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Integrated MRP and Wagner-Whitin Planning for Vehicle Cargo-Body Materials

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Abstract. PT. XYZ is a vehicle-body manufacturer producing four cargo-body variants and experiencing a persistent mismatch between growing demand and material readiness. This study develops an integrated material-planning framework that combines trend forecasting, production planning, a Master Production Schedule (MPS), Material Requirements Planning (MRP), and a cost comparison between Lot for Lot (LFL) and the Wagner–Whitin algorithm. The dataset covers monthly sales and production from January 2024 to December 2025, bills of material, beginning inventory, supplier lead times, and company-provided inventory-cost parameters. Holt's double exponential smoothing with α=0.3 and β=0.2 achieved a mean absolute percentage error of 2.50%, a mean absolute deviation of 0.737 units, and a mean squared error of 0.902. The 2026 demand forecast totaled 680 units and was consistently disaggregated among the four product variants. MRP generated time-phased gross requirements, net requirements, planned-order receipts, and planned-order releases. Under the company's cost-accounting scope, Wagner–Whitin reduced total cost from IDR 330.40 million to IDR 271.29 million, saving IDR 59.11 million (17.89%). When the invariant finished-product component was excluded, the lot-sizing-sensitive cost decreased by 67.53%. The results indicate that combining MRP with dynamic lot sizing can improve material-timing reliability and inventory-cost efficiency, particularly for stable-demand items with relatively high ordering costs.

Keyword: *Material Requirements Planning, Wagner–Whitin, Holt forecasting, lot sizing, PPIC.*

A. INTRODUCTION

Production planning and inventory control are central to manufacturing competitiveness because demand, capacity, and material availability must be synchronized before shop-floor execution begins. Modern manufacturing systems increasingly require integrated planning rather than isolated purchasing decisions (Gola, 2025). This need is especially pronounced in mixed make-to-order and make-to-stock environments, where product variety and customer-specific timing create a shifting decoupling point between forecast-driven and order-driven activities (Renna, 2024). In vehicle-body manufacturing, a missing structural or finishing component can stop welding, assembly, painting, or final inspection, thereby propagating delays across the entire order portfolio.

PT. XYZ manufactures four vehicle cargo-body variants: Panther, Futura Carry, Mitsubishi, and Suzuki APV. Historical records show that sales increased from 17 units in January 2024 to 48 units in December 2025. During the same 24-month period, cumulative sales reached 790 units, whereas cumulative production reached only 730 units, producing a 60-unit shortfall and an average monthly gap of 2.5 units. The problem was not limited to demand volatility; production records indicated repeated shortages associated with delayed or insufficient raw-material availability. Supplier lead times varied from 3 to 10.5 days, and the company had no fully time-phased material-planning procedure that linked demand forecasts, product structures, existing inventory, and procurement timing.

Demand forecasting provides the first quantitative input to production planning. For nonseasonal series with a sustained trend, Holt's double exponential smoothing is parsimonious because it updates both level and trend without introducing a seasonal component (Lesmana, 2023; Segerstedt, 2006; Utami, 2017). Forecasts must subsequently be translated into an aggregate plan and an MPS so that product-level production quantities are explicit (Imansuri, 2024; Pekarcikova, 2025). MRP then explodes the MPS through the bill of material, nets requirements against available inventory, and offsets planned releases by lead time. Previous studies have demonstrated the usefulness of MRP in aviation components, food production, construction materials, and small manufacturing enterprises (Abdillah, 2023; K. F. Firdaus, 2024; R. Firdaus, 2025; Khairani, 2023; Rani, 2025). However, many applications stop after generating net requirements and do not critically evaluate the lot-sizing policy applied to time-varying demand.

LFL minimizes cycle inventory by ordering exactly the net requirement in each period, but it may generate excessive order frequency. In contrast, the Wagner–Whitin algorithm uses dynamic programming to minimize the sum of setup or ordering costs and inventory-holding costs over a finite deterministic horizon (Katias, 2018; Wagner, 1958). The method is particularly relevant when ordering costs are large relative to holding costs and future requirements are known with reasonable accuracy. Its benefits have been reported in inventory-management applications, although operational feasibility still depends on storage capacity, supplier reliability, and the stability of cost parameters (Katias, 2018).

