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Evaluation of Supplier Performance at PT. XYZ Using a Combined Method of Purchasing Portofolio Matrix (PPM) and Supplier Potential Matrix (SPM)

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ABSTRACT

The FMCG manufacturing industry faces complex challenges in the supply chain, where supplier performance evaluation is a crucial factor in maintaining production continuity. PT XYZ currently conducts supplier evaluations in a general manner without considering specific segmentation, making it less effective in identifying strategic suppliers and managing risks. The Purchasing portfolio matrix classifies raw materials into strategic, leverage, bottleneck and non-critical groups based on supply risk and profit impact. Meanwhile, the Supplier Potential Matrix (SPM) adds the dimensions of supplier capability and willingness in innovation and collaboration. The combination of these two methods can enhance the effectiveness of supplier evaluation, support procurement strategies, and ensure more optimal business relationships. The weighting of each criterion will be carried out using the Best-Worst Method. Next, the scoring process is conducted based on 13 agreed criteria for each evaluated supplier, totaling 148 suppliers. The results of data processing will be used for segmentation using a hybrid PPM-SPM model. Recommendations are provided for selecting the appropriate supplier relationship management strategy for each supplier segment.

INTRODUCTION

Fast-Moving Consumer Goods (FMCG) manufaturing industry faces complex operational challenges where the success of production processes cannot rely solely on one party. These processes involve cross-functional coordination, from production planning to distribution, demanding close collaboration between internal teams and external suppliers.

One critical aspect of supply chain management is supplier performance evaluation. It is known that companies allocate nearly 60% of their operational funds to procure raw materials to support production processes (Bai, Rezaei, and Sarkis 2017). Suppliers hold a crucial position at the beginning of the supply chain, significantly influencing the smooth continuation activities of the production (Muhammad, Syarawy, and Fahreza 2024). Supplier performance evaluation not only helps companies select the right partners but also supports strategic decision-making for the long term (Drake, Myung Lee, and Hussain 2013). Conversely, suppliers that do not meet performance standards can disrupt the supply chain (Rahayu, Wiyatno, and Romli 2021).

In supplier performance evaluation, supplier segmentation becomes necessary when the supplied raw materials have diverse characteristics and types. Evaluating suppliers through segmentation is a key strategy to ensure effective business relationships. Supplier segmentation is conducted after the selection process and before supplier relationship management (Drake, Myung

Lee, and Hussain 2013). Effective execution is crucial in supply chain management, as failure can result in losses such as wasted time, increased costs, and partnerships with unsuitable suppliers (Hallikas et al. 2005).

However, challenges arise when supplier performance evaluations are conducted without adequate segmentation methods. Currently, PT XYZ performs general evaluations without considering the specific characteristics of raw materials and suppliers. This lack of focused segmentation results in less effective evaluations. Without clear segmentation, the company struggles to optimally identify strategic suppliers, manage risks, or establish appropriate relationship development strategies. Consequently, the evaluation process often takes longer, incurs additional costs, and risks forming partnerships with unsuitable suppliers.

Using appropriate methods for supplier performance evaluation is crucial. Procurement strategies involve clear decisions about how many supply segments to purchase from, the available supplier options, the types of collaboration possible for each product, suitable contract types for supplier partnerships, and the best operational procurement strategies. One commonly used approach in supplier segmentation is the Purchasing Portfolio Matrix (PPM). This matrix is designed to reduce supply vulnerabilities by classifying procurement materials based on the level of supply risk and their influence on company profitability (Montgomery, Ogden, and Boehmke 2018). These categories include strategic, bottleneck, leverage, and non-critical (Wu et al. 2020). PPM provides guidance for companies to prioritize supplier management, such as building strategic partnerships for strategic items or increasing cost efficiency for non-critical items.

