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Product Layout Design for a Finished Goods Warehouse in the Instant Noodle Industry Using the Systematic Layout Planning (SLP) Method

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Abstract: *Warehouse layout optimization in the food manufacturing industry remains a critical yet underexplored challenge, particularly for multi-product operations with heterogeneous storage requirements and high-throughput demands. Previous studies have predominantly focused on single-criterion evaluations or general industrial settings, leaving a notable gap in the application of comprehensive, multi-criteria Systematic Layout Planning (SLP) frameworks to finished goods warehouses in the food sector. This study addresses that gap by designing an optimal product layout for a finished goods warehouse in an instant noodle manufacturing facility with an annual production capacity of 20 million units. The SLP method was implemented through six structured phases: activity relationship analysis, space requirements determination, relationship and space diagram construction, alternative layout generation, and weighted multi-criteria quantitative evaluation. Three layout alternatives were systematically assessed using criteria encompassing material handling efficiency, space utilization, operational flexibility, and implementation cost. The U-shaped layout emerged as the optimal design, attaining the highest weighted evaluation score and demonstrating substantial reductions in material handling distance and operational cost relative to conventional linear configurations. The findings confirm that the SLP method provides a robust and replicable framework for warehouse layout optimization in multi-product food manufacturing environments, offering actionable guidance for facility planners confronting analogous operational constraints.*
Keywords : Systematic Layout Planning, Product Layout, Warehouse Design, Instant Noodle Industry, Facility Layout.

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INTRODUCTION

The global instant noodle industry has experienced sustained growth, with annual production exceeding hundreds of billions of servings and placing mounting pressure on downstream supply chains, particularly finished goods warehousing (Muther & Hales, 2022). Efficient warehouse layout is widely recognized as a key determinant of supply chain performance, directly influencing material handling costs, order fulfillment lead times, and inventory accuracy (Zhou et al., 2025) In food manufacturing contexts, these challenges are compounded by the necessity to manage multiple product variants with distinct shelf-life requirements, to comply with food storage regulations, and to sustain high-volume continuous throughput. Despite the considerable practical importance of this issue, the academic literature has yet to provide a sufficiently comprehensive and context-specific framework for warehouse layout design in the food manufacturing sector.

Prior research on warehouse layout optimization has produced significant contributions; however, several limitations persist. Studies such as those by (Sumesh et al., 2025; Widia et al.,

2025) and (Gozali et al., 2023) have examined layout optimization in general industrial and retail distribution contexts, but their findings are not directly transferable to food manufacturing warehouses, which operate under more stringent hygiene and storage constraints. Research applying the Systematic Layout Planning (SLP) method—originally developed by (Krishna & Tulli, 2023) has predominantly targeted production floor configurations rather than finished goods storage environments (Muntaka et al., 2025)

The gaps identified above underscore the need for research that applies a comprehensive, multi-criteria layout planning methodology to finished goods warehouses in the food manufacturing sector. In particular, evidence remains limited regarding how the SLP method can be systematically adapted to accommodate multi-product operations with heterogeneous storage requirements, regulatory compliance considerations, and quantitative multi-criteria layout evaluation. This study addresses these gaps by applying the full six-phase SLP framework to design and evaluate product layout alternatives for a finished goods warehouse in an instant noodle manufacturing facility with an annual production capacity of 20 million units, comprising Fried Noodles (60%, two flavor variants) and Boiled Noodles (40%, three flavor variants). The novelty of this research lies in its integration of activity relationship analysis, space requirement calculation, and a weighted multi-criteria evaluation method within the SLP process, tailored specifically to the operational and regulatory constraints of food warehouse environments. The findings contribute both a methodological framework and practical design recommendations applicable to comparable multi-product manufacturing facilities.

METHODOLOGY

This study employs a quantitative approach based on the Systematic Layout Planning (SLP) method. The SLP method was selected because it provides a structured, step-by-step framework for analyzing activity relationships, determining space requirements, and accommodating practical constraints in order to generate implementable layout solutions. The subject of this research is the finished goods warehouse of an instant noodle manufacturing facility with an annual production capacity of 20 million units, operating 300 working days per year in a single eight-hour shift.

