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Optimization of Coffee Production and Distribution under Multi-Demand Scenarios: A Linear Programming and Dual Analysis Approach

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Abstract
Efficient production and distribution planning is essential for improving profitability in the coffee industry under varying market demand. This study developed a Linear Programming (LP) model integrated with dual analysis to optimize coffee production and distribution across low, medium, and high-demand scenarios. The model incorporated production capacity, distribution capacity, market demand, minimum production, and service level constraints, and was solved using the Simplex algorithm implemented in Python-PuLP. The optimal profits obtained were Rp56.585 million, Rp80.375 million, and Rp94.350 million for the low, medium, and high-demand scenarios, respectively. Under the high-demand scenario, only 3,000 kg of coffee could be distributed despite a production capacity of 3,100 kg, resulting in an unmet demand of 350 kg due to distribution capacity limitations. Shadow price analysis revealed that distribution capacity generated higher marginal economic value than production capacity, with Mataram exhibiting the highest shadow price of Rp30,000 per kilogram. These findings indicate that future profitability depends on integrated expansion of production and logistics capacity rather than production alone. The proposed framework provides practical decision support for identifying operational bottlenecks, prioritizing resource allocation, and guiding strategic investment in coffee production systems.

Keywords: Dual analysis; distribution optimization; linear programming; shadow price; supply chain

Abstrak
Perencanaan produksi dan distribusi yang efisien merupakan faktor penting dalam meningkatkan profitabilitas industri kopi pada kondisi permintaan yang bervariasi. Penelitian ini mengembangkan model Linear Programming (LP) yang terintegrasi dengan analisis dual untuk mengoptimalkan produksi dan distribusi kopi pada skenario permintaan rendah, sedang, dan tinggi. Model mempertimbangkan kapasitas produksi, kapasitas distribusi, permintaan pasar, batas produksi minimum, dan tingkat pelayanan minimum, kemudian diselesaikan menggunakan algoritma Simplex pada Python-PuLP. Keuntungan optimal yang diperoleh berturut-turut sebesar Rp56.585.000, Rp80.375.000, dan Rp94.350.000. Pada skenario permintaan tinggi, hanya 3.000 kg kopi yang dapat didistribusikan meskipun kapasitas produksi mencapai 3.100 kg, sehingga terjadi kekurangan pasokan sebesar 350 kg akibat keterbatasan kapasitas distribusi. Analisis shadow price menunjukkan bahwa kapasitas distribusi memiliki nilai ekonomi marjinal lebih tinggi dibandingkan kapasitas produksi, dengan distribusi ke Mataram menghasilkan shadow price tertinggi sebesar Rp30.000 per kilogram. Hasil penelitian menunjukkan bahwa peningkatan profit di masa depan memerlukan pengembangan kapasitas produksi dan distribusi secara terpadu. Model yang diusulkan dapat digunakan sebagai pendukung keputusan untuk mengidentifikasi bottleneck operasional, menentukan prioritas alokasi sumber daya, dan merencanakan investasi strategis pada sistem produksi kopi.

Kata Kunci: Analisis dual; optimasi produksi; pemrograman linear; rantai pasok; shadow price

1. INTRODUCTION

Coffee is one of the most important agricultural commodities in the global food industry and plays a significant role in economic development, employment generation, and international trade (Pancsira, 2022). The coffee sector contributes substantially to the livelihoods of farmers, processors, distributors, and retailers while supporting regional and national economies (V. A. & Pai, 2023). Increasing domestic consumption and expanding international markets have intensified the need for efficient production and distribution planning within coffee supply chains (Ribeiro et al., 2025).

Effective management of coffee supply chains is challenging because production resources are limited while market demand varies across regions and time periods (Kamal et al., 2025). Coffee enterprises must determine how much of each product should be produced and distributed to different markets in order to maximize profitability (Putu Jenny Natasia & Putu Yudi Setiawan, 2025). Poor production and distribution decisions may lead to excessive costs, unmet demand, underutilized resources, and reduced competitiveness (Islamiyah et al., 2025).

