 0.55 0.71
633 410 412 267 145 206 53 179 39 76 17 10 10 6 0.47 0.72 1.4 0.48
437 999 388 318 70 65 109 61 98 194 18 9 9 5 0.06 0.98 1.26 0.92
243 589 388 250 138 194 178 140 186 148 13 10 8 6 0.03 0.55 0.42 0.36
699 85 342 171 171 110 86 138 93 107 15 11 8 6 0.47 1.15 1.18 1.08
633 226 404 227 177 151 202 82 103 139 13 13 10 6 0.68 0.64 0.55 0.35
315 68 396 278 118 121 198 115 151 165 19 12 10 6 0.8 0.63 0.84 1.2
402 8 573 542 31 154 191 113 101 158 14 10 9 4 0.96 0.1 0.72 1.26
341 842 597 485 112 144 42 96 95 199 13 14 9 5 0.73 0.99 0.52 1.15
592 445 552 411 141 184 132 169 107 130 14 11 8 4 0.89 0.48 0.63 0.45
901 228 615 460 155 200 40 157 205 84 19 9 9 5 0.18 0.32 0.17 0.74
47 259 516 344 172 65 72 139 155 139 16 10 8 4 0.22 0.25 0.54 0.24
```

181 308 552 459 93 112 63 52 64 184 17 9 9 4 0.78 0.61 0.78 0.72
1 758 358 202 156 96 179 45 169 75 14 11 10 6 0.27 0.84 0.26 0.69
191 312 358 263 95 179 87 85 55 72 19 11 8 5 0.43 1.31 0.65 0.69
178 87 621 435 186 207 109 56 67 120 12 13 9 6 0.16 1.05 0.6 0.69
553 163 522 353 169 130 65 57 174 42 16 12 10 6 0.71 0.2 1.17 1.3

Raw Dataset: `pirp-50-3-3-6-3.dat`

50 3 3 6 2587
509 638 12419 12419 12419 12419 12419 12419 12419 0.74 0.91 0.48 0.91
801 478 585 499 86 123 151 56 75 195 16 15 10 4 0.09 0.31 0.4 0.95
965 973 540 360 180 165 65 169 110 110 18 13 8 5 0.51 0.96 0.36 0.86
374 82 588 437 151 196 176 181 37 105 12 10 9 4 0.34 0.68 0.72 0.79
5 294 618 578 40 84 145 93 156 206 11 10 7 4 0.52 0.51 1.29 0.25
680 652 546 501 45 182 107 139 124 95 19 15 9 5 0.39 0.47 0.8 0.89
273 624 410 368 42 46 189 78 51 205 11 10 8 6 0.19 1.24 0.96 0.85
226 204 561 374 187 149 128 87 100 154 11 10 9 4 0.79 0.79 0.83 0.58
484 177 408 204 204 48 83 179 95 97 12 12 11 6 0.54 0.99 0.33 0.79
727 633 404 361 43 71 202 162 119 170 12 9 7 5 0.64 0.19 0.35 0.55
176 693 418 334 84 45 192 209 73 111 15 11 10 6 0.66 0.96 0.45 0.96
749 362 344 247 97 105 72 62 172 118 15 14 7 6 0.04 0.01 0.99 0.47
497 338 384 321 63 99 84 101 192 173 18 13 9 5 0.31 0.57 1.08 0.73
190 83 390 289 101 195 56 195 119 167 18 11 8 4 0.72 0.96 1.38 0.55
699 715 362 228 134 36 152 181 72 119 14 10 8 5 0.6 0.27 1.13 0.63
512 406 501 424 77 87 167 133 36 42 15 12 11 6 0.66 0.55 0.65 0.73
554 871 416 266 150 65 208 161 187 192 13 9 9 4 0 0.62 0.88 0.72
243 688 416 343 73 205 208 66 198 108 13 11 10 5 0.72 0.68 0.35 0.54
485 920 384 260 124 160 191 128 68 192 10 8 7 6 0.13 1.15 0.69 1.03
686 721 364 327 37 144 182 96 86 49 15 15 8 6 0.76 0.07 0.54 1.02
132 592 402 277 125 201 85 157 95 78 14 15 9 4 0.28 1.19 0.89 0.33
190 944 358 205 153 179 63 89 177 179 15 11 8 4 0.36 0.91 1.15 0.57
23 19 483 322 161 71 48 62 112 156 19 11 11 6 0.02 0.56 0.47 1.29
52 9 412 331 81 206 190 129 180 41 16 12 8 6 0.26 1.16 0.95 0.48
594 713 352 196 156 50 175 165 176 43 14 10 8 4 0.24 0.4 1.12 0.66
205 982 585 444 141 66 145 187 174 195 15 14 8 5 0.03 0.51 0.44 0.9
664 873 416 314 102 108 204 69 58 208 11 13 7 6 0.21 0.27 0.87 0.86
565 670 352 285 67 39 147 56 176 34 18 15 7 5 0.85 0.49 1.11 0.71
212 676 606 440 166 202 188 101 61 149 12 12 9 5 0.59 0.75 0.79 0.94
401 216 600 439 161 104 200 107 47 136 15 10 9 6 0.52 1.04 0.57 0.9
484 155 588 481 107 196 152 157 60 102 11 15 9 4 0.53 0.91 0.74 0.49