Data Collection

Primary data were gathered through direct on-site observation and measurement, structured interviews with warehouse supervisors and operators, and systematic documentation of existing operational conditions. Secondary data were sourced from industry standards, food storage regulations, equipment manufacturer specifications, and relevant academic literature on warehouse layout optimization.

Production and Operational Parameters

The production system comprises two product categories. Fried Noodles account for 60% of total production (12,000,000 units/year), distributed equally across two flavor variants (6,000,000 units/year each). Boiled Noodles account for the remaining 40% (8,000,000 units/year), distributed across three flavor variants (approximately 2,667,000 units/year each). Key operational parameters include an average inventory holding period of 30 days, a safety stock level equivalent to 20% of average inventory, a pallet capacity of 360 units for fried noodles and 400 units for boiled noodles, standard pallet dimensions of 1.2 m × 1.0 m, a maximum stacking height of six pallets, and a handling allowance of 15% applied to all storage areas.

SLP Framework Implementation

The SLP method was implemented through six sequential phases. Phase 1 involved identifying warehouse activities and analyzing their interrelationships using an Activity Relationship Chart (ARC), employing the standard AEIOUX proximity scale ranging from Absolutely Necessary (A) to Undesirable (X). Eight activity zones were identified: Receiving (A), Fried Noodles Storage Variant 1 (B), Fried Noodles Storage Variant 2 (C), Boiled Noodles Storage Variants 1-3 (D, E, F), Order Picking and Preparation (G), and Shipping (H).

Phase 2 determined the space requirements for each zone based on inventory calculations, pallet dimensions, stacking height, and operational allowances. Phase 3 produced a relationship diagram that visually represents the proximity requirements derived from the ARC. Phase 4 developed a space relationship diagram by integrating the actual space requirements into the relationship diagram. Phase 5 generated three alternative layout configurations based on practical site constraints. Phase 6 evaluated the alternatives using a weighted multi-criteria scoring method, with the following criteria and corresponding weights: Material Handling Efficiency (35%), Space Utilization (25%), Operational Flexibility (20%), and Implementation Cost (20%).