The contribution of this study is an integrated PPIC framework for a multi-variant vehicle cargo-body manufacturer. The framework combines: (i) trend-sensitive demand forecasting, (ii) aggregate production planning, (iii) product-mix disaggregation with an exact monthly balance, (iv) BOM-based MRP and material pegging, and (v) a two-level cost interpretation that distinguishes total reported cost from the cost component actually influenced by lot sizing. This distinction prevents an invariant finished-product cost from diluting the observed effect of the inventory policy. The study therefore aims to develop a time-phased material plan for 2026 and determine whether Wagner–Whitin offers a meaningful economic advantage over LFL.

B. METHOD

1. Research Design and Data

This applied quantitative case study was conducted at PT. XYZ, an anonymized vehicle-body manufacturer in Purwakarta, Indonesia. The planning horizon was January–December 2026. Primary and secondary company data comprised monthly sales and production for January 2024–December 2025, four product structures, twelve shared raw-material groups, beginning inventory, safety stock, ordering cost, holding cost, and supplier lead time. The analysis assumed deterministic bills of material and fixed cost parameters within the annual horizon. Lead-time information was retained as a procurement-timing parameter, while the cost comparison followed the cost definitions supplied by the company.

Table 1. Research Data and Planning Scope

Input	Coverage	Description
Demand history	24 monthly observations	January 2024–December 2025
Planning horizon	12 monthly periods	January–December 2026
Finished products	4 variants	Panther, Futura Carry, Mitsubishi, Suzuki APV
Raw materials	12 groups	Structural steel, finishing materials, hardware, welding consumables
Supplier lead time	3–10.5 days	Company procurement records
Lot-sizing policies	2 alternatives	Lot for Lot and Wagner–Whitin

2. Analytical Procedure

The analytical sequence is shown in Figure 1. Historical data were first checked for trend and seasonality. The selected forecast was then used to construct the aggregate plan and MPS. Product-level quantities were exploded through the BOM, netted against available inventory, and evaluated under alternative lot-sizing rules. The final stage compared total and lot-sizing-sensitive costs and translated the results into implementation recommendations.

Figure 1. Integrated Forecasting–MPS–MRP–Lot-Sizing Procedure

3. Holt's Double Exponential Smoothing

The demand series exhibited an upward trend without a recurring seasonal pattern. Holt's method was therefore applied with level-smoothing parameter $\alpha=0.3$ and trend-smoothing parameter $\beta=0.2$. The parameters were selected by trial and error to minimize in-sample percentage error. The level, trend, and h-step-ahead forecasts were calculated as follows:

$$L_t = \alpha Y_t + (1-\alpha)(L_{t-1} + T_{t-1}) \quad (1)$$

$$T_t = \beta(L_t - L_{t-1}) + (1-\beta)T_{t-1} \quad (2)$$

$$F_{t+h} = L_t + hT_t \quad (3)$$

Forecast accuracy was assessed using mean absolute deviation (MAD), mean squared error (MSE), and mean absolute percentage error (MAPE). The first observation was used for initialization and excluded from error averaging. A MAPE below 10% was interpreted as highly accurate for the operational planning purpose of this study (Asfan, 2024; Utami, 2017).

4. Aggregate Planning and Master Production Schedule

The aggregate plan used a level-strategy structure with regular production of 45 units per month and a stable core workforce of five employees. Monthly capacity gaps were covered by overtime and subcontracting in the company model. The annual forecast was disaggregated using historical product-mix proportions: 15.95% Panther, 43.92% Futura Carry, 18.23% Mitsubishi, and 21.90% Suzuki APV. Because direct rounding in the thesis draft produced monthly totals that did not always equal the aggregate forecast, this manuscript applies the largest-remainder method. This adjustment preserves the product-mix proportions while ensuring that every monthly MPS exactly equals the forecast total.

5. Material Requirements Planning

The MPS served as the level-0 requirement. Gross material requirements were obtained by multiplying planned finished-product quantities by the usage quantity in the corresponding BOM and aggregating shared materials through pegging. Net requirements were computed after considering scheduled receipts, beginning inventory, and safety stock. The general netting equation was:

$$NR_t = \max\{0, GR_t + SS - SR_t - POH_{t-1}\} \quad (4)$$

where NR_t is net requirement, GR_t is gross requirement, SS is safety stock, SR_t is scheduled receipt, and POH_{t-1} is projected on-hand inventory from the preceding period. Planned-order receipts were determined by the selected lot-sizing rule, and planned-order releases were offset by the supplier lead time. Because the planning bucket was monthly while supplier lead times were less than one-month, operational implementation should release orders within the preceding month according to the exact day-based lead time.