276 583 567 405 162 189 94 152 60 39 18 14 9 5 0.27 0.44 0.49 0.5
897 730 522 348 174 102 140 110 36 96 11 10 10 4 0.27 0.42 0.32 1.13
820 569 394 273 121 33 197 188 158 37 15 11 10 6 0.46 0.11 0.73 0.36
721 2 260 140 120 130 109 87 56 73 19 13 7 4 0.29 0.88 0.19 0.24
305 948 384 332 52 192 71 64 163 119 14 14 10 5 0.32 0.78 0.92 0.87
216 161 579 451 128 72 161 193 151 137 10 10 10 5 0.81 1.26 1.05 0.67
934 333 378 225 153 97 107 189 181 160 11 10 7 6 0.07 0.8 0.88 0.71

350 876 398 359 39 32 199 74 73 168 18 13 7 5 0.14 0.55 0.62 0.74
848 276 561 453 108 187 151 122 96 84 14 14 9 4 0.71 0.78 0.25 1.21
986 562 358 222 136 57 33 163 179 51 19 13 7 5 0.44 0.11 0.39 0.37
774 13 579 481 98 128 101 193 97 179 14 13 9 4 0.55 1.08 0.67 0.53
437 833 356 255 101 110 178 50 36 92 13 14 7 4 0.36 0.39 0.98 0.34
828 12 594 527 67 172 69 57 198 94 16 11 8 4 0.47 1.02 1.02 0.13
377 171 410 213 197 177 99 179 205 30 15 12 8 5 0.26 0.32 0.69 0.35
169 437 370 273 97 124 185 101 140 158 10 10 7 6 0.76 0.44 0.91 1.29
168 607 414 207 207 121 91 193 192 142 15 12 7 5 0.71 0.28 0.78 0.49
919 954 570 531 39 32 149 47 126 190 16 9 9 6 0.41 0.53 0.25 0.99
804 910 348 293 55 127 43 174 60 120 12 14 9 4 0.52 0.48 1.17 0.32
67 785 417 314 103 139 122 66 80 30 16 11 7 6 0.09 0.55 0.23 0.08
996 695 519 355 164 173 140 152 157 81 15 11 8 6 0.86 0.32 0.74 1.2

Raw Dataset: pirp-50-3-3-6-4.dat

50 3 3 6 2453
748 610 11775 11775 11775 11775 11775 11775 11775 0.22 0.99 0.48 0.74
952 246 483 396 87 161 76 152 30 42 18 14 10 4 0.34 0.9 1.32 0.25
786 553 370 185 185 96 168 161 45 57 17 11 8 4 0.07 1.14 0.44 0.57
727 267 573 525 48 136 40 82 191 119 14 14 7 4 0.82 0.45 0.97 0.55
197 780 390 195 195 38 125 136 180 59 19 12 9 6 0.3 0.76 0.28 0.43
911 950 210 138 72 76 61 105 33 73 10 13 6 5 0.62 0.32 1.22 1.13
542 235 582 452 130 41 80 41 86 194 10 9 8 4 0.77 0.25 0.69 0.3
367 478 412 265 147 97 144 128 94 206 12 10 9 6 0.23 1.02 0.57 1.07
456 362 558 375 183 68 146 102 186 117 10 13 7 6 0.6 1.12 0.8 0.69
387 605 594 473 121 93 115 140 198 139 15 13 7 5 0.15 1.09 1.15 0.31
587 315 564 376 188 72 60 156 114 128 15 9 10 5 0.16 0.64 1.05 0.71
601 606 462 408 54 46 146 72 49 154 17 10 10 6 0.66 0.69 0.8 0.33
70 18 393 334 59 124 79 100 131 99 14 12 10 6 0.49 0.41 0.96 0.01
217 229 350 300 50 37 175 93 93 118 19 9 9 6 0.5 0.93 0.4 1.15
146 636 498 332 166 73 166 106 88 100 14 10 9 4 0.21 0.23 0.5 0.8
664 556 278 172 106 46 137 116 139 110 17 11 7 4 0.02 0.5 0.2 0.3
143 167 344 205 139 172 107 38 45 170 18 14 8 4 0.92 0.25 1.23 0.48
429 339 603 437 166 56 201 70 157 52 12 15 9 6 0.56 1.14 0.81 0.4
125 127 597 482 115 116 156 199 177 74 19 14 8 6 0.92 0.83 0.79 0.31
525 627 406 203 203 114 124 97 149 118 13 12 7 4 0.45 0.7 0.75 1.02
886 759 390 195 195 184 192 105 140 123 10 12 7 6 0.65 0.4 0.64 0.77
175 583 366 278 88 122 99 32 31 58 16 12 10 5 0.77 0.68 0.33 0.24
372 25 416 208 208 43 146 178 110 73 15 14 9 5 0.54 0.48 0.4 0.57
142 725 354 177 177 58 102 85 127 166 10 11 8 4 0.82 0.17 0.67 0.53
874 150 489 455 34 163 57 145 104 68 18 9 8 6 0.51 0.84 0.52 1.32
514 516 324 284 40 138 162 66 78 67 14 11 7 5 0.88 0.7 1.03 0.65
184 776 591 558 33 197 69 49 34 74 13 13 9 5 0.04 0.83 0.95 0.58
809 764 540 378 162 66 64 174 180 143 18 15 8 4 0.33 0.6 0.79 0.39