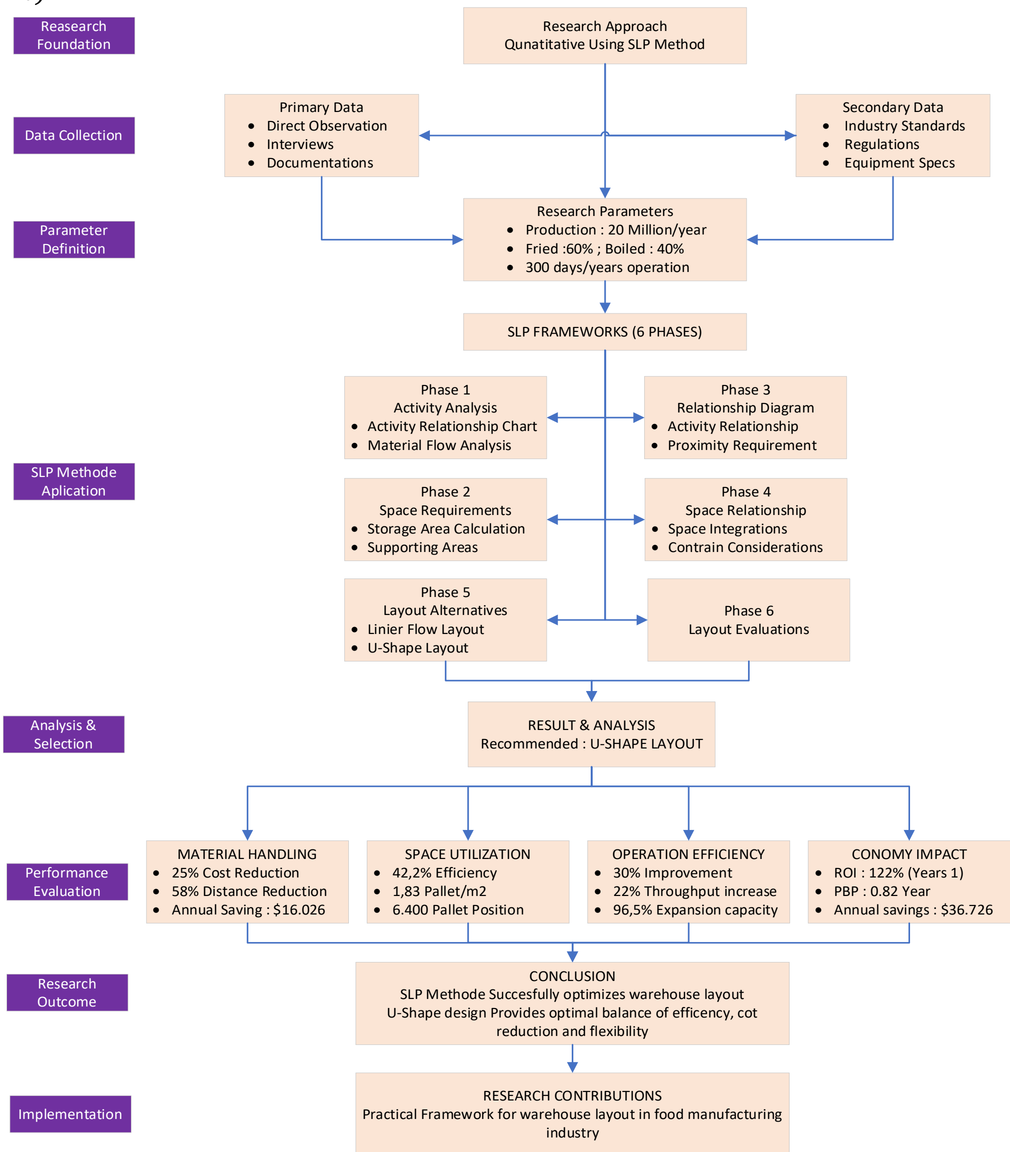

Figure 1 : Systematic Layout Planning (SLP) Research Methodology

Evaluation Method:

1. Score assignment 1-10 for each criterion
2. Weighted score calculation
3. Sensitivity analysis
4. Best alternative selection

RESULTS

Activity Relationship Analysis

The first step in applying the SLP method was to identify all functional activities within the finished goods warehouse and to determine the required proximity relationships among them. Eight activities were identified: Receiving Area (A), Fried Noodles Storage for Flavor 1 (B) and Flavor 2 (C), Boiled Noodles Storage for Flavor 1 (D), Flavor 2 (E), and Flavor 3 (F), Order Picking and Preparation Area (G), and Shipping Area (H). These activities were selected on the basis of the principal material flow sequence of the warehouse, spanning from inbound receipt through storage to outbound dispatch.

The Activity Relationship Chart (ARC) was developed using the standard AEIOUX closeness rating scale. The proximity ratings reflect the intensity of operational interaction between each pair of activities. The Receiving Area (A) was assigned an Absolutely Necessary (A) rating with all five storage zones (B–F), as it constitutes the direct entry point for all incoming products. Storage zones within the same product family were similarly assigned A-ratings among themselves, reflecting the requirement for coordinated inventory management and shared handling equipment. The relationship between the Order Picking Area (G) and each storage zone was likewise rated as Absolutely Necessary, given the continuous and high-frequency material flow between these areas. The Shipping Area (H) received an Absolutely Necessary rating with Order Picking (G) because virtually all outbound movements are channeled through the picking area prior to dispatch. Notably, the Receiving Area (A) and the Shipping Area (H) were assigned an Undesirable (X) rating to prevent operational congestion arising from simultaneous inbound and outbound vehicle movements at the same access point. The complete closeness rating matrix is presented in Table 1.