Mathematical optimization techniques have been widely applied to support decision-making in food supply chains (Nozari et al., 2025). Among these techniques, linear programming has proven to be one of the most effective approaches for solving resource-allocation problems involving production planning, transportation, distribution management, and profit maximization (Hansraj Gupta, 2024). Linear programming enables decision makers to identify optimal solutions while simultaneously considering multiple operational constraints (Singh, 2025). In practice, coffee enterprises frequently face simultaneous production and distribution decisions under varying market conditions. Determining the optimal allocation of limited resources across multiple products and destinations is therefore essential for maximizing profitability and maintaining operational efficiency (Otoo et al., 2023).

Although previous studies have investigated optimization problems in agricultural and food supply chains, many studies focus on single-demand conditions and provide limited analysis of how optimal decisions change under different market-demand scenarios (Behzadi et al., 2018; Taşkıner & Bilgen, 2021). Furthermore, dual information derived from optimization models, such as shadow prices and reduced costs, is often underutilized despite its importance for managerial decision-making and resource allocation (Aal, 2024). These analytical tools provide additional economic insights by identifying critical resources, bottleneck constraints, and non-competitive distribution routes that may not be apparent from optimal solutions alone (Abid & Saqlain, 2023).

To address these gaps, this study develops a linear programming model for optimizing coffee production and distribution under multiple demand scenarios. Three demand scenarios, namely low, medium, and high demand, are considered to evaluate the robustness of optimal decisions under varying market conditions. In addition, shadow price analysis and reduced cost analysis are performed to identify critical resources and economically inefficient distribution routes. The findings are expected to provide practical insights for improving profitability and operational efficiency in coffee-based food enterprises.

2. MATERIALS AND METHODS

Research Design

This study employs a quantitative mathematical modeling approach using linear programming to optimize coffee production and distribution decisions under different market demand conditions. The model is evaluated under three demand scenarios: 1) Low demand, 2) Medium demand, and 3) High demand. The optimization model was implemented using the PuLP library in Python. All scenarios were solved using the simplex algorithm to obtain optimal production and distribution decisions while satisfying all operational constraints.

The objective is to maximize total net profit while satisfying production capacity, distribution capacity, market demand, and minimum service level requirements. The study uses simulated data representing the operational characteristics of a hypothetical small-to-medium coffee enterprise.

Research Framework

The overall research procedure is illustrated as follows:

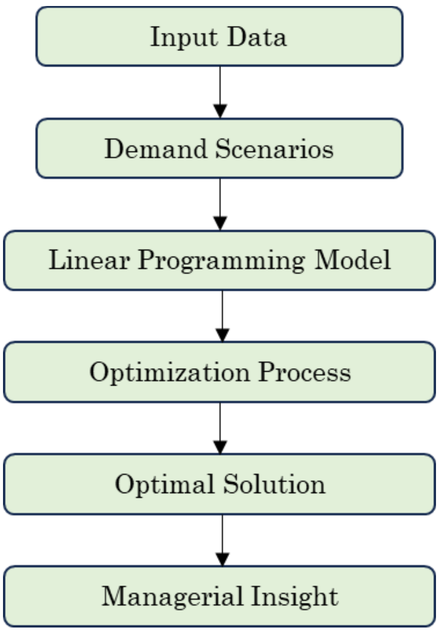

Figure 1. Research Framework

The research framework begins with data preparation and demand-scenario generation. Subsequently, a linear programming model is formulated and solved to obtain optimal production and distribution decisions. Finally, the resulting solutions are evaluated through profit comparison and dual analysis to generate managerial insights.

Set and Indices

Table 1. Set and Indices

Symbol	Description
i	Coffee product index
j	Distribution destination index
$I = \{1,2,3\}$	Set of coffee products
$J = \{1,2,3,4\}$	Set of destination areas

Table 2. Coffee Product Codes

Index	Product
1	Robusta
2	Arabica
3	Blend

Table 3. Distribution Destination Codes

Index	Destination
1	Mataram
2	West Lombok
3	Central Lombok
4	East Lombok

Decision Variables

The decision variable is defined as x_{ij}. These decision variables represent the quantity of each coffee product allocated to each destination market and constitute the primary optimization decisions within the model.