564 980 400 333 67 200 146 100 98 84 13 14 7 5 0.26 0.5 1.12 1.06
720 649 320 197 123 69 51 99 160 83 15 13 10 4 0.49 0.62 0.24 0.03

430 164 540 426 114 61 47 63 109 180 19 14 11 5 0 0.51 0.98 0.74
166 345 618 557 61 135 80 202 193 206 16 15 7 6 0.77 0.35 0.83 0.71
373 663 414 300 114 202 207 205 158 143 10 10 8 6 0.88 0.68 0.99 0.54
717 286 594 401 193 123 198 118 83 147 10 14 9 6 0.17 1.21 0.94 1.04
172 900 412 226 186 206 184 57 136 109 19 11 10 4 0.57 0.43 0.76 0.32
818 578 348 292 56 74 174 161 112 114 10 14 7 5 0.17 0.39 1.05 0.47
598 314 603 508 95 201 116 112 84 48 18 14 10 6 0.2 0.19 1.24 1.09
162 705 416 337 79 102 203 109 69 208 15 11 6 6 0.76 0.77 1.08 0.77
997 975 627 418 209 70 203 36 115 59 13 15 9 6 0.88 0.66 0.56 0.69
138 641 392 263 129 196 91 171 176 158 11 10 9 5 0.23 0.98 0.37 1.43
874 387 309 206 103 100 51 92 38 36 15 12 9 4 0.6 0.29 0.52 0.95
801 940 606 404 202 97 152 137 49 37 16 12 10 5 0.69 1.04 1.22 1.02
625 734 406 268 138 114 203 46 107 102 13 13 7 6 0.76 0.46 1.01 0.84
654 753 412 326 86 206 140 40 160 30 17 12 9 4 0.43 0.08 1.34 0.55
353 712 456 341 115 149 141 124 95 152 12 10 8 6 0.35 0.53 0.26 0.28
26 93 418 209 209 122 97 133 156 91 15 12 9 5 0.83 1.13 0.79 0.6
490 409 416 250 166 167 138 80 208 132 12 9 8 5 0.37 0.46 0.96 0.86
657 280 570 522 48 180 108 179 98 190 14 13 8 4 0.16 0.86 0.9 0.11
713 295 374 220 154 153 42 46 113 187 18 12 9 4 0.01 0.4 0.63 0.42
298 958 328 295 33 164 71 62 112 96 17 13 10 4 0.81 0.21 0.34 0.94
711 481 414 211 203 119 32 155 207 30 19 12 9 6 0.06 0.72 1.15 0.9

Raw Dataset: `pirp-50-3-3-6-5.dat`

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79 893 11824 11824 11824 11824 11824 11824 11824 0.93 0.45 0.31 0.21
500 937 324 209 115 143 44 162 128 70 19 13 9 6 0.5 0.13 0.4 1.02
486 195 362 238 124 59 181 170 70 51 15 9 9 4 0.04 0.28 0.16 0.78
44 362 279 238 41 63 75 83 93 48 13 14 7 5 0.45 1.03 1.27 0.74
37 139 597 399 198 125 106 199 54 52 18 9 9 4 0.13 1 0.6 0.69
789 540 362 245 117 84 181 118 31 174 14 14 9 6 0.85 0.25 1.07 0.57
186 550 357 238 119 38 112 115 42 97 14 8 10 5 0.6 0.46 0.84 0.55
346 159 534 399 135 164 178 126 87 127 18 15 9 6 0.38 0.66 0.93 0.83
972 253 498 332 166 37 136 114 55 134 12 14 6 5 0.29 0.3 0.46 1.28
396 603 381 303 78 67 52 53 119 127 10 10 7 4 0.14 1.18 0.69 0.82
664 182 528 360 168 176 138 67 165 149 11 12 8 6 0.53 0.7 0.56 1.09
207 867 612 510 102 204 116 171 59 129 17 14 10 6 0.02 0.7 0.38 1.06
209 672 380 310 70 190 53 51 53 184 11 15 7 4 0.39 0.75 0.76 1.35
515 539 612 409 203 75 204 197 104 53 15 12 7 5 0.1 0.67 0.78 0.61
830 289 414 207 207 35 116 123 162 205 14 13 7 5 0.64 1.08 0.45 0.67
185 870 338 184 154 155 169 160 49 101 15 13 9 4 0.89 0.88 0.75 0.17
591 434 334 282 52 164 48 167 36 52 15 13 11 6 0.83 0.59 0.63 0.92
276 552 552 470 82 65 45 83 160 184 17 12 8 6 0.34 0.65 0.57 1.26
133 109 603 402 201 67 179 178 168 172 13 15 9 6 0.15 0.29 0.6 1.09
220 130 513 342 171 102 49 134 93 99 13 12 7 6 0.3 0.88 0.99 0.17
132 128 334 174 160 111 98 160 97 167 18 15 8 6 0.15 0.88 0.63 0.74
746 292 597 492 105 62 160 199 55 162 10 11 9 6 0.85 0.98 0.95 0.72

592 645 594 456 138 172 55 112 198 125 17 10 10 4 0.77 0.63 0.46 0.15
585 554 618 586 32 206 137 61 152 46 19 10 8 6 0.05 0.25 0.43 0.54