A review of previous studies shows that approaches like AHP, BWM, PPM, and SPM are commonly used in research concerning supplier assessment and selection across diverse industrial sectors. Muhammad et al. (2024) and Pebrian et al. (2024) examined the chemical manufacturing industry using a combination of AHP and PPM methods. Mellisa et al. (2023) and Seung-Kuk (2021) applied the AHP and PPM approaches in studies focusing on micro, small, and medium enterprises, while Siti et al. (2021) combined BWM, PPM and SPM methods in a study focused on the automotive sector.

Studies conducted by Muningrum et al. (2021), Alim et al. (2021), and Melek et al. (2021) demonstrated the application of AHP and PPM within the shipbuilding, mining, and general manufacturing industries. Rezaei (2019), as well as Zemmy (2021) serve as important references for incorporating more than two decision-making methods—including AHP, PPM, and SPM—to assess suppliers in the manufacturing and electrical industry sectors.

However, no previous studies have been found that specifically implement the combination of Best-Worst Method, and hybrid PPM-SPM in the Fast Moving Consumer Goods (FMCG) sector. Regarding to that, this research conducts a detailed supplier performance analysis and contributes to the development of long-term management strategies for suppliers in the FMCG industry.

Kraljic introduced Purchasing Portfolio Matrix examines two essential dimensions: the level of supply-related risk and the significance of profit contribution. The initial dimension involves the likelihood of supply chain interruptions that may hinder the consistent availability of particular goods or services. This risk increases when companies are dependent on particular suppliers, face distribution constraints, or experience fluctuations in raw material prices. On the other hand, profit impact measures how significantly a component or material contributes to the company's financial performance, particularly in terms of profit growth potential or cost impact.

Items that are both highly profitable and subject to considerable supply uncertainty fall under the category of strategic products, as they are crucial for maintaining smooth operations and have a direct influence on financial performance. The framework divides procurement elements into four main groups: strategic, bottleneck, leverage, and routine items (Olsen and Ellram 1997).

Strategic items play a vital role in driving profit margins and are often associated with elevated levels of supply vulnerability (Caniëls and Gelderman 2005). Typically, these items are available from only one supplier, increasing the potential for supply disruptions. Therefore,

managing supplier relationships in this category generally involves establishing strong partnerships (Caniëls and Gelderman 2005). Practitioners often use two approaches in this situation: strengthening the existing partnership or terminating it and seeking a new supplier. Bottleneck items have a moderate impact on company profits and tend to pose a high supply risk (Caniëls and Gelderman 2005). Suppliers have greater control over these items. The recommended procurement strategy in this case is to accept the dependence on suppliers while minimizing the negative impact of the unfavorable position. One common strategy is to seek alternative suppliers or shift to a less critical quadrant. Leverage items typically come from several suppliers and make a notable impact on the overall production cost, yet they are associated with minimal supply uncertainty (Caniëls and Gelderman 2005). Because of this, buyers usually have strong bargaining power. A suitable approach for managing these items involves utilizing this purchasing influence to secure favorable terms, while also exploring the potential for long-term collaboration with suppliers. Non-critical items generally have a low unit value and are easily sourced from various suppliers (Caniëls and Gelderman 2005). These items rarely cause technical or commercial issues. The recommended procurement strategy for these items is to consolidate purchasing needs and place individual orders when necessary.

On the other hand, the Supplier Potential Matrix (SPM) offers an additional dimension in evaluating suppliers by considering their technical capabilities as well as their willingness to innovate and collaborate (Jafar Rezaei and Ortt 2012). Capabilities refer to technical expertise, production capacity, and the quality of products or services offered. Companies have a better chance of reaching their desired performance when working with suppliers that demonstrate strong capabilities. On the other hand, willingness reflects the dedication and loyalty of suppliers in maintaining a long-term relationship with the company (Jafar Rezaei and Ortt 2012).

The combination of the PPM and SPM approaches helps companies formulate more effective procurement strategies, ranging from risk mitigation to managing supplier relationships. These two approaches are essential as they focus on different aspects: PPM focuses on the suppliers themselves, while SPM evaluates the relationship between the company and the suppliers.