Model Parameter

Table 4. Model Parameter

Parameter	Description
P_i	Selling price of product i
C_i	Production cost of product i
T_{ij}	Distribution cost of product i to destination j
K_i	Production capacity of product i
D_j	Demand of destination j
U_j	Distribution capacity of destination j
π_{ij}	Net profit per kilogram

Net profit is calculated as:

$$\pi_{ij} = P_i - C_i - T_{ij}$$

Objective Function

The objective of the model is to maximize total net profit.

$$\max Z = \sum_{i=1}^{3}\sum_{j=1}^{4} \pi_{ij} x_{ij}$$

or

$$\max Z = \sum_{i=1}^{3}\sum_{j=1}^{4} \left(P_i - C_i - T_{ij}\right) x_{ij}$$

The objective function seeks to maximize total net profit generated from coffee production and distribution activities while accounting for production and transportation costs.

Constraints

Production Capacity Constraint

$$\sum_{j=1}^{4} x_{ij} \leq K_i, \qquad i = 1,2,3$$

Demand Constraint

$$\sum_{i=1}^{3} x_{ij} \leq D_j, \qquad j = 1,2,3,4$$

Minimum Service Level Contsraint

$$\sum_{i=1}^{3} x_{ij} \geq 0{,}5\, D_j, \qquad j = 1,2,3,4$$

Distribution Capacity Constraints

$$\sum_{i=1}^{3} x_{ij} \leq U_j, \qquad j = 1,2,3,4$$

Demand Satisfaction Constraints

$$\sum_{i=1}^{3} x_{ij} \geq 0.8\, D_j$$

Non-Negativity Constraints

$$x_{ij} \geq 0$$

for all $i \in I,$ and $j \in J$.

Collectively, these constraints ensure that the optimization model reflects realistic operational conditions, including limited production resources, market demand requirements, logistics capacity restrictions, and minimum service obligations.

Mathematical Model Validation

Feasibility

The feasible region is non-empty because there exists at least one solution satisfying all constraints (Ghobadi & Mahmoudzadeh, 2021).

Boudedness

The model is bounded since all production capacities are finite (Alnaqbi et al., 2023):

$$K_1 + K_1 + K_3 = 3100$$

Thus, the objective function cannot increase indefinitely.

Linearity

All objective and constraint functions are linear combinations of decision variables. Therefore, the model satisfies the assumptions of linear programming (Bagshaw, 2019).

In addition, all optimization scenarios returned an optimal solution status, confirming that the formulated model is computationally feasible and numerically stable.

Simulated Data

Table 5. Production Capacity

Product	Capacity
Robusta	1200
Arabica	900
Blend	1000

Table 6. Selling Price and Production Cost

Product	Selling Price (Rp/kg)	Production Cost (Rp/kg)
Robusta	90000	55000
Arabica	120000	78000
Blend	105000	65000

Table 7. Distribution Cost Matrix (Rp/kg)

Destination	Robusta	Arabica	Blend
Mataram	5000	5500	5200
West Lombok	6500	7000	6800
Central Lombok	8000	8500	8200
East Lombok	10000	10500	10200

Table 8. Demand Scenarios

Scenario	Mataram	West Lombok	Central Lombok	East Lombok	Total
Low	500	450	400	350	1700
Medium	750	650	600	500	2500
High	1000	850	800	700	3350

Table 9. Distribution Capacity

Destination	Capacity (kg/month)
Mataram	900
West Lombok	800
Central Lombok	700
East Lombok	600

3. RESULTS AND DISCUSSIONS

Low Demand Scenario

The first scenario represents a low demand market condition with a total demand of 1,700 kg distributed across four destination areas. The optimization model generated an optimal profit of Rp,56,585,000 The optimal allocation obtained from the model is presented in Table 10.

Table 10. Optimal Allocation under Low Demand Scenario (Kg)

Product	Mataram	West Lombok	Central Lombok	East Lombok
Arabica	500	400	0	0
Blend	0	0	350	350
Robusta	0	50	50	0

The results indicate that Arabica was allocated at its maximum production capacity of 900 kg, reflecting its superior profitability compared with the other products. Blend coffee was primarily distributed to Central Lombok and East Lombok, while Robusta was only produced at the minimum production requirement level. This finding demonstrates that the optimization model strongly favors products with higher net profit margins (Abid & Saqlain, 2023; Islamiyah et al., 2025). Without the minimum production requirement constraint, Robusta would not appear in the optimal solution due to its relatively lower profitability. Under low-demand conditions, available production capacity exceeds market demand, allowing the optimization model to allocate resources selectively toward products with the highest profit contributions.