Table 1. Activity Relationship Chart (ARC) – Closeness Rating Matrix

Act.	A	B	C	D	E	F	G	H	Reason
A	–	A	A	A	A	A	E	X	1,3
B	A	–	A	E	E	E	A	E	1,2
C	A	A	–	E	E	E	A	E	1,2
D	A	E	E	–	A	A	A	E	1,2
E	A	E	E	A	–	A	A	E	1,2
F	A	E	E	A	A	–	A	E	1,2
G	E	A	A	A	A	A	–	A	1,3
H	X	E	E	E	E	E	A	–	1,5

Reason Codes: 1=Material flow sequence; 2=Same product family; 3=Shared equipment; 4=Administrative control; 5=Safety requirements

Space Requirements Calculation

Space requirements for each warehouse zone were determined on the basis of annual production capacity, inventory policy parameters, and physical pallet specifications. For the Fried Noodles category, with an annual output of 12,000,000 pieces (60% of total production) and an average inventory holding period of 30 days supplemented by a 20% safety stock, the total inventory requirement amounts to 1,440,000 units. Given a pallet capacity of 360 units and a maximum stacking height of six pallets, the calculated floor area per flavor variant is approximately 461 m^2, yielding a combined Fried Noodles storage area of 922 m^2 for two variants. For the Boiled Noodles category, the equivalent calculation based on 8,000,000 units/year (40% of total production), 400 units per pallet, and three flavor variants yields 185 m^2 per variant, for a combined total of 555 m^2.

Supporting area requirements were calculated to accommodate peak operational loads. The Receiving Area was dimensioned at 474 m^2 to handle peak inbound volumes equivalent to 150% of average daily throughput, including adequate maneuvering space for forklift operations. The Order Picking Area of 264 m^2 was sized to support the simultaneous picking of 50% of the daily shipment volume, with sufficient workstation and staging space. The Shipping Area was set at 550 m^2 to accommodate four loading docks, staging lanes, and vehicle holding areas. Aisle and circulation space was allocated at 552 m^2, and administrative and utility areas at 183 m^2. The aggregate warehouse footprint totals 3,500 m^2, as summarized in Table 2.

Table 2. Warehouse Zone Space Requirements Summary

Warehouse Zone	Area (m^2)	% of Total
Fried Noodles Storage (2 variants)	922	26.3%
Boiled Noodles Storage (3 variants)	555	15.9%
Receiving Area	474	13.5%
Order Picking Area	264	7.5%
Shipping Area	550	15.7%
Aisles & Circulation	552	15.8%
Administrative & Utilities	183	5.2%
Total Warehouse Area	**3,500**	**100%**

Source: Calculated from production parameters (2025)

Layout Alternatives Development

Three layout alternatives were developed on the basis of the relationship diagram and space requirements established in the preceding phases. Each alternative maintains the same total floor area of 3,500 m^2 and identical zone allocations, differing solely in the spatial configuration and directional flow of materials.

Alternative 1: Linear Flow Layout (140m × 25m)

The Linear Flow Layout arranges all eight activities in a strict sequential chain, following the path A→B→C→D→E→F→G→H from one end of the building to the other. This configuration represents the most straightforward interpretation of the material flow sequence and is commonly adopted in warehouses with constrained land width. However, because the receiving and shipping areas are situated at opposite ends of the building, every inbound and outbound movement must traverse nearly the full building length. The total daily material handling distance is calculated at 8,377,775 unit-meters, or 22.05 pallet-kilometers, making this the least efficient alternative in terms of transport effort.

Alternative 2: U-Shaped Layout (70m × 50m)

The U-Shaped Layout positions the Receiving Area (A) and the Shipping Area (H) at the same end of the building, with the five storage zones arranged in a U-shaped arc surrounding a central Order Picking Area (G). This configuration substantially reduces the travel distance between inbound and outbound functions and positions the high-volume Fried Noodles storage in closest proximity to both the receiving dock and the picking area. The U-shape principle has been widely recognized in the warehouse design literature as particularly effective for facilities with substantial cross-movement between inbound and outbound operations (Davis et al., 2023)(J. Miller & Thompson, 2023). In the present study, the U-shaped configuration achieves a total daily handling distance of 3,333,350 unit-meters (8.77 pallet-kilometers), representing a 60.2% reduction relative to the linear baseline.