To assist in determining the criteria weights required for both segmentation approaches, the Best Worst Method (BWM) will be used as a tool for the weighting process in this study (Jafarac Rezaei, Wang, and Tavasszy 2015). The Best Worst Method (BWM) is a decision-making technique used to assign weights in supplier performance evaluations (Jafarac Rezaei, Wang, and Tavasszy 2015). This method involves comparing relevant criteria by selecting two extreme elements: the best (most important) criterion and the worst (least important) criterion (Jafar Rezaei 2015). In supplier performance evaluations, BWM will be used to assign weights to factors such as price, quality, delivery time, service, and availability (Jafar Rezaei and Fallah Lajimi 2019). The resulting weights will be applied in the PPM and SPM to determine the positions of the supplier based on their performance. By conducting supplier segmentation and performance evaluation, PT XYZ is expected to enhance its market competitiveness. A well-executed evaluation will enable PT XYZ to retain high-quality suppliers, encourage other suppliers to improve their performance, enhance operational efficiency, and reduce production costs.

RESEARCH METHODS

Type of Research

This study uses a case study approach with both quantitative and qualitative data.

Data Collection Technique

Primary and secondary data collection will be used in the process. Primary data will be gathered directly through interviews, surveys, or discussions with relevant stakeholders. This information supports the identification of strategic factors that influence supplier positioning within the PPM and SPM matrices. On the other hand, secondary data will be sourced from company documents, such as supplier performance reports, purchase records, product quality reports, and historical data on delivery accuracy and supplier reliability. These secondary sources

provide additional insights that support the analysis and assist in mapping supplier positions in the portfolio matrix.

Data Processing and Analysis Techniques

The initial phase of data analysis involves comparing the top-rated criterion individually against each of the remaining criteria in both methods, followed by the construction of the Best-to-Others (BO) vector.

$$A_B = (a_{B1}, a_{B2}, \dots, a_{Bn}) \quad (1)$$

Where a_{Bj} indicates the preference of the best criterion B compared to criterion j.

Following the initial stage, another pairwise comparison is performed, this time involving the least significant criterion compared against all the remaining criteria in both the PPM and SPM methods. This step results in the development of the Others-to-Worst (OW) vector, which will be used in the subsequent analysis:

$$A_W = (a_{1W}, a_{2W}, \dots, a_{nW})^T \quad (2)$$

Here a_{jW} indicates how much more important criterion j is when compared to the worst criterion w. The criteria used in data processing are those identified during the data collection phase. Pairwise comparisons are conducted using Microsoft Office Excel with the predetermined weight values.

Next, the optimal weights for each criterion $(w_1^*, w_2^*, \dots, w_n^*)$ are determined. The goal of determining the optimal weights is to minimize the maximum absolute difference $\{|w_B - a_{Bj}w_{Bj}|, |w_j - a_{jw}w_w|\}$ for all j, resulting in the following min-max model:

$$\min \max j \ \{|w_B - a_{Bj}w_{Bj}|, |w_j - a_{jw}w_w|\}$$

$$s.t.$$

$$\sum_j w_j = 1$$

$$w_j \geq 0, \text{ for all } j \quad (3)$$

Next, the equation is transformed into the following linear programming problem:

$$\min \xi^L$$

$$s.t.$$

$$|w_B - a_{Bj}w_{Bj}| \leq \xi^L, \text{ for all } j$$

$$|w_j - a_{jw}w_w| \leq \xi^L, \text{ for all } j$$

$$\sum_j w_j = 1$$

$$w_j \geq 0, \text{ for all } j \quad (4)$$

The determination of weights and consistency ratios is conducted using the equation with the help of the solver in Microsoft Office Excel. A lower consistency ratio indicates that the comparison results are more reliable and consistent.