Medium Demand Scenario

The second scenario considers a medium-demand condition with a total demand of 2,500 kg. The optimization model produced an optimal profit of Rp80,375,000 The optimal allocation is shown in Table 11.

Table 11. Optimal Allocation under Medium Demand Scenario (Kg)

Product	Mataram	West Lombok	Central Lombok	East Lombok
Arabica	0	300	600	0
Blend	750	0	0	250
Robusta	0	350	0	250

The results reveal a significant increase in product utilization compared with the low-demand scenario. Both Arabica and Blend reached their maximum production capacities of 900 kg and 1,000 kg, respectively. The remaining demand was satisfied by Robusta.

The allocation pattern suggests that the optimization process prioritizes high-profit products first and subsequently utilizes lower-profit products when demand exceeds the available capacity of premium products. This behavior is consistent with profit-maximizing decision-making principles in linear programming (Rusescu, 2026). This scenario represents a transition stage where premium products approach their production limits and additional demand begins to be satisfied by lower-margin products.

High Demand Scenario

The third scenario represents a high-demand market condition with a total demand of 3,350 kg. Since the total production capacity is only 3,100 kg, this scenario introduces a resource-constrained environment. The optimization model generated an optimal profit of Rp,94,350,000. The optimal allocation is presented in Table 12.

Table 12. Optimal Allocation under High Demand Scenario (Kg)

Product	Mataram	West Lombok	Central Lombok	East Lombok
Arabica	0	0	400	500
Blend	900	0	0	100
Robusta	0	800	300	0

The results indicate a substantial shift in allocation patterns. Arabica and Blend continue to operate near their production capacity limits, while Robusta is increasingly utilized to satisfy the remaining market demand. Under this scenario, the optimization model successfully fulfilled 3,000 kg of total demand, leaving an unmet demand of 350 kg. The unmet demand occurred because the total distribution capacity across the four destination areas was limited to 3,000 kg, despite the available production capacity of 3,100 kg. Consequently, all distribution facilities operated at full capacity, indicating that the logistics network rather than overall production capacity became the dominant operational bottleneck under high-demand conditions.

The optimization process allocates products strategically according to both profitability and distribution constraints. Premium products, particularly Arabica and Blend, were prioritized because of their higher contribution margins, while Robusta was utilized to satisfy the remaining demand once the production capacities of the premium products had been exhausted. This allocation strategy reflects the fundamental objective of linear programming to maximize total profit while satisfying operational constraints simultaneously (Hamidah et al., 2026).

An important managerial implication emerging from this scenario is that increasing production capacity alone would not necessarily improve profitability because the existing distribution network has already reached its maximum utilization. Future profit growth therefore depends not only on expanding production capacity but also on increasing distribution capacity, particularly in destination markets that have reached their logistics limits. These findings demonstrate that coordinated investment in both production and distribution infrastructure is essential for supporting business expansion under rapidly increasing market demand.

Profit Comparison Across Demand Scenarios

Figure 2 presents the optimal profits obtained under the three demand scenarios. The optimal profit increased from Rp 56.585 million under low demand to Rp 80.375 million under medium demand and further increased to Rp 94.350 million under high demand.

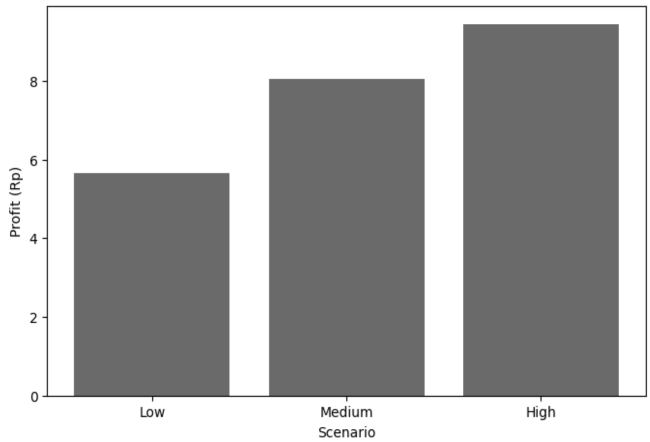

Figure 2. Optimal Profit under Demand Scenarios

The increase from the low-demand scenario to the medium-demand scenario was approximately 42.05%, whereas the increase from the medium-demand scenario to the high-demand scenario declined to approximately 17.39%. Although profit continued to increase as market demand increased, the rate of profit growth gradually decreased because the optimization model encountered progressively tighter operational constraints.