479 9 326 294 32 106 34 163 141 32 18 13 10 5 0.41 0.48 0.55 0.23
841 541 618 412 206 54 187 30 175 75 14 13 10 6 0.04 0.79 0.58 0.94
714 641 480 361 119 53 115 53 160 114 18 12 9 5 0.79 0.11 0.8 0.74
396 271 288 209 79 70 34 43 143 144 18 11 10 6 0.06 0.91 0.53 0.17
111 504 627 418 209 195 205 171 60 110 11 8 7 6 0.64 0.95 1.02 1.13
129 476 378 256 122 46 139 189 174 131 18 12 7 5 0.4 0.84 0.34 0.22
425 828 404 328 76 91 202 83 87 36 19 12 10 6 0.29 0.47 1.37 0.9
591 719 332 182 150 51 166 164 108 105 18 11 10 6 0.48 0.53 0.28 1.02
235 83 561 503 58 174 78 187 104 137 10 9 8 4 0.13 0.34 0.39 0.93
202 474 468 362 106 123 37 89 156 56 11 12 9 4 0.97 0.87 0.55 0.56
925 883 388 194 194 173 38 102 30 53 19 12 10 5 0.51 0.75 0.72 0.94
696 690 615 513 102 126 95 205 51 32 16 11 7 4 0.76 1.15 1.05 0.5
817 262 597 514 83 103 40 49 199 66 14 9 9 6 0.31 0.2 0.54 0.8
263 722 504 357 147 87 162 53 168 130 19 15 7 5 0.12 1.11 1.36 1.4
140 755 362 274 88 97 97 134 181 141 15 13 9 6 0.18 0.21 1.03 1.02
821 663 396 284 112 90 198 140 171 154 14 14 9 5 0.32 0.42 0.34 0.95
17 239 400 350 50 84 131 80 135 200 15 9 10 5 0.11 0.65 0.89 0.6
261 260 414 294 120 125 138 44 97 49 11 13 10 4 0.58 0.1 0.2 0.44
864 875 334 227 107 31 43 32 167 77 16 9 10 5 0.91 0.5 0.3 0.33
537 435 474 388 86 32 158 102 146 72 14 13 8 5 0.94 0.26 0.4 0.23
841 113 350 226 124 175 129 169 149 163 15 12 6 6 0.37 0.6 0.89 0.38
342 200 612 526 86 93 204 141 126 191 13 13 9 5 0.93 1.02 0.59 0.4
123 68 408 375 33 43 161 64 198 204 19 14 8 5 0 0.64 1.01 0.66
309 547 519 440 79 172 52 92 54 173 11 13 9 4 0.37 0.61 0.65 0.57
365 934 416 375 41 208 154 121 161 150 10 11 8 6 0.89 0.61 1 0.16
80 515 396 313 83 60 198 169 192 169 18 12 10 6 0.92 0.5 0.2 0.67
862 716 624 416 208 144 114 54 50 65 17 13 9 4 0.04 0.75 1.1 0.84

Raw Dataset: `pirp-50-5-3-10-1.dat`

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456 357 12316 12316 12316 12316 12316 12316 12316 12316 12316 12316 12316 0.45 0.34 0.93 0.52 1.11 0.66
814 396 624 553 71 72 56 51 208 132 80 159 49 93 15 12 9 8 6 5 0.47 1.23 0.97 0.52 0.96 1.13
749 273 418 225 193 48 54 76 103 209 204 133 208 92 13 15 9 9 6 4 0.91 0.73 0.77 0.39 0.88 0.79
922 543 370 271 99 97 103 161 43 185 126 165 116 152 15 17 14 9 8 6 0.06 0.5 0.78 0.64 0.62 0.57
205 458 358 215 143 155 179 85 108 41 128 82 148 56 17 14 10 12 8 5 0.64 1.11 1.11 0.65 0.42 0.93
739 506 504 421 83 93 131 109 87 89 79 161 73 168 19 12 9 10 7 4 0.37 0.41 1.32 0.88 0.71 0.22
639 161 600 447 153 143 39 111 112 70 97 200 188 127 14 12 11 10 6 6 0.86 0.71 1.11 1.2 0.72 0.49
381 442 627 462 165 209 101 134 118 141 87 151 59 91 13 16 12 11 8 4 0.08 0.87 0.28 1.37 1.06 0.25
776 440 384 312 72 93 192 185 156 133 99 46 41 73 14 15 13 10 7 5 0.31 0.68 0.39 0.84 0.63 0.8
256 758 390 195 195 40 177 110 98 105 171 38 88 147 15 16 12 10 7 5 0.56 0.3 0.77 0.77 0.59 0.97
849 824 380 333 47 103 87 165 104 176 63 31 112 190 15 14 12 12 9 4 0.74 0.23 0.59 0.44 0.95 0.17
671 797 370 223 147 159 185 127 69 34 131 110 180 129 14 12 12 7 8 6 0.45 1.14 0.51 0.4 0.87 0.56
179 651 621 526 95 87 206 194 57 89 103 195 134 207 16 13 10 9 8 5 0.76 0.5 0.79 1.3 0.32 0.15
850 481 360 205 155 180 94 152 127 85 175 91 133 41 12 14 10 9 8 5 0.44 1.03 0.57 0.85 0.71 0.56