Subsequently, the collected data will be assessed to determine the total score of each supplier across all dimensions, utilizing a score aggregation formula. In order to compute these total scores across each dimension, it is essential to incorporate the weight of each criterion w_j along with the individual performance scores of each supplier for every criterion x_{ij}. The final aggregated score for supplier i in each respective dimension is then calculated using the formula provided below:

$$S_i = \sum_{j=1}^{n} w_j x_{ij}, \forall i \quad (5)$$

The next step involves normalizing the scores for each supplier across both evaluation aspects used in the analysis. The data used for score normalization includes the aggregate score data, as well as the maximum and minimum score values for each dimension in both the PPM and SPM approaches. The normalization of the S_i values is carried out using the following formula.

$$\widehat{S_P} = \frac{S_P - \min\{S_i\}}{max\{S_i\} - \min\{S_i\}} \quad (6)$$

The results of this normalization will be presented in a table, making it easier for the author to perform supplier segmentation using both the PPM and SPM approaches. The final step in data processing is to combine the segmentation results from the PPM and SPM approaches, commonly referred to as the Purchasing Portofolio Matrix and Supplier Potential Matrix combination.

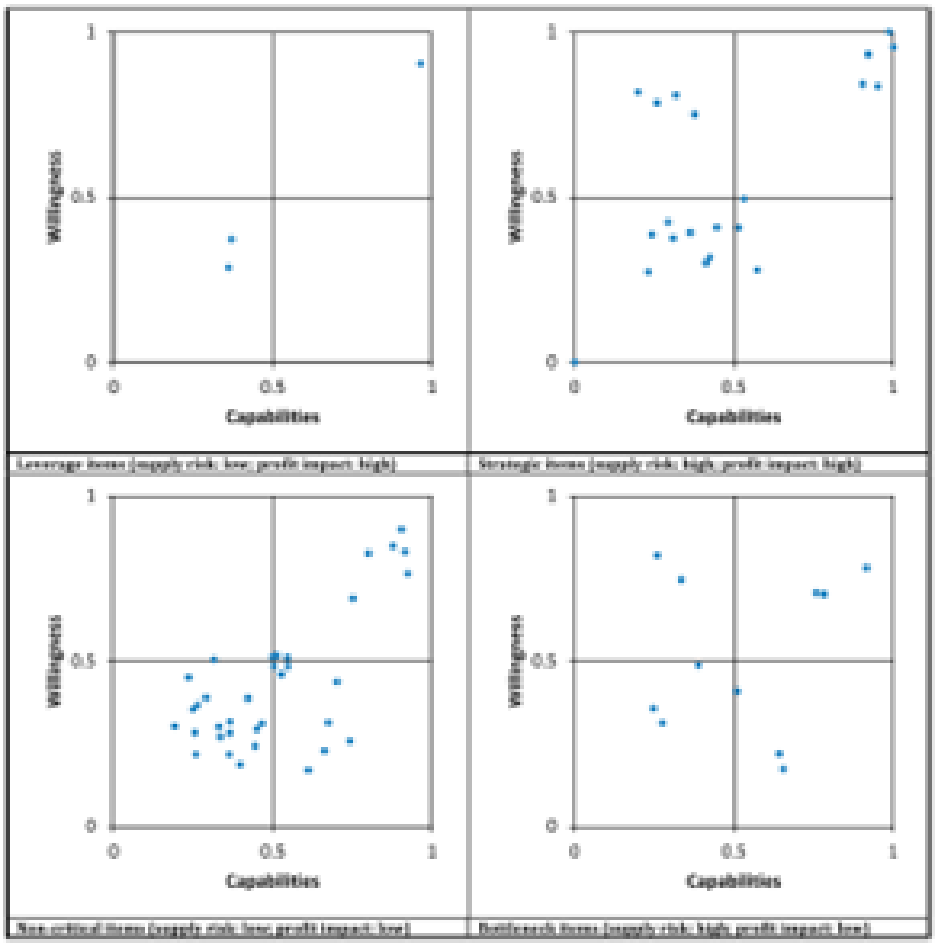

Figure 1. Hybrid PPM-SPM Model Segmentation

(**Source:** Rezaei, Jafar Fallah Lajimi, Hamidreza, 2019)

The figure above is a visualization of the combined PPM-SPM model application. By using the combined PPM and SPM, each segment in the PPM matrix is further divided into four segments by the SPM matrix, which assesses two dimensions: the capabilities and willingness of each supplier.