Under the low-demand scenario, available production and distribution capacities exceeded market demand, allowing the optimization model to allocate resources primarily according to product profitability. In the medium-demand scenario, premium products such as Arabica and Blend reached their production capacity limits, requiring Robusta to satisfy the remaining demand. Under the high-demand scenario, however, the system experienced simultaneous production and distribution constraints. While the total production capacity reached 3,100 kg, only 3,000 kg could be distributed because all destination markets had already reached their maximum distribution capacities. Consequently, an unmet demand of 350 kg remained despite the availability of unused production capacity.

These findings demonstrate that the slower growth in profit was not caused by declining market demand but rather by increasing capacity saturation within the production distribution system. As operational constraints became binding, additional market demand could no longer be converted efficiently into higher profit. Therefore, future investments should focus not only on expanding production capacity but also on strengthening distribution infrastructure to ensure that additional production can be delivered effectively to destination markets. This result further confirms that integrated production and logistics planning is essential for sustaining profitability under rapidly increasing market demand (Tran & Chiadamrong, 2025).

Shadow Price Analysis

Shadow price analysis was conducted to identify critical constraints affecting the optimal solution under the high-demand scenario (Otoo et al., 2023). Table 13 summarizes the most important shadow prices.

Table 13. Significant Shadow Prices under High Demand Scenario

Constraint	Shadow Price
Production Capacity – Arabica	6500
Production Capacity – Blend	4800
Distribution Capacity – Mataram	30000
Distribution Capacity – West Lombok	28500
Distribution Capacity – Central Lombok	27000
Distribution Capacity – East Lombok	25000

The results show that the production capacity of Arabica generated a shadow price of Rp 6,500 per kilogram, indicating that each additional kilogram of Arabica production capacity would increase the optimal profit by approximately Rp 6,500, provided that all other constraints remain unchanged. Similarly, Blend production capacity produced a positive shadow price of Rp 4,800 per kilogram, confirming that both premium coffee products remained economically attractive under high-demand conditions because their production capacities were fully utilized.

A more important finding is that all distribution capacity constraints generated substantially higher shadow prices than the production capacity constraints. Distribution capacity in Mataram exhibited the highest shadow price (Rp 30,000 per kilogram), followed by West Lombok (Rp 28,500), Central Lombok (Rp 27,000), and East Lombok (Rp 25,000). These values indicate that an additional one kilogram of distribution capacity in these destinations would generate a larger increase in total profit than an equivalent increase in production capacity.

This result can be explained by the fact that all distribution facilities reached 100% utilization under the high-demand scenario, while a portion of the overall production capacity remained unused because the distribution network had already reached its maximum capacity. Consequently, the logistics system rather than the overall production system became the dominant bottleneck limiting further profit growth. The higher shadow price observed in Mataram does not indicate that its distribution capacity is smaller than those of other destinations. Instead, it reflects the greater marginal economic value of additional distribution capacity in Mataram, where distribution costs are relatively lower and the corresponding net profit contribution per kilogram is the highest among all destination markets. Therefore, each additional unit of distribution capacity allocated to Mataram provides the greatest increase in the objective function.

From a managerial perspective, these findings suggest that expanding logistics capacity should be prioritized before increasing overall production capacity. Although additional production resources remain beneficial, their economic impact would be limited unless sufficient distribution capacity is available to deliver the products to market. Consequently, coordinated investment in production and logistics infrastructure is required to maximize profitability under rapidly growing market demand.

Bottleneck Analysis and Managerial Implications

The optimization results provide important insights into the evolution of operational bottlenecks under different market demand scenarios. During the low-demand scenario, neither production capacity nor distribution capacity constrained the optimization process because available resources exceeded market demand. Consequently, the model primarily allocated production according to product profitability, allowing premium products such as Arabica and Blend coffee to dominate the optimal solution.