```
134 178 320 168 152 150 150 35 122 160 89 31 65 131 19 11 13 10 7 4 0.13 0.5 0.62 1.09 0.97 1.02
389 587 618 530 88 174 171 61 206 97 59 204 170 141 17 13 8 10 7 5 0.4 0.27 0.37 1.22 1.1 0.15
408 61 567 397 170 175 34 153 189 63 100 154 116 77 12 12 13 8 9 4 0.78 0.14 0.54 0.96 0.48 1.06
593 373 549 407 142 52 33 62 183 82 143 60 92 97 15 9 14 8 6 6 0.27 0.54 0.79 0.98 0.74 0.96
180 102 374 327 47 64 42 167 52 187 120 171 75 48 16 13 10 11 7 5 0.98 1.06 0.81 0.73 0.98 0.8
240 237 603 534 69 160 121 139 139 113 201 59 112 168 18 17 12 9 7 6 0.08 0.22 0.96 0.5 0.42 0.56
726 733 414 261 153 41 30 163 200 122 180 207 103 181 14 13 11 11 6 6 0.04 0.26 1.2 0.74 0.65 1.08
609 36 400 200 200 175 87 171 197 113 96 159 97 82 15 15 14 8 7 4 0.24 0.41 0.39 0.72 1.14 1.26
277 750 621 414 207 204 120 80 157 61 56 199 66 141 18 16 11 11 7 4 0.4 0.48 0.43 1.04 0.94 1.12
560 354 597 562 35 171 49 199 66 127 69 91 179 159 14 9 9 9 6 5 0.74 0.34 0.01 0.81 0.38 0.41
460 32 388 315 73 159 154 74 86 194 120 93 120 185 16 13 9 11 8 5 0.14 0.34 1.03 0.41 0.97 1.01
972 75 388 241 147 140 176 174 115 68 38 181 182 194 11 9 13 11 8 4 0.65 0.61 0.96 0.4 0.52 0.58
343 920 615 562 53 176 114 37 134 146 205 108 104 198 14 10 8 11 6 4 0.94 0.3 0.63 0.99 0.49 0.79
462 444 618 414 204 92 146 192 118 121 165 206 176 171 15 12 13 8 7 6 0.14 0.83 0.56 0.58 1.34 0.92
619 527 546 428 118 181 182 131 87 144 155 65 111 62 14 13 9 7 7 5 0.44 0.4 0.23 0.13 0.83 0.62
407 273 600 543 57 200 140 141 169 119 149 102 95 93 17 11 8 9 8 4 0.57 0.37 0.96 0.69 0.2 0.62
307 320 573 386 187 135 191 122 72 38 87 107 176 94 17 11 11 10 6 5 0.63 1.06 0.92 0.72 0.5 0.38
22 656 350 239 111 172 64 175 73 51 35 46 86 114 14 10 12 7 8 6 0.44 0.97 1.18 0.79 1.17 1.14
485 550 360 293 67 180 116 151 134 130 88 152 74 52 18 12 8 7 6 5 0.78 1.08 1.04 0.22 0.92 1.21
44 50 414 332 82 144 81 156 92 59 118 66 57 207 15 16 8 11 7 5 0.61 1 0.78 0.9 1.05 0.77
422 449 340 227 113 91 119 162 155 135 93 52 48 170 12 17 11 9 6 5 0.67 0.38 0.27 0.28 0.03 0.6
611 515 394 197 197 93 190 157 139 172 158 66 132 120 19 10 13 9 6 4 0.18 0.76 0.84 0.95 0.6 0.32
507 496 576 430 146 76 55 108 192 138 123 81 136 113 11 11 14 9 6 4 0.46 0.31 0.47 0.91 0.46 0.68
426 211 585 439 146 195 116 101 108 35 78 32 161 141 10 15 12 9 8 4 0.34 0.75 0.98 0.71 0.48 1.16
98 334 615 412 203 134 181 186 141 87 110 205 53 120 14 16 10 9 6 4 0.29 0.72 0.97 1.24 1.13 0.51
850 338 418 212 206 69 155 116 184 193 103 209 142 89 12 12 14 8 7 6 0.77 0.83 0.88 0.78 0.5 0.18
337 53 408 263 145 105 80 204 123 190 94 203 68 149 10 10 12 11 9 4 0.63 0.82 0.82 0.14 0.78 0.68
436 46 627 458 169 45 177 108 193 206 142 138 209 144 18 14 14 10 8 6 0.94 0.37 0.83 1.13 0.65 0.57
537 485 350 223 127 175 125 113 98 161 39 83 96 67 13 11 9 9 7 4 0.25 1.08 0.89 0.96 0.98 0.82
374 154 615 448 167 64 123 205 70 32 202 133 177 67 14 10 13 10 7 4 0.47 0.86 0.78 1 0.21 0.84
643 222 594 434 160 111 69 198 68 196 124 59 35 90 13 14 9 8 7 5 0.99 0.53 0.59 1.22 0.36 1
44 702 402 201 201 159 117 81 108 72 175 121 144 188 11 15 12 9 6 4 0.06 0.21 0.36 1.04 0.57 1.47
84 853 330 249 81 39 30 60 51 47 54 94 93 165 14 12 8 10 9 6 0.66 1.23 0.32 0.83 0.65 1.44
393 751 603 470 133 62 156 140 102 201 174 37 99 90 17 17 9 8 7 4 0.76 1.02 0.77 1.07 0.96 1.22
574 992 396 234 162 128 54 94 105 188 85 198 176 94 17 17 12 8 7 6 0.42 0.76 0.12 0.49 0.93 1.12
504 825 597 514 83 33 149 199 120 156 72 88 118 39 12 14 10 7 7 4 0.98 0.56 0.99 0.91 0.96 1.51
772 676 306 215 91 49 60 153 134 56 38 146 54 62 14 12 14 11 8 4 0.47 0.96 0.53 1.24 0.75 0.44
```

Raw Dataset: `pirp-50-5-3-10-2.dat`

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50 5 3 10  2514
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888 943 573 531 42 55 76 182 110 115 146 179 118 191 11 16 14 10 8 6 0.42 0.26 1.11 0.9 1 1.28
276 289 606 560 46 135 55 79 148 124 202 135 118 95 15 11 13 7 9 5 0.55 0.26 0.99 0.79 1 0.65
138 722 364 224 140 166 178 77 169 66 46 175 182 161 13 16 9 11 8 6 0.92 0.29 0.94 0.69 0.6 1
741 489 567 483 84 88 136 87 68 66 189 103 98 73 15 13 13 9 7 4 0.66 1.04 1.32 0.99 0.6 0.73
824 283 615 566 49 78 93 144 51 147 145 205 165 131 15 17 13 9 7 4 0.49 0.61 0.89 0.48 1.04 0.82
```