The final stage is data analysis, where the combined PPM-SPM model will be used for analysis, followed by designing strategies based on the results obtained from each previous stage of data processing.

RESULTS AND DISCUSSION

Identification of Criteria

The criteria that have previously been applied at PT XYZ will be used as a reference in the criteria identification process. In this stage, the company classifies each criterion used in PT XYZ's evaluation process into several dimensional groups.

Assessment and Pairwise Comparison of Each Criterion

After identifying the relevant criteria for evaluating suppliers, an assessment and pairwise comparison of each criterion were conducted. The evaluation data and the pairwise comparisons for PPM and SPM criteria, determined in the previous stage, were collected through interviews with the purchasing team, structured based on the BWM framework.

The comparisons and assessments were carried out using a scale from 1 to 9, with 1 indicating "i holds equal importance to j," and 9 indicating "i holds significantly greater importance than j." A similar assessment was also performed to compare each criterion against the least important one, using the same scale, where 1 reflects equal lack of importance, and 9 means "i is far more unimportant than j."

The results of this pairwise comparison assessment is shown in Table 1:

Tabel 1. Pairwise Comparison

Dimension	Consistency Value	Weighting			
Supply Risk		Quality (SR1)	Delivery Time (SR2)	Warranty (SR3)	Product Availability (SR4)
	ξ ^L = 0.1667	0.351351	0.189189	0.351351	0.108108
Profit Impact		Price (PI1)	Payment (PI2)	Warranty (PI3)	
	ξ ^L = 0.1667	0.541667	0.291667	0.166667	
Capability		Quality (SC1)	Delivery (SC2)	Technical Capability (SC3)	
	ξ ^L = 0.1354	0.657143	0.142857	0.2	
Willingness		Commitment To Quality (SW1)	Cost Efficiency (SW2)	Willingness to Share Information (SW3)	
	ξ ^L = 0.1354	0.627907	0.232558	0.139535	

Supplier Segmentation

The determination of scores for each supplier is based on the assessment conducted by the purchasing team over one quarter, specifically in Q4 of 2023. The evaluated suppliers consist of 148 vendors that provide raw materials for PT XYZ's operations. The assessment was conducted based on each criterion for the selected suppliers, using a numerical scale from 5 to 9, where 5 represents "very poor" and 9 represents "very good." The weight and consistency ratio for each criterion in the PPM and SPM approaches are determined based on the previously identified criteria.

The problem-solving for the equation was carried out using the Solver feature in Excel. Through the Solver results, the weight for each criterion and the consistency ratio for each dimension were obtained. A low consistency ratio value indicates that the comparisons made are highly consistent. The weighting results for each criterion in the PPM and SPM dimensions can be seen in Table 1 above.

To calculate the total or overall score for each chosen supplier in each dimension under both methods, namely PPM and SPM, it is necessary to have the criteria weights and the individual scores of each supplier. To calculate the score normalization, the aggregated score data, as well as the minimum and maximum score values from the aggregated data, will be used as calculation variables After obtaining the data on the minimum and maximum scores for each dimension in PPM and SPM, the next step is to calculate the score normalization. The result of supplier segmentation is carried out by grouping each supplier from every dimension into the PPM and SPM quadrants based on their values (low and high) with a cutoff point of 0.5. In Table 2 Supplier Segmentation Results below, the segmentation results based on the PPM and SPM models are presented.