As market demand increased to the medium-demand scenario, production capacities of Arabica and Blend became binding constraints, indicating that these premium products had reached their maximum production limits. Under these conditions, Robusta production increased to satisfy the remaining market demand. This transition demonstrates that the optimization model gradually shifted from a purely profit-driven allocation strategy toward a resource-constrained allocation strategy as production resources became increasingly limited.

A more significant structural change occurred under the high-demand scenario. Although the total production capacity reached 3,100 kg, the model was able to distribute only 3,000 kg because all destination markets simultaneously reached their maximum distribution capacities. Consequently, 350 kg of market demand remained unmet despite the availability of unused production capacity. This finding indicates that the primary operational bottleneck shifted from production capacity to the distribution network. In other words, further increases in production alone would not generate additional profit unless supported by corresponding expansion of distribution capacity.

The shadow price analysis further reinforces this conclusion. Distribution capacity constraints generated substantially higher shadow prices than production capacity constraints, indicating that additional logistics capacity would provide greater marginal economic benefits than equivalent increases in production capacity. Among all destinations, Mataram exhibited the highest shadow price because additional distribution capacity in this market generated the largest increase in total profit. This result reflects the higher marginal economic value of expanding distribution capacity in markets with relatively lower distribution costs and higher net profit contributions.

From a managerial perspective, these findings suggest that investment priorities should not focus exclusively on increasing production capacity. Instead, decision makers should adopt an integrated production distribution planning strategy in which production expansion is accompanied by proportional improvements in logistics infrastructure. Such coordinated capacity planning would enable coffee enterprises to convert growing market demand into higher profitability while minimizing the risk of operational bottlenecks. Therefore, linear programming combined with dual analysis provides not only an optimal allocation solution but also valuable strategic information for identifying critical resources and supporting long-term investment decisions under dynamic market conditions.

Reduced Cost Analysis

Reduced cost analysis was performed to evaluate the competitiveness of non-selected distribution decisions. Most variables included in the optimal solution exhibited reduced costs equal to zero, indicating that they formed part of the optimal basis. However, the variable corresponding to Blend distribution to West Lombok exhibited a reduced cost of -100. This result implies that the net profit associated with this distribution route would need to increase by at least Rp 100 per kilogram before it becomes economically attractive within the optimal solution (Ndubuisi, 2021). Reduced cost analysis provides additional managerial insight by identifying routes that are currently uncompetitive and highlighting opportunities for future cost reduction or pricing improvements (Govindan & Gholizadeh, 2021). This information can assist managers in redesigning pricing strategies or reducing operational costs to improve route competitiveness.

Overall, the combined use of scenario analysis, shadow price analysis, and reduced cost analysis demonstrates the effectiveness of the proposed linear programming framework in supporting production and distribution decisions under varying market conditions.

Managerial and Mathematical Implications

The results of this study provide both managerial and mathematical implications for coffee production and distribution planning. From a managerial perspective, the optimization results indicate that product profitability strongly influences allocation decisions. Arabica consistently received priority allocation across all demand scenarios because it generated the highest net profit per kilogram. Consequently, coffee enterprises should prioritize investments aimed at increasing Arabica production capacity whenever market demand continues to grow.

The shadow price analysis further revealed that distribution capacities constitute critical operational resources. The positive shadow prices associated with distribution capacities indicate that expanding logistics infrastructure may generate significant economic benefits (Abid & Saqlain, 2023). In particular, the distribution capacity of Mataram exhibited the highest marginal value, suggesting that investments in transportation and distribution facilities serving this market may provide the largest increase in profitability.

From a mathematical perspective, the study demonstrates the usefulness of linear programming as a decision support framework for food supply chain optimization (Mehmet & Salamah, 2023). The integration of demand-scenario analysis enables the evaluation of optimal solutions under varying market conditions, while shadow price and reduced cost analyses provide additional economic interpretation of model constraints and decision variables (Baghizadeh et al., 2022).

The results also illustrate how capacity constraints influence optimal solutions. Under low-demand conditions, the model primarily selected high-profit products. However, as demand increased, lower-profit products were gradually incorporated into the optimal solution because of production-capacity limitations. This behavior reflects the ability of linear programming models to balance resource constraints and profit objectives simultaneously (Rusescu, 2026).