6. Lot-Sizing Cost Evaluation

Under LFL, the planned-order receipt in each period equals the net requirement. The Wagner–Whitin model evaluates the cost of placing an order in period c to cover requirements through period e. The variable cost is expressed as:

$$Z(c,e) = S + H \Sigma^{e}_{t=c} (t-c)D_t \quad (5)$$

where S is ordering cost, H is the unit holding cost per period, and D_t is the net requirement in period t. Dynamic programming identifies the minimum cumulative cost for each terminal period, followed by backtracking to recover the optimal order periods (Wagner, 1958). Two percentages were reported: the reduction in the company's total-cost table and the reduction in the lot-sizing-sensitive cost after excluding the finished-product component that was identical under both alternatives.

C. RESULT AND DISCUSSION

1. Demand Pattern and Forecast Accuracy

Figure 2 shows a clear upward demand trajectory. Sales rose by 182.35% between the first and last observations, while a linear trend fitted to the 24-month sales series increased by approximately 1.30 units per month. Production generally followed the same direction but remained below sales in 23 of the 24 periods. The cumulative shortfall of 60 units confirms that the planning problem was persistent rather than an isolated monthly deviation.

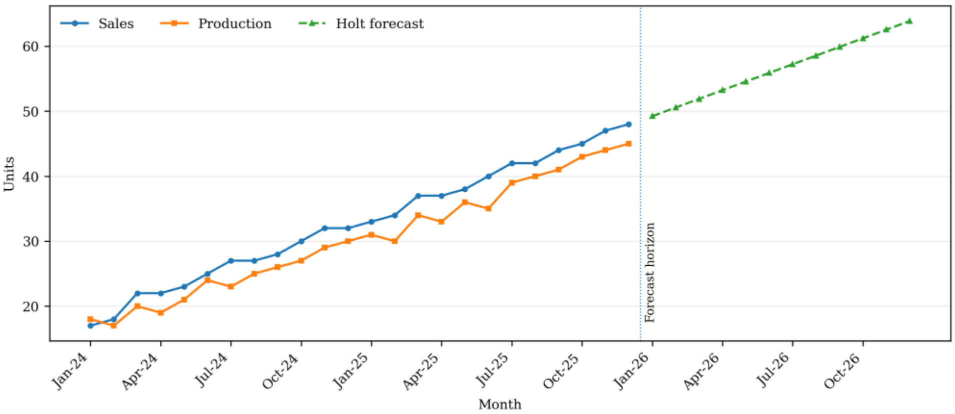

Figure 2. Historical sales, production, and the 2026 Holt forecast

The recalculated in-sample error measures were MAD=0.737 units, MSE=0.902, and MAPE=2.50%. These values are internally consistent with the period-by-period error table in the thesis and replace the inconsistent 6.85% value that appeared in several narrative sections of the draft. A low MAPE indicates that the model captured the dominant trend without requiring a seasonal term. The raw forecast increased from 49.23 units in January 2026 to 63.87 units in December 2026. After integer rounding, the annual demand totaled 680 units.

Table 2. Monthly 2026 Demand Forecast

No.	Period	Holt Forecast	MPS Demand (Units)
1	Jan-26	49.23	49
2	Feb-26	50.56	51
3	Mar-26	51.89	52
4	Apr-26	53.23	53
5	May-26	54.56	55
6	Jun-26	55.89	56
7	Jul-26	57.22	57
8	Aug-26	58.55	59
9	Sep-26	59.88	60

10	Oct-26	61.21	61
11	Nov-26	62.54	63
12	Dec-26	63.87	64

2. Aggregate Plan and Product-Level MPS

The aggregate forecast rises gradually from 49 to 64 units per month. A level regular-production rate of 45 units therefore requires complementary overtime and subcontracting, particularly in the second half of the year. The product mix is dominated by Futura Carry, which accounts for 299 of the 680 planned units. The corrected MPS in Table 3 exactly matches every monthly aggregate demand value and avoids the two-unit annual imbalance present in the original direct-rounding table.