464 98 414 321 93 56 48 66 207 204 181 174 194 96 18 14 14 9 6 4 0.58 0.24 0.79 1.26 0.7 1.34
270 821 573 543 30 76 108 96 191 92 186 167 42 44 15 17 14 11 7 5 0.01 0.36 0.71 0.79 0.2 0.95
731 816 404 264 140 102 96 154 186 106 187 65 48 202 10 11 13 7 9 5 0.92 0.61 0.87 0.69 1.18 0.84
975 236 358 308 50 62 176 95 179 79 71 127 152 73 19 12 14 9 7 6 0.69 0.4 0.75 0.87 0.98 0.74
700 740 615 488 127 48 53 170 34 168 39 205 50 168 11 10 12 10 7 5 0.65 0.11 0.21 0.73 0.62 0.72
258 124 627 556 71 93 64 209 98 76 110 96 41 193 19 16 9 9 7 4 0.79 0.26 0.76 1.01 0.8 0.19
807 79 382 251 131 136 81 115 105 191 171 58 90 80 18 15 14 9 7 6 0.47 0.72 0.82 1.04 0.84 0.78
297 135 408 345 63 151 171 113 163 71 44 204 138 115 18 15 11 7 6 4 0.03 0.43 0.05 1.03 0.88 0.44
735 448 615 410 205 64 33 110 104 63 205 34 58 75 17 14 12 8 8 4 0.6 0.8 1.38 0.63 1.16 1.27
714 331 627 493 134 42 167 51 50 142 60 209 115 169 16 12 14 9 7 5 0.36 0.88 0.6 0.95 0.51 0.86
979 633 573 421 152 152 42 111 191 136 123 86 164 49 19 16 13 11 7 6 0 1.07 0.95 0.67 0.91 0.5
671 651 398 328 70 199 122 141 50 81 127 185 33 176 14 10 8 11 7 4 0.21 0.75 1.02 0.66 1.12 0.91
381 470 525 412 113 69 124 131 61 175 154 132 49 58 13 17 14 9 8 4 0.54 0.78 0.27 0.77 0.29 1.1
369 332 410 247 163 103 77 63 89 138 146 97 205 39 12 16 12 7 8 4 0.36 0.76 0.9 1.03 1.23 0.86
249 611 594 498 96 48 172 157 198 93 69 140 190 53 18 15 8 12 8 4 0.39 1.06 0.68 1.15 0.69 0.43
285 85 376 275 101 183 188 124 40 57 48 46 37 186 15 15 13 7 8 5 0.69 0.14 0.97 0.59 0.3 0.36
554 428 378 348 30 146 33 186 88 30 72 40 172 189 18 16 14 10 7 6 0.4 0.68 0.83 1.06 0.52 1.18
832 952 368 216 152 42 102 184 104 168 144 183 140 114 12 16 11 10 7 5 0.96 0.67 1.23 0.92 0.7 0.55
521 738 591 496 95 197 183 51 53 156 163 170 64 65 16 14 12 10 7 4 0.17 0.93 0.97 0.06 0.22 0.83
480 501 412 264 148 181 205 55 206 199 185 30 136 131 13 14 11 9 8 5 0.53 0.31 1.2 0.95 0.9 0.84
645 800 603 435 168 201 48 89 108 200 163 130 114 136 10 14 10 11 9 5 0.5 1.2 1.02 1.17 1.05 1.09
767 854 606 512 94 160 86 72 202 132 64 184 202 145 15 16 13 8 7 6 0.78 0.74 0.77 0.61 0.84 0.71
890 227 370 185 185 180 57 172 51 144 86 57 55 73 10 11 10 11 7 5 0.01 0.74 0.55 0.69 0.82 1.03
559 699 432 340 92 114 144 135 123 54 62 44 76 104 18 14 9 10 6 6 0.43 0.36 0.73 0.98 0.77 1.33
616 337 412 280 132 76 70 206 41 81 65 41 105 205 19 9 13 9 8 4 0.44 0.06 0.32 0.85 0.63 0.54
836 767 396 318 78 167 76 73 173 112 83 198 128 42 18 10 10 8 8 5 0.23 0.47 0.94 0.64 0.05 0.67
785 526 374 200 174 64 163 58 110 91 106 187 134 84 13 14 13 10 7 5 0.42 0.64 0.74 0.77 0.42 0.91
879 166 621 560 61 41 102 115 207 39 113 174 101 197 19 10 13 11 7 4 0.62 0.35 0.87 0.44 0.96 1.09
831 460 588 500 88 101 196 127 109 87 85 95 129 155 13 12 11 11 7 6 0.24 1.14 1.35 0.62 1.29 0.58
413 599 546 506 40 114 168 37 91 151 69 160 147 182 18 10 13 7 6 6 0.21 1.07 0.19 1.1 1.07 1.09
7 876 513 447 66 47 142 90 171 135 81 139 68 160 12 12 9 9 8 4 0.7 1 0.56 1.04 0.55 0.83
596 763 398 266 132 57 195 82 199 155 158 41 105 30 17 17 13 9 7 6 0.08 1.01 0.74 0.99 1.25 0.77
367 294 624 469 155 182 51 208 153 167 51 108 175 50 11 16 12 9 7 4 0.77 0.64 0.58 0.23 1.22 0.65
295 765 338 191 147 147 149 40 42 169 154 71 138 97 18 15 10 9 9 6 0.29 0.7 1.3 0.79 0.26 0.82
247 122 410 205 205 194 126 92 66 93 149 178 202 57 14 12 11 9 8 5 0.4 0.58 0.85 1.02 0.7 0.18
33 604 412 350 62 119 206 89 101 86 72 149 38 58 18 9 9 7 7 5 0.85 0.21 1.04 0.62 0.66 1.27
488 726 615 536 79 205 109 107 153 162 143 67 139 123 13 14 13 8 8 5 0.52 0.26 0.75 0.65 0.64 1.01
940 685 624 549 75 172 208 168 193 56 146 204 161 70 19 11 12 9 8 6 0.06 0.83 1.27 0.77 0.56 0.55
504 426 410 205 205 179 188 117 158 188 103 176 86 124 12 17 13 8 7 4 0.14 0.96 0.49 1.4 1.01 0.83
948 63 342 204 138 144 84 53 108 89 171 124 75 123 15 10 12 8 9 5 0.31 0.84 1.02 0.86 1.04 0.87
424 291 585 390 195 61 102 108 157 102 152 95 185 79 14 13 14 10 7 6 0.81 1.03 0.89 1.2 0.37 0.98
803 707 618 530 88 206 95 189 54 111 181 141 64 77 17 16 11 10 7 6 0.28 1.22 0.67 0.97 0.78 0.51
700 37 412 330 82 170 138 129 202 61 148 190 61 206 15 13 9 10 9 4 0.09 1.19 0.89 1.34 0.95 1
625 128 336 259 77 44 127 125 168 108 54 54 129 39 13 17 14 8 6 4 0.2 0.32 0.41 0.52 0.61 0.32
804 285 416 371 45 172 66 54 205 151 154 173 171 208 12 12 12 11 7 4 0.36 0.5 0.58 0.92 0.57 0.62