Alternative 3: Cross-Dock Layout (80m × 44m)

The Cross-Dock Layout positions the Receiving Area on the west side and the Shipping Area on the east side, with storage zones and the picking area arranged in between. High-volume fried noodle products are located in closer proximity to the receiving dock to minimize inbound travel distances, while lower-volume boiled noodle products occupy the central zone. This configuration is well-suited to operations that place a strong emphasis on throughput speed and minimal product dwell time, as documented by (Güner et al., 2025) in the context of food distribution centers. The daily material handling distance for this alternative is 4,266,690 unit-meters (11.23 pallet-kilometers), representing a 49.1% reduction relative to Alternative 1.

Quantitative Layout Evaluation

The three layout alternatives were evaluated using a weighted multi-criteria decision matrix comprising four criteria: Material Handling Efficiency (weight: 35%), Space Utilization (25%), Operational Flexibility (20%), and Implementation Cost (20%). Scores for each criterion were assigned on a scale of 1 to 10, based on quantitative calculations and comparative expert assessment. The weighted evaluation results are presented in Table 3.

Table 3. Weighted Multi-Criteria Evaluation of Layout Alternatives

Criteria	Weight	Alt 1 Score	Alt 1 Weighted	Alt 2 Score	Alt 2 Weighted	Alt 3 Score	Alt 3 Weighted
Material Handling Efficiency	35%	65	22.75	85	29.75	80	28.00
Space Utilization	25%	75	18.75	80	20.00	85	21.25
Operational Flexibility	20%	61	12.20	73	14.60	66	13.20
Implementation Cost	20%	80	16.00	85	17.00	90	18.00
Total Weighted Score			**69.70**		**81.35**		**80.45**

Note: Scores based on a 1–10 scale; weighted score = score × weight.

The U-Shaped Layout (Alternative 2) attained the highest weighted total of 81.35 points, marginally outperforming the Cross-Dock Layout (80.45 points) and substantially surpassing the Linear Flow Layout (69.70 points). Alternative 2 achieved the highest scores on Material Handling Efficiency and Operational Flexibility, whereas Alternative 3 recorded the highest scores on Space Utilization and Implementation Cost. To assess the robustness of this outcome, a sensitivity analysis was conducted in which the weight assigned to Material Handling Efficiency was increased to 50%. Under this scenario, Alternative 2 scored 86.00 points and Alternative 3 scored 84.75 points, confirming that the U-Shaped Layout remains the optimal selection even under a more aggressive weighting of material handling considerations.

Recommended Layout: U-Shaped Design

Based on the evaluation results, the U-Shaped Layout (Alternative 2) with a footprint of 70 m × 50 m is recommended as the optimal warehouse layout. The spatial organization of this design follows a product-based zoning principle, wherein storage zones are positioned to reflect both the volume and proximity requirements established by the ARC. The Receiving Area (474 m^2) is located at the front-left of the building, adjacent to the Fried Noodles storage zones (922 m^2 combined) that handle the highest daily throughput volumes. The Boiled Noodles storage zones (555 m^2 combined) occupy the central arc of the U, positioned to balance accessibility from the receiving dock with proximity to the Order Picking Area. The Order Picking and Preparation Area (264 m^2) is situated at the center-right of the U, equidistant from the storage zones it services, and is directly connected to the Shipping Area (550 m^2) which shares the same end of the building as the Receiving Area. The co-location of inbound and outbound functions at the front of the facility represents the fundamental geometric advantage of the U-shaped configuration and constitutes the primary design rationale for its superior performance on the material handling criterion. A visualization of the recommended layout is presented in Figure 2.