Table 3. Corrected Product-Level Master Production Schedule for 2026

Product	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Panther	8	8	8	8	9	9	9	9	10	10	10	10	108
Futura Carry	21	23	23	23	24	25	25	26	26	27	28	28	299
Mitsubishi	9	9	10	10	10	10	10	11	11	11	11	12	124
Suzuki APV	11	11	11	12	12	12	13	13	13	13	14	14	149
Monthly total	49	51	52	53	55	56	57	59	60	61	63	64	680

The exact monthly balance is important because MRP is demand-driven: an MPS discrepancy is multiplied by BOM usage quantities and can create sizable material errors at lower levels. The corrected allocation yields annual quantities of 108 Panther bodies, 299 Futura Carry bodies, 124 Mitsubishi bodies, and 149 Suzuki APV bodies. The dominance of Futura Carry also creates a product-mix concentration risk; procurement contracts for materials heavily used by this variant should receive priority in supplier-capacity planning.

3. MRP Implications

The MRP explosion produced time-phased gross requirements, net requirements, planned-order receipts, and planned-order releases for twelve shared material groups. Positive net requirements appeared in most periods, demonstrating that beginning inventory alone could not support the rising schedule. Structural items—especially galvanized hollow sections, galvanized sheet, checkered plate, and UNP channel—generated high cumulative requirements because their usage quantities were multiplied across all four product variants. Finishing materials and hardware had smaller physical quantities but were operationally critical because a shortage could block painting, door installation, or final completion.

From a PPIC perspective, the principal value of the MRP output is timing rather than merely annual quantity. Supplier lead times ranged from 3 to 10.5 days. Consequently, planned-order releases should be translated from monthly buckets into dated purchase requisitions within the preceding month. A rolling update is also required: actual customer orders should replace forecast quantities inside the demand time fence, while the forecast can remain the primary input outside the frozen zone. This practice reduces schedule nervousness while maintaining responsiveness.

4. Cost Performance of LFL and Wagner–Whitin

Table 4 summarizes the cost comparison. Under the company's original accounting scope, LFL generated IDR 330.40 million, whereas Wagner–Whitin generated IDR 271.29 million. The absolute saving was IDR 59.11 million, equivalent to 17.89% of the reported LFL total. The finished-product component of IDR 242.88 million was identical under both policies and therefore did not influence the lot-sizing decision. When this invariant component is excluded, the controllable material-planning cost falls from IDR 87.52 million to IDR 28.41

million, a reduction of 67.53%. This second percentage more clearly reflects the economic effect of the lot-sizing policy.

Table 4. Inventory-Cost Comparison by Item Group

Item group	LFL cost	Wagner–Whitin cost	Saving	Saving (%)
Finished products (4 variants)	IDR 242,880,000.00	IDR 242,880,000.00	IDR 0.00	0.00%
Compound	IDR 3,244,518.99	IDR 2,400,000.00	IDR 844,518.99	26.03%
Thinner	IDR 2,070,624.76	IDR 503,952.00	IDR 1,566,672.76	75.66%
Top-coat paint	IDR 5,373,436.23	IDR 1,348,118.40	IDR 4,025,317.83	74.91%
Primer epoxy	IDR 4,753,910.28	IDR 1,200,048.00	IDR 3,553,862.28	74.76%
Polyester putty	IDR 3,438,734.18	IDR 1,140,000.00	IDR 2,298,734.18	66.85%
Hollow 40×40×1.6	IDR 5,893,968.07	IDR 1,523,318.40	IDR 4,370,649.67	74.15%
Hollow 30×30×1.6	IDR 3,649,600.71	IDR 920,356.80	IDR 2,729,243.91	74.78%
Checkered plate	IDR 17,422,500.00	IDR 5,760,000.00	IDR 11,662,500.00	66.94%
Galvanized sheet	IDR 15,456,084.92	IDR 3,964,843.20	IDR 11,491,241.72	74.35%
UNP channel	IDR 4,527,502.53	IDR 4,223,760.00	IDR 303,742.53	6.71%
4-mm hinges	IDR 12,341,950.56	IDR 3,112,089.60	IDR 9,229,860.96	74.78%
Welding wire	IDR 9,349,541.77	IDR 2,318,400.00	IDR 7,031,141.77	75.20%
TOTAL	**IDR 330,402,373.00**	**IDR 271,294,886.40**	**IDR 59,107,486.60**	**17.89%**