Table 2. Supplier Segmentation Results

Dimension	Segmentation	Description	Number of Supplier	Percentage
PPM	Strategic	High Supply Risk and High Profit Impact	29	20%
	Bottleneck	High Supply Risk and Low Profit Impact	39	26%
	Leverage	Low Supply Risk and High Profit Impact	9	6%
	Non-Critical	Low Supply Risk and Low Profit Impact	71	48%
		Total	148	100%
SPM	Core	High Cappability and High Willingness	43	29%
	Niche	High Cappability and Low Willingness	28	19%
	Developing	Low Cappability and High Willingness	40	27%
	Commodity	Low Cappability and Low Willingness	37	25%
		Total	148	100%

The following is a visualization of the position of each supplier in each category within the PPM-SPM matrix chart.

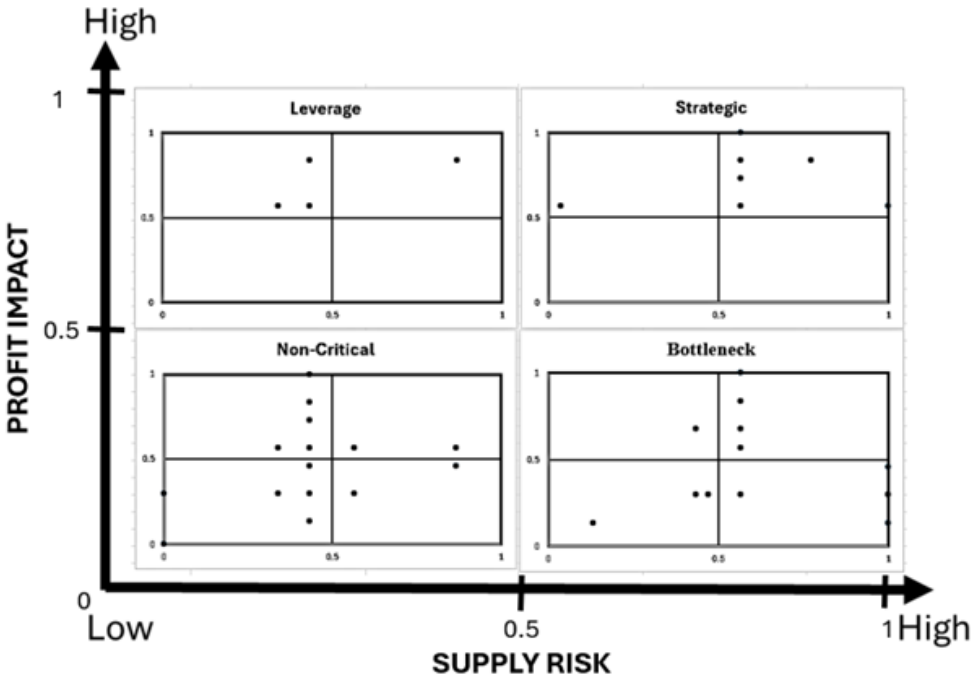

Figure 2. PPM-SPM Matrix Visualization

Strategy for Non-Critical Item Suppliers

For the 32 suppliers classified as commodities, an efficient procurement mechanism can be implemented, such as selecting suppliers solely based on the lowest price, avoiding long-term relationships, using them only for routine, non-critical needs, and switching to alternative suppliers if better pricing is available (Caniëls and Gelderman 2005). For the 6 suppliers in the niche category, maintaining relationships is advisable only if they have unique advantages, using them as supplementary suppliers for more specific needs (Caniëls and Gelderman 2005). Meanwhile, for the 31 suppliers in the developing category, providing limited opportunities for growth and reliability improvement can be beneficial, utilizing them as alternatives if primary suppliers encounter issues (Caniëls and Gelderman 2005). As for the 2 suppliers in the core category, establishing medium-term contracts with the best pricing, applying bulk purchasing strategies to reduce procurement costs, and improving efficiency through e-procurement systems are recommended (Caniëls and Gelderman 2005).