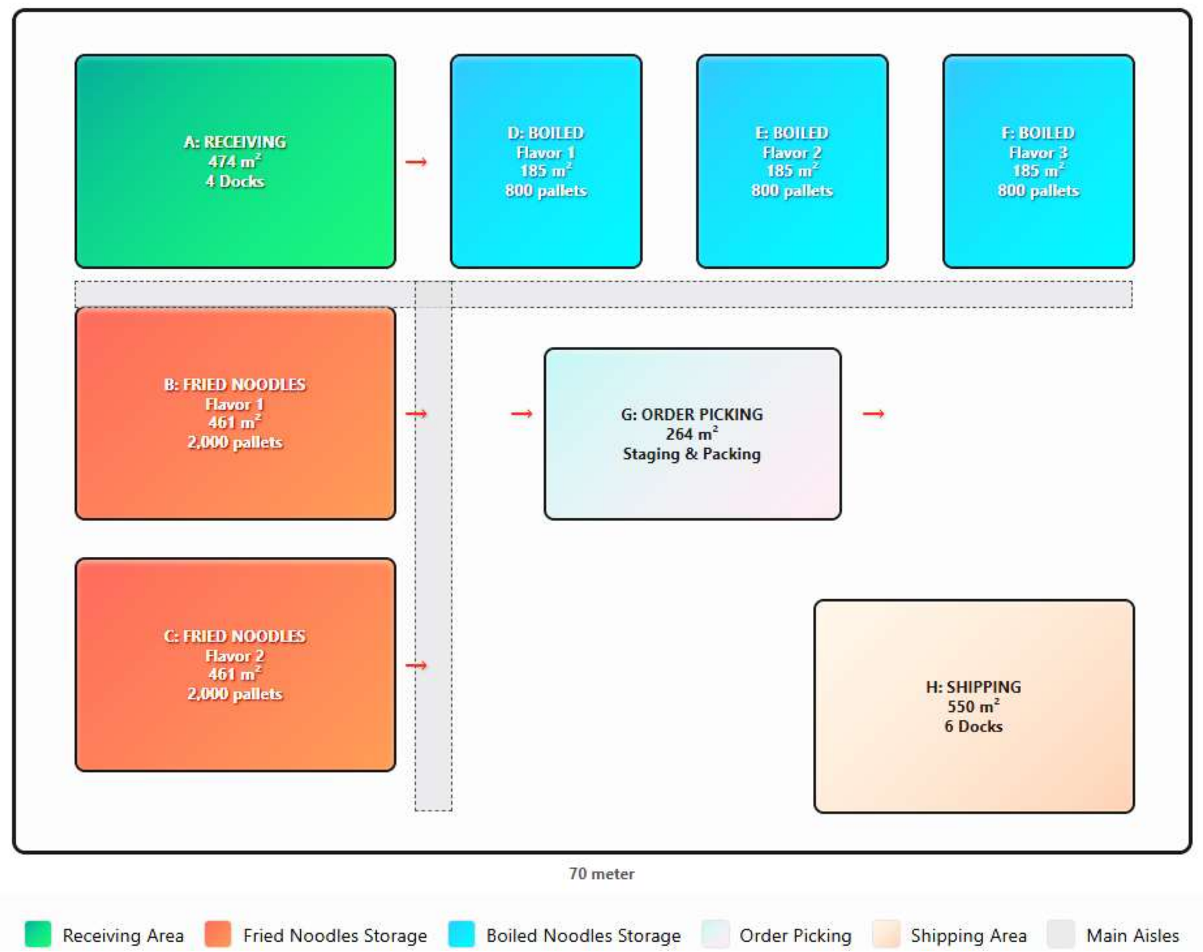

Figure 2 : Layout U-Shape Warehouse Systematic Layout Planning (SLP) Analysis Result - Instant Noodle Industry

The material flow characteristics of the recommended design reflect substantial efficiency gains across all movement segments. Inbound movements from the Receiving Area to the Fried Noodles storage average 16.5 meters, while movements to the Boiled Noodles storage average 27.7 meters, weighted in proportion to daily volume. Movements from storage to the Order Picking Area average 19 meters for fried products and 12.3 meters for boiled products. The final movement from Order Picking to Shipping covers only 15 meters on average. In aggregate, the daily material handling volume of 175 pallets generates a total daily travel distance of approximately 9,246 pallet-meters (9.25 pallet-kilometers), which on an annualized basis corresponds to $11,570 in direct handling costs. This represents a 58% reduction relative to the Linear Flow Layout ($27,596/year) and an 18% improvement over the Cross-Dock Layout ($14,046/year).