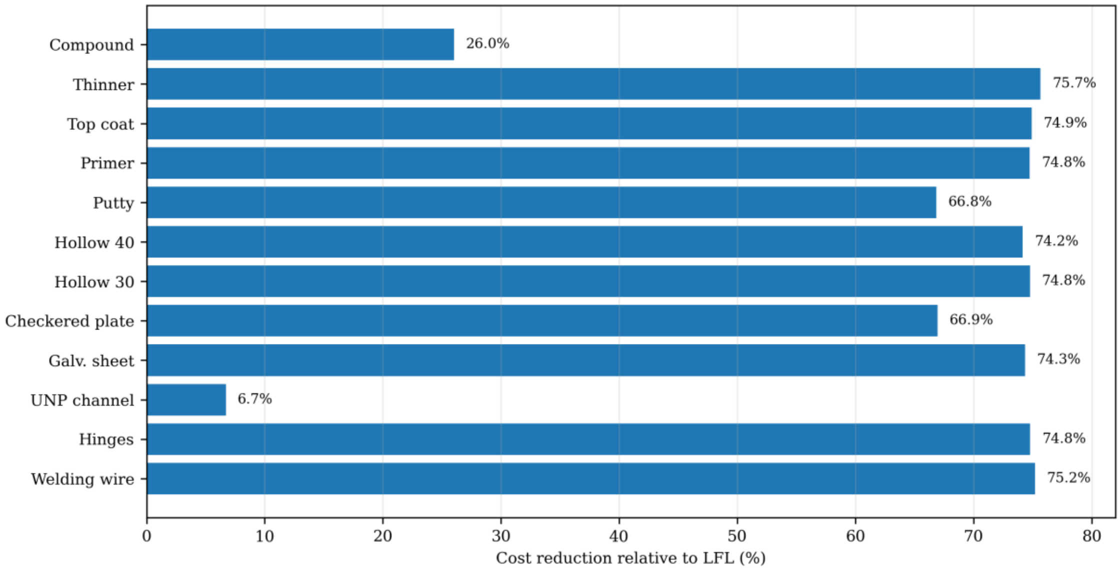

Figure 3. Material-Level Cost Reduction Under Wagner–Whitin

The highest reductions were observed for thinner (75.66%), welding wire (75.20%), hollow 30×30 (74.78%), hinges (74.78%), primer epoxy (74.76%), top-coat paint (74.91%), and galvanized sheet (74.35%). These items share a cost structure in which repeated ordering is expensive relative to carrying inventory. Compound showed a moderate reduction of 26.03%, whereas UNP channel produced only 6.71%. For the latter item, the flexibility of LFL may outweigh the small theoretical saving, especially when storage space, handling risk, or schedule uncertainty is considered. The results support a selective rather than universal implementation of Wagner–Whitin.

The findings are consistent with the theoretical logic of dynamic lot sizing and with applied Wagner–Whitin studies reporting savings when ordering costs dominate holding costs (Katias, 2018; Wagner, 1958). Nevertheless, mathematical optimality is conditional. The model assumes deterministic requirements and stable costs, whereas real procurement may face quantity discounts, minimum order quantities, supplier capacity limits, material deterioration, and demand revisions. Moreover, the company-provided ordering-cost values should be decomposed in future implementation into administration, freight, receiving, inspection, and transaction components. Such validation is essential because an overstated ordering cost will bias Wagner–Whitin toward large consolidated orders.

5. Managerial Implications and Study Limitations

The proposed framework can be implemented in a spreadsheet or integrated PPIC system using a monthly rolling horizon. Forecast accuracy should be reviewed every month, the MPS should be frozen for the near-term procurement window, and supplier lead times should be updated from actual delivery performance. Materials with savings above approximately 65% are strong candidates for dynamic lot sizing, subject to warehouse and cash-flow constraints. Materials with low savings should retain LFL or a short coverage policy to preserve flexibility. This classification translates the optimization output into an operational rule that purchasing and warehouse personnel can apply without rerunning every scenario manually.

The study has four main limitations. First, the forecast is a point estimate and does not explicitly model forecast-error distributions. Second, supplier lead times and cost parameters are treated as fixed. Third, capacity constraints are handled at the aggregate level and are not embedded in the Wagner–Whitin recursion. Fourth, the research uses a single-company case, limiting statistical generalization. Future research should incorporate stochastic lead times, service-level-based safety stock, warehouse capacity, cash-flow constraints, and rolling-horizon simulation. A comparison with Silver–Meal, Part-Period Balancing, or capacitated lot-sizing models would also strengthen policy selection.