Raw Dataset: pirp-50-5-3-10-3.dat

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462 927 410 374 36 33 58 205 47 34 81 169 205 60 18 13 13 7 8 5 0.02 0.88 0.63 0.28 0.99 0.74
95 698 370 267 103 108 96 185 169 99 104 44 113 103 18 17 14 11 7 4 0.06 0.91 0.31 0.99 1.04 0.98
98 914 396 243 153 198 149 98 128 136 56 146 83 176 11 15 13 9 6 5 0.23 0.38 1.12 1.11 0.65 1.15
532 191 621 582 39 198 34 57 32 132 71 158 207 93 16 16 11 11 8 6 0 0.93 0.27 0.95 1.17 0.37
632 264 597 544 53 199 118 168 44 162 171 97 42 199 11 11 10 11 9 5 0.52 0.94 1.04 1.37 0.95 0.92
838 288 412 323 89 45 181 78 193 206 202 58 130 46 19 14 13 7 8 5 0.83 0.47 0.57 0.96 0.74 0.61
571 662 394 213 181 46 179 197 169 70 65 116 133 126 15 12 14 8 7 4 0.69 0.76 0.41 1.05 0.18 0.71
147 919 390 195 195 187 36 163 118 119 85 104 108 150 19 12 13 8 9 6 0.48 0.64 0.29 1.19 0.81 0.42
706 558 374 187 187 73 69 179 75 168 171 86 97 180 18 17 13 9 8 5 0.1 0.27 0.45 1.16 0.79 0.49
128 725 356 178 178 98 92 148 68 139 46 41 41 76 15 12 10 9 8 5 0.66 0.74 1.34 0.72 0.81 0.38
778 606 372 186 186 166 175 52 94 115 177 102 73 164 17 11 11 8 9 4 0.99 1.15 0.76 0.22 1.19 1
45 656 272 143 129 98 49 136 63 48 62 81 59 101 14 13 11 8 6 5 0.35 0.44 1.22 0.65 0.7 0.79
641 175 594 521 73 196 39 145 198 196 133 43 151 30 11 13 12 8 7 6 0.31 0.28 0.81 0.61 0.46 0.51
156 620 528 352 176 51 40 176 166 113 71 93 116 64 10 14 14 9 8 5 0.11 1.31 0.9 0.34 0.58 1.03
40 656 374 293 81 94 175 116 187 171 116 135 42 176 17 17 9 7 7 6 0.78 0.8 0.45 0.92 0.58 0.7
392 679 558 374 184 166 171 150 186 123 179 123 113 78 14 13 10 9 7 6 0.65 0.7 0.34 0.85 0.42 1.04
181 757 338 169 169 50 65 37 61 157 109 153 42 73 12 15 9 9 8 6 0.05 0.69 0.44 0.46 0.94 0.59
432 943 579 482 97 193 140 192 53 33 110 110 51 172 18 10 14 10 7 4 0.82 0.36 0.41 0.92 0.36 0.56
613 655 624 494 130 108 31 145 141 55 208 82 197 38 15 17 10 8 8 6 0.97 0.61 0.76 0.44 0.73 0.04
385 723 603 521 82 201 76 90 176 189 105 54 78 162 17 16 8 9 8 4 0.72 0.42 1.19 1.33 0.63 0.76
466 338 324 195 129 76 120 81 159 77 144 51 49 162 17 13 12 10 6 6 0.72 1.09 0.44 1.26 0.41 0.56
847 716 400 302 98 109 100 102 86 98 200 39 82 189 19 14 13 7 7 5 0.59 0.54 0.92 0.33 0.85 0.41
491 535 372 314 58 125 166 38 135 65 186 79 64 126 12 16 12 7 6 5 0.18 0.3 0.39 1.22 0.67 0.35
42 211 396 346 50 191 91 198 157 34 93 128 184 147 15 10 11 9 9 5 0.62 0.3 0.36 1.01 0.45 0.63
89 818 534 414 120 136 143 58 66 178 69 155 112 176 10 12 10 7 7 6 0.36 0.55 0.6 0.72 0.86 1.14
407 771 372 214 158 151 57 124 112 178 134 186 114 164 16 15 14 8 6 6 0.73 0.64 0.3 0.83 0.64 0.52
294 529 534 362 172 128 154 178 66 81 89 121 126 57 16 14 14 10 8 6 0.52 0.84 0.52 0.52 0.97 0.34
90 910 546 433 113 75 77 141 75 131 110 182 116 158 17 12 9 9 7 4 0.45 0.98 0.43 1.12 0.62 1.03
467 817 404 284 120 201 35 68 126 197 31 167 202 130 19 16 9 11 8 4 0.4 0.43 1.28 0.87 0.77 0.74
72 10 609 549 60 203 196 160 133 136 129 169 156 191 15 11 10 11 6 5 0.48 1.21 0.36 0.81 0.54 1.17
959 888 621 465 156 117 75 189 207 99 100 166 147 67 11 11 12 11 8 6 0.57 0.93 1.18 0.95 1.09 0.49
207 738 278 232 46 127 133 84 139 72 44 45 122 85 12 15 9 8 7 5 0.26 0.51 0.38 1.12 0.69 0.93
88 439 618 428 190 157 187 65 181 206 115 179 172 120 19 13 8 10 8 5 0.67 0.43 0.27 1.25 0.83 0.61
561 41 603 464 139 56 201 101 173 161 52 95 200 201 12 14 13 9 8 6 0.27 0.53 0.3 0.39 0.77 0.7
70 584 316 230 86 158 92 129 75 153 30 48 100 32 15 14 14 10 6 6 0.52 0.72 1.05 0.94 0.61 0.72
534 717 340 290 50 52 115 104 70 157 129 155 170 166 16 16 8 10 7 4 0.51 0.38 0.4 0.92 0.79 0.29
748 494 414 207 207 136 87 163 112 93 172 101 57 179 11 16 10 12 8 4 0.67 0.77 0.32 0.58 0.55 1.1
913 732 390 296 94 135 46 63 40 195 37 44 54 31 18 13 11 10 6 4 0.91 0.92 0.87 1.31 0.83 1.53
38 693 362 234 128 60 96 181 94 61 153 61 32 94 14 12 12 9 7 6 0.87 0.85 0.3 0.19 0.8 0.64
573 900 609 413 196 137 71 80 203 201 65 145 169 51 10 17 9 10 7 5 0.51 0.14 0.4 1.46 0.53 0.51
33 882 435 320 115 114 69 136 145 143 89 59 94 99 11 16 8 11 7 5 0.56 0.71 0.63 0.64 0.17 0.89
550 507 600 511 89 105 198 30 157 172 133 188 200 116 15 12 12 11 7 6 0.46 0.52 0.88 1.12 0.82 0.86
610 768 400 200 200 100 94 106 189 96 125 76 182 110 18 12 12 8 7 4 0.65 0.38 0.57 0.32 0.2 0.92
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Raw Dataset: pirp-50-5-3-10-4.dat