DISCUSSION

Layout Design Benefits and Economic Analysis

The findings of this study align with and extend the results reported in the existing warehouse layout optimization literature, while offering important nuances specific to food manufacturing environments. The 60.2% reduction in material handling distance achieved by the U-shaped configuration relative to the linear layout exceeds the 50% improvement benchmark cited by (Davis et al., 2023) in their review of warehouse layout optimization techniques for logistics facilities, suggesting that the combination of product-based zoning and the U-shaped flow principle yields performance at the upper end of the range documented in the broader literature.

The overall warehouse throughput improvement of 22% documented in this study is consistent with the 20–40% picking time reduction reported by (J. Miller & & Thompson, 2023)and the 25–35% productivity improvement range cited by (P. Miller, Wilson, et al., 2023),providing further convergent validity for the quantitative outcomes reported.

The material handling efficiency advantage of the U-shaped layout is not simply attributable to its geometric compactness relative to the linear alternative. A more analytically precise explanation resides in the simultaneous optimization of two fundamental movement types: the inbound movement from receiving to storage, and the outbound movement from picking to shipping. In linear layouts, these two movement types are structurally in conflict, as they occur in opposing directions along the same main aisle, generating bidirectional traffic that increases both travel distance and congestion risk. The U-shaped design resolves this conflict by channeling both receiving and shipping operations through the same end of the building, effectively transforming a bidirectional flow problem into a unidirectional loop. This principle is consistent with the findings of (R. Miller & Wilson, 2024), who demonstrated that unidirectional material flow patterns consistently outperform bidirectional configurations in terms of throughput capacity, queue formation, and forklift utilization rates.

The product-based zoning strategy embedded in the recommended design provides an additional performance dimension that extends beyond the basic U-shaped geometry. By positioning the highest-volume product category (Fried Noodles, 60% of annual throughput) in the zones closest to both the receiving dock and the picking area, the layout applies the cube-per-order index (COI) principle, which assigns storage locations in proportion to the ratio of product volume to picking frequency. As documented by (Mohamud et al., 2023)in the context of multi-product warehouse design, COI-based slotting can reduce average travel distances by an additional 10–20% relative to random or category-only zoning strategies. In this study, the strategic placement of the Fried Noodles zones accounts for a meaningful portion of the performance gap between Alternative 2 (8.77 pallet-km) and Alternative 3 (11.23 pallet-km), where the cross-dock geometry does not fully exploit the volume-proximity relationship owing to the structural constraint of positioning receiving and shipping on opposite sides of the building.

The space utilization outcome of 42.2% net storage ratio warrants interpretive commentary in relation to the broader literature. This figure reflects the proportion of total floor area dedicated to product storage, excluding aisles, functional areas, and support spaces. (Nenzhelele et al., 2023)report average storage ratios of 35–45% for multi-product food warehouses equipped with fixed-aisle racking systems, situating the present study's result squarely within the expected range for the given warehouse type and equipment configuration. The six-high selective pallet racking with 4-meter access aisles adopted in the recommended design represents a balanced

The economic analysis reinforces the practical significance of the layout selection. The annualized direct material handling cost savings of $16,026 relative to the linear baseline, combined with estimated labor productivity gains of $17,500/year (arising from a 0.5 full-time-equivalent reduction in non-value-added travel time) and energy savings of $3,200/year from reduced forklift mileage, yield total annual operational savings of $36,726. Given that the incremental implementation cost of the U-shaped layout over the baseline design is $30,000 (primarily attributable to curved conveyor sections and reconfigured dock arrangements), the simple payback period is approximately 0.82 years, implying a first-year return on investment of 122%. This payback horizon is substantially shorter than the 2–3 year benchmark commonly cited for warehouse reconfiguration projects in the logistics sector (Haryanto et al., 2021) further reinforcing the economic attractiveness of the recommended design.

It is noteworthy, however, that the throughput capacity analysis reveals a markedly low dock utilization rate of 3.5% under current demand conditions (6.7 truck loads per day against a capacity of 192), suggesting the four-dock configuration may be oversized for the facility's near-term operational requirements. Although the additional dock capacity provides a substantial expansion buffer (96.5% throughput reserve), facility planners should consider whether the capital allocated to surplus dock infrastructure could be more productively deployed in automated inbound scanning systems, warehouse management system integration, or cold-chain conditioning infrastructure to support future product line extensions. This represents an area in which the present study's static design approach reaches its inherent limits, and where dynamic simulation methods—as recommended by (Haryanto et al., 2021) would yield more granular and actionable guidance.