D. CONCLUSION

This study developed an integrated PPIC approach for planning vehicle cargo-body materials at PT. XYZ. Holt's double exponential smoothing captured the nonseasonal upward demand trend with a recalculated MAPE of 2.50%, MAD of 0.737 units, and MSE of 0.902. The resulting 2026 forecast totaled 680 units. After correcting product-mix rounding, the MPS allocated 108 Panther, 299 Futura Carry, 124 Mitsubishi, and 149 Suzuki APV units while preserving exact monthly totals. BOM explosion and MRP converted the schedule into time-phased gross requirements, net requirements, planned-order receipts, and lead-time-offset releases. Under the company's reported cost scope, Wagner–Whitin reduced total cost by IDR 59.11 million, or 17.89%, compared with LFL. Excluding the invariant finished-product component, the cost influenced by lot sizing decreased by 67.53%. Wagner–Whitin is therefore recommended selectively for stable-demand materials with high ordering costs, while LFL remains appropriate for low-saving or operationally uncertain items. The framework can improve material availability and cost control, but practical adoption requires validated ordering-cost components, rolling forecast updates, supplier-performance data, and explicit checks on storage and working-capital capacity.

REFERENCES

Abdillah, G. (2023). Pengendalian persediaan main wheel ATR 72 dengan metode MRP pada PT Trans Nusa. *Jurnal E-Bis*, *7*(1), 48–60. https://doi.org/10.37339/e-bis.v7i1.1179

Asfan, D. F. (2024). Forecasting analysis of raw material needs for manjakani and pepet key in the manufacture of Madurese herb products. *PROZIMA*, *8*(1), 35–45. https://doi.org/10.21070/prozima.v8i1.1689

Firdaus, K. F. (2024). Analisis pengendalian persediaan bahan baku menggunakan metode material requirement planning (MRP) pada Risma Brownies & Cake Gemolong. *Jurnal Riset Manajemen dan Ekonomi*, *2*(3), 226–248. https://doi.org/10.54066/jrime-itb.v2i3.2133

Firdaus, R. (2025). Perencanaan bahan baku sosis menggunakan metode material requirement planning (MRP) di PT RF. *Jurnal Teknik Industri Terintegrasi*, *8*(4), 3811–3821. https://doi.org/10.31004/jutin.v8i4.48457

Gola, A. (2025). Manufacturing systems operations and engineering. *Applied Sciences*, *15*(9). https://doi.org/10.3390/app15094617

Imansuri, F. (2024). Perencanaan agregat produksi tiang besi dengan pola permintaan musiman. *JISI: Jurnal Integrasi Sistem Industri*, *11*(2), 203–212. https://doi.org/10.24853/jisi.11.2.203-212

Katias, P. (2018). Implementasi algoritma Wagner–Whitin pada manajemen inventori di PT X. *Business and Finance Journal*, *3*(1), 63–76. https://doi.org/10.33086/bfj.v3i1.420

Khairani, W. (2023). Penerapan metode material requirement planning (MRP) dalam perencanaan persediaan kopi. *TIN: Terapan Informatika Nusantara*, *4*(7), 464–473. https://doi.org/10.47065/tin.v4i7.4676

Lesmana, N. Y. A. (2023). Analisis permintaan tas anak di UD Wijaya menggunakan metode peramalan time series. *Jurnal Teknik Industri*, *9*(2), 403–414. https://doi.org/10.24014/jti.v9i2.22745

Pekarcikova, M. (2025). Master production schedule in the consumer product goods industry: Benefits of APS applications. *Applied Sciences*, *15*(3). https://doi.org/10.3390/app15031642

Rani, H. A. (2025). Optimization of construction material inventory using material requirement planning. *Jurnal Linears*, *8*(1). https://doi.org/10.26618/j-linears.v8i1.17116

Renna, P. (2024). Comparison of dynamic decoupling point and dynamic buffer level for flexible flow shops in a hybrid MTS–MTO production model. *Applied Sciences*, *14*(17). https://doi.org/10.3390/app14177975

Segerstedt, A. (2006). Master production scheduling and a comparison of material requirements planning and cover-time planning. *International Journal of Production Research*, *44*(18–19), 3585–3606. https://doi.org/10.1080/00207540600622498

Utami, R. (2017). Perbandingan metode Holt exponential smoothing dan Winter exponential smoothing untuk peramalan penjualan souvenir. *Jurnal Ilmiah Teknologi Informasi Asia*, *11*(2), 123–132. https://doi.org/10.32815/jitika.v11i2.191

Wagner, H. M. (1958). Dynamic version of the economic lot size model. *Management Science*, *5*(1), 89–96.