Overall, the proposed framework provides a transparent and computationally efficient approach for supporting production and distribution planning decisions in coffee-based food enterprises. Furthermore, the proposed framework can be adapted to other food-processing industries facing similar production and distribution planning challenges, demonstrating its broader applicability beyond the coffee sector.

4. CONCLUSION

This study developed a linear programming model integrated with dual analysis to optimize coffee production and distribution under multiple market demand scenarios. The proposed model successfully identified the optimal production and distribution allocation while satisfying production capacity, distribution capacity, market demand, minimum production, and service-level constraints. The optimization results demonstrated that total profit increased consistently as market demand increased, reaching Rp 56.585 million, Rp 80.375 million, and Rp 94.350 million under the low, medium, and high-demand scenarios, respectively.

The comparative scenario analysis revealed that the operational characteristics of the system changed as market demand increased. Under low-demand conditions, available resources exceeded market demand, allowing the optimization model to allocate production primarily according to product profitability. As demand increased, the production capacities of Arabica and Blend became binding constraints, requiring Robusta to satisfy the remaining demand. Under the high-demand scenario, however, all distribution facilities reached full utilization, limiting the total quantity that could be delivered to 3,000 kg despite the availability of 3,100 kg of production capacity. Consequently, unmet demand emerged, indicating that the distribution network became the dominant operational bottleneck under high-demand conditions.

The dual analysis provided additional managerial insights beyond the optimal allocation itself. Shadow price analysis demonstrated that expanding distribution capacity would generate greater marginal economic benefits than equivalent increases in production capacity, particularly in Mataram, which exhibited the highest shadow price among all operational constraints. These findings indicate that future investments should prioritize integrated expansion of both production and logistics capacity rather than focusing solely on increasing production output.

Overall, the integration of linear programming with scenario analysis and dual analysis provides a comprehensive decision-support framework for coffee production and distribution planning. Beyond identifying optimal allocation decisions, the proposed approach enables decision makers to recognize critical bottlenecks, evaluate the economic value of constrained resources, and establish investment priorities for improving operational efficiency and long-term profitability in coffee-based food enterprises

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6. REFERENCES

Aal, M. A. M. A. (2024). Matheuristic approach and a mixed-integer linear programming model for biomass supply chain optimization with demand selection. *International Journal of Industrial Engineering Computations*, *15*(1), 235–254. https://doi.org/10.5267/j.ijiec.2023.10.001

Abid, M., & Saqlain, M. (2023). Decision-Making for the Bakery Product Transportation using Linear Programming. *Spectrum of Engineering and Management Sciences*, *1*(1), 1–12. https://doi.org/10.31181/sems1120235a

Alnaqbi, A., Trochu, J., Dweiri, F., & Chaabane, A. (2023). Tactical supply chain planning after mergers under uncertainty with an application in oil and gas. *Computers & Industrial Engineering*, *179*, 109176. https://doi.org/10.1016/j.cie.2023.109176

Bagshaw, K. B. (2019). A Review of Quantitative Analysis (QA) in Production Planning Decisions Using the Linear Programming Model. *American Journal of Operations Research*, *09*(06), 255–269. https://doi.org/10.4236/ajor.2019.96017

Behzadi, G., O'Sullivan, M. J., Olsen, T. L., & Zhang, A. (2018). Agribusiness supply chain risk management: A review of quantitative decision models. *Omega*, *79*, 21–42. https://doi.org/10.1016/j.omega.2017.07.005

Ghobadi, K., & Mahmoudzadeh, H. (2021). Inferring linear feasible regions using inverse optimization. *European Journal of Operational Research*, *290*(3), 829–843. https://doi.org/10.1016/j.ejor.2020.08.048

Govindan, K., & Gholizadeh, H. (2021). Robust network design for sustainable-resilient reverse logistics network using big data: A case study of end-of-life vehicles. *Transportation Research Part E: Logistics and Transportation Review*, *149*, 102279. https://doi.org/10.1016/j.tre.2021.102279