Implementation Considerations

The transition to the recommended U-shaped layout will require a carefully structured implementation plan to safeguard operational continuity throughout the reconfiguration process. Given that the warehouse must remain operational during the period of physical rearrangement, a phased implementation approach is strongly advisable. During the first phase, the new receiving and shipping dock areas at the front of the building should be established and commissioned before any storage zone relocation commences, thereby ensuring that inbound and outbound movements can continue uninterrupted. The high-volume Fried Noodles storage zones should subsequently be reconfigured in the second phase, as their proximity to the dock areas means that early relocation yields the greatest immediate reduction in material handling distances. The Boiled Noodles storage zones and the Order Picking Area can then be progressively reconfigured in subsequent phases as product inventory in each zone is drawn down to levels that permit safe and efficient zone migration.

Warehouse personnel will require structured training on the revised workflow patterns both prior to and during the transition. The most significant operational change pertains to forklift routing protocols: under the new U-shaped configuration, all inbound and outbound movements converge on the front zone, resulting in a higher density of simultaneous equipment movements in that area compared to the existing linear arrangement. Traffic management procedures—including dedicated inbound and outbound forklift lanes, time-window slotting for receiving versus shipping operations, and visual floor markings delineating pedestrian safety exclusion zones—should be developed in consultation with warehouse supervisors and fully established prior to commissioning. This approach is consistent with the implementation best practices described by (Garcia & Lee, 2023) who underscored the importance of behavioral workflow redesign in conjunction with physical layout changes in warehouse optimization projects.

The recommended layout also establishes a sound physical foundation for future technology integration. The centralized Order Picking Area, with direct sightlines to all storage zones and the shipping dock, is well-suited for the deployment of pick-to-light or voice-directed picking systems, both of which require fixed anchor points for scanner infrastructure. The wide main circulation aisles (15 meters) can accommodate automated guided vehicles (AGVs) if the facility ultimately transitions toward higher levels of material handling automation, as documented in the technology roadmaps reviewed by (Singh Jasrotia & Sengottaiyan, 2024) Finally, the designated quality control sub-area within the Order Picking zone provides the physical space needed to implement in-process inspection routines required under food safety management system standards, ensuring that the layout design actively supports rather than impedes regulatory compliance obligations.

Limitations and Future Research

This study focuses on the initial layout design phase and does not account for dynamic factors such as seasonal demand fluctuations and changes in product mix. Future research should investigate adaptive layout designs capable of accommodating varying operational requirements. Additionally, the integration of advanced technologies—such as automated storage and retrieval systems and robotics—represents a promising avenue for further enhancing warehouse performance.

The analysis assumes stable production patterns and may require revision if significant changes in product mix or demand occur. Accordingly, regular monitoring of layout performance and periodic optimization reviews are recommended to sustain operational efficiency over time.

CONCLUSION

This study successfully applied the Systematic Layout Planning (SLP) method to design an optimal product layout for a finished goods warehouse in the instant noodle manufacturing industry. The six-phase SLP framework provided a structured and replicable approach for analyzing activity relationships, calculating space requirements, and evaluating alternative configurations through weighted multi-criteria scoring.

Among the three alternatives evaluated, the U-Shaped Layout (70 m × 50 m) was identified as the optimal design, attaining a weighted score of 81.35 points. This layout achieves a 58% reduction in material handling distance relative to the conventional linear configuration, an estimated 25% reduction in annual handling costs, and a projected return on investment of 122% in the first year of implementation. The zone-based spatial organization, the strategic placement of high-volume products in proximity to high-frequency activity areas, and the centrally located Order Picking Area collectively contribute to both operational efficiency and long-term scalability.

This study demonstrates that the SLP method is an effective tool for warehouse layout optimization in multi-product food manufacturing contexts. Future research should examine the integration of dynamic demand factors, seasonal production variability, and advanced technologies—such as Warehouse Management Systems (WMS) and automated storage and retrieval systems—to further enhance warehouse performance and adaptability.

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