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Raw Dataset: `pirp-50-5-3-10-5.dat`

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524 297 370 212 158 105 34 104 56 185 81 82 124 155 15 15 8 11 8 5 0.27 1.02 1.05 0.9 1.06 0.92
34 98 627 426 201 55 74 146 209 130 195 189 189 112 18 9 12 9 8 4 0.97 0.44 0.81 1.09 1.08 0.18
724 823 615 445 170 162 141 72 89 127 122 166 205 92 13 12 9 7 9 5 0.02 0.97 0.68 0.47 1.21 0.93
861 300 567 380 187 59 189 70 142 66 45 136 100 188 16 12 9 10 8 5 0.07 1.1 1.28 1.25 1 1.4
960 665 402 201 201 181 59 179 108 192 131 91 79 67 15 13 10 8 8 5 0.15 1.16 0.62 0.49 0.82 0.95
721 149 382 233 149 191 164 59 105 164 184 113 99 170 16 14 10 9 9 5 0.26 0.36 0.31 0.65 0.99 0.57
252 539 330 298 32 76 71 44 142 72 165 85 39 123 18 10 11 8 8 6 0.68 0.44 1.33 0.44 0.95 0.7
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841 979 368 221 147 135 179 156 79 60 184 59 38 158 11 14 9 10 9 6 0.06 1.08 0.42 0.37 0.67 0.8
388 281 402 312 90 79 166 90 77 127 201 86 33 165 15 17 12 10 8 6 0.91 1.15 0.72 0.79 0.47 0.82
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303 858 615 410 205 59 191 205 81 38 159 96 69 45 10 11 8 10 8 6 0.43 0.82 1.04 0.82 0.88 1.17
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467 825 396 242 154 141 180 134 152 198 75 179 151 128 18 15 9 8 7 6 0.39 0.66 0.55 0.63 1.02 1.24
995 54 360 237 123 114 166 94 97 65 159 59 165 180 11 10 12 10 6 4 0.8 0.37 0.47 1.37 1.27 0.74
830 556 418 240 178 209 81 200 60 156 94 159 116 157 16 16 9 7 6 4 0.47 1.01 1.03 0.54 0.95 0.57
501 448 408 221 187 133 204 135 60 34 191 139 53 49 18 12 13 8 6 6 0.78 0.93 0.33 0.97 0.29 0.86
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137 890 579 518 61 186 35 61 75 102 59 137 193 188 10 14 13 8 7 4 0.83 0.76 1.05 1 0.45 0.07

423 380 282 239 43 84 112 73 61 141 43 104 84 46 17 10 11 10 7 4 0.45 0.84 1.01 1.06 0.74 0.32

745 673 328 244 84 122 156 152 36 151 33 164 69 140 14 14 11 10 8 4 0.09 0.74 0.77 0.6 0.48 1

331 147 402 214 188 201 57 170 144 162 143 30 43 79 14 11 10 10 7 6 0.74 0.6 0.65 0.61 0.54 0.96

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Zusammenfassung

Diese Arbeit befasst sich mit dem Multi-Perioden-Inventar-Routing-Problem (PIRP) unter Unsicherheit, einer kritischen Herausforderung in Lieferketten für verderbliche Waren. Eine effiziente Verwaltung von Inventar- und Routing-Entscheidungen ist unerlässlich, um Kosten zu minimieren und Service-Levels aufrechtzuerhalten, während gleichzeitig die Verderblichkeit und die dynamischen Kundenanforderungen berücksichtigt werden.

Die Forschung konzentriert sich auf die Bewertung der Metaheuristik Greedy Randomized Adaptive Search Procedure (GRASP) als Lösungsmethode für PIRPs. Die Leistung von GRASP wird mit einem exakten Löser über verschiedene Datensätze hinweg verglichen, wodurch sein Potenzial hervorgehoben wird, Lösungsqualität, Laufzeiteffizienz und Skalierbarkeit in Einklang zu bringen. Aufgrund der Nichtverfügbarkeit realer Daten wurden simulierte Datensätze verwendet, die mehrere Planungszeiträume, Kundenanforderungen und betriebliche Einschränkungen abdecken.

Die Ergebnisse zeigen, dass GRASP durchweg qualitativ hochwertige Lösungen liefert und bis zu 90% des optimalen Zielwerts des exakten Lösers für kleinere Datensätze erreicht und akzeptable Leistungsniveaus (50% bis 90%) für größere, komplexere Instanzen aufrechterhält. GRASP übertrifft den exakten Löser in Bezug auf die Rechenleistung deutlich und löst groß angelegte Probleme in einem Bruchteil der Zeit, die der exakte Löser benötigt. Diese Effizienz positioniert GRASP als praktisches Werkzeug für zeitkritische und groß angelegte Entscheidungsfindung in Lieferketten.

Trotz seiner Stärken erkennt die Studie Einschränkungen an, wie z. B. die Abhängigkeit von simulierten Daten und die Herausforderungen bei der vollständigen Erfassung realer Komplexitäten. Zukünftige Forschung könnte die Anwendung von GRASP auf reale Datensätze untersuchen und seine Integration mit ergänzenden Methoden untersuchen, um seine Leistung weiter zu verbessern.

Alles in allem trägt diese Arbeit dazu bei, heuristikbasierte Ansätze für PIRPs voranzutreiben und umsetzbare Erkenntnisse für Lieferkettenmanager bereitzustellen. Die Skalierbarkeit und Anpassungsfähigkeit von GRASP unterstreichen seine Praktikabilität für Branchen, die mit verderblichen Waren arbeiten, und bieten ein wertvolles Entscheidungsinstrument zur Optimierung von Lieferkettenabläufen unter Unsicherheit.