Hamidah, S. N., Aprilia, H., & Abdullah, F. (2026). Optimasi Perencanaan Produksi Menggunakan Linear Programming dan Analisis Sensitivitas Pada UMKM Coffee Suganda Majalengka. *IMTechno: Journal of Industrial Management and Technology*, *7*(1), 38–46. https://doi.org/10.31294/imtechno.v7i1.11608

Hansraj Gupta. (2024). Advances in Linear Programming for Supply Chain Optimization. *Innovative Research Thoughts*, *10*(3), 339–342. https://doi.org/10.36676/irt.v10.i3.1701

Islamiyah, A. H., Sa'adah, U., & Karim, C. (2025). MILP Model Solution Steps: Implementation of Big M Simplex and Branch and Bound in the Coffee Supply Chain. *CAUCHY: Jurnal Matematika Murni Dan Aplikasi*, *10*(2), 764–776. https://doi.org/10.18860/cauchy.v10i2.35380

Kamal, M. A., Santoso, I., Effendi, U., Astuti, R., Mulyarto, A. R., Hidayat, A., & Effendi, M. (2025). A Framework of Hybrid System Dynamics and Agent Based Model With Cooperative Game Theory for Sustainable Coffee Supply Chain. *Journal of Applied Engineering and Technological Science (JAETS)*, *6*(2), 922–939. https://doi.org/10.37385/jaets.v6i2.7007

Ndubuisi, Dr. P. O. (2021). Application Of Transportation Model For Optimal Product Distribution Chain Management. *International Journal of Management & Entrepreneurship Research*, *3*(3), 107–117. https://doi.org/10.51594/ijmer.v3i3.218

Nozari, H., Abdi, H., Szmelter-Jarosz, A., & Rahmaty, M. (2025). A digital twin-based neutrosophic multi-objective optimization model for smart supply chains in the food industry. *Journal of Intelligent Manufacturing*. https://doi.org/10.1007/s10845-025-02689-z

Otoo, D., Adjei, B. A., & Appiah, S. T. (2023). A mixed-integer quadratic programming production-transportation problem. *International Journal of Operational Research*, *48*(3), 338–356. https://doi.org/10.1504/IJOR.2023.134781

Pancsira, J. (2022). International Coffee Trade: a literature review. *Journal of Agricultural Informatics*, *13*(1). https://doi.org/10.17700/jai.2022.13.1.654

Putu Jenny Natasia, & Putu Yudi Setiawan. (2025). Optimization Of Production Combination in Umah Lokal Coffee Roastery. *International Journal of Economics, Management and Accounting*, *2*(2), 340–350. https://doi.org/10.61132/ijema.v2i2.637

Ribeiro, A. B., Cosvock, E. A., Cupertino, G., & Servare Junior, M. W. J. (2025). Revisão bibliométrica utilizando o ProKnow-c: análise da cadeia de suprimentos na distribuição do café. *Brazilian Journal of Production Engineering*, *11*(3), 34–45. https://doi.org/10.47456/bjpe.113.47998

Rusescu, C. (2026). A Profit Maximization Method using Post Optimal Analysis in Linear Programming. *Bulletin of the Transilvania University of Brasov. Series V: Economic Sciences*, 131–142. https://doi.org/10.31926/but.es.2025.18.67.2.13

Singh, J. P. (2025). Linear And Goal Programming: Foundations And Applications In Multi-Objective Optimization. *International Journal of Research -Granthaalayah*, *13*(12), 213–217. https://doi.org/10.29121/granthaalayah.v13.i12.2025.6624

Taşkıner, T., & Bilgen, B. (2021). Optimization Models for Harvest and Production Planning in Agri-Food Supply Chain: A Systematic Review. *Logistics*, *5*(3), 52. https://doi.org/10.3390/logistics5030052

Tran, U. L. T., & Chiadamrong, N. (2025). Maximizing EVA in a Cocoa Supply Chain Network Design with a Hybrid Optimization Approach: A Case Study in Vietnam. *Engineering Journal*, *29*(7), 61–83. https://doi.org/10.4186/ej.2025.29.7.61

V. A., N. A., & Pai, R. (2023). A Quantitative ABCD Analysis of Coffee Industry Stakeholders. *International Journal of Case Studies in Business, IT, and Education*, 287–313. https://doi.org/10.47992/IJCSBE.2581.6942.0303