Strategy for Leverage Item Suppliers

For the 7 suppliers in the developing category, the strategy involves providing technical support or knowledge transfer to improve supplier efficiency and offering opportunities for greater involvement in the supply chain if their performance improves (Caniëls and Gelderman 2005). For the 2 suppliers in the core category, the company can enhance economies of scale through aggressive price negotiations, develop performance-based contracts (Performance-Based Contracting), and implement just-in-time procurement to reduce storage costs (Caniëls and Gelderman 2005).

Strategy for Strategic Item Suppliers

For the 28 core suppliers, the primary strategy includes building long-term partnerships with exclusive contracts, encouraging collaboration in R&D and product innovation, integrating information systems with suppliers to enhance supply chain transparency, and providing joint

training to ensure high-quality standards (Jafar Rezaei and Ortt 2012). Then, for the one supplier classified in the Developing category, the company should carry out supplier development through mentoring and knowledge sharing to improve the supplier's capabilities (Lee and Drake 2010).

Strategy for Bottleneck Item Suppliers

For the 22 niche suppliers, strategies include negotiating more favorable agreements to secure long-term supply, mitigating risks by implementing safety stock strategies, and, if feasible, identifying alternative suppliers to reduce dependency (Valipour Parkouhi, Safaei Ghadikolaei, and Fallah Lajimi 2019). Meanwhile, for 11 suppliers which in core suppliers category, maintaining long-term relationships to ensure supply stability, increasing commitment through exclusive contracts, and ensuring suppliers have backup plans or alternatives in case of supply disruptions are recommended (Bai, Rezaei, and Sarkis 2017). For the five suppliers in the Commodity category, the strategy that can be applied is to seek alternative suppliers in order to reduce dependency. Meanwhile, for the one supplier in the Developing category, the company needs to implement supplier development to improve the supplier's capabilities and quality (Caniëls and Gelderman 2005).

CONCLUSION

Based on the research conducted at PT XYZ, several conclusions can be drawn as follows: Based on the data processing results, 13 criteria were identified as variables for assessing two analytical dimensions. In the PPM approach, the highest weight in the supply risk dimension is quality and warranty, with a weight of 0.351, while in the profit impact dimension, the highest weight is price, with a weight of 0.542. Meanwhile, in the SPM approach, quality is the highest weight in supplier capabilities dimension, with a weight of 0.657, whereas in the supplier willingness dimension, the highest weight is commitment to quality, with a weight of 0.628.

By combining the PPM and SPM models, it was found that out of 148 suppliers collaborating with PT XYZ, the majority, or 48% (a total of 71 suppliers), these suppliers fall under the category of having minimal supply-related challenges and contribute only slightly to overall profitability. Among them, 45%, or 32 out of 71 suppliers, were classified as having low capability and willingness.

The combined PPM and SPM model resulted in 12 segments, each requiring different strategic handling. The company can implement effective strategies in managing supplier relationships, such as maintaining existing collaborations, accepting locked-in partnerships, and minimizing potential negative impacts. To strengthen its position, the company can also leverage its bargaining power in procurement processes. Another commonly used strategy is the application of bundled purchasing requirements. In certain situations, if a supplier has low capability and willingness, the company may seek alternative suppliers. However, if that is not feasible, the company can adopt a supplier development strategy to enhance their capabilities.

REFERENCES

Bai, Chunguang, Jafar Rezaei, and Joseph Sarkis. 2017. "Multicriteria Green Supplier Segmentation." *IEEE Transactions on Engineering Management* 64(4): 515–28.

Caniëls, Marjolein C.J., and Cees J. Gelderman. 2005. "Purchasing Strategies in the Kraljic Matrix - A Power and Dependence Perspective." *Journal of Purchasing and Supply Management* 11(2–3): 141–55.

Drake, Paul R., Dong Myung Lee, and Matloub Hussain. 2013. "The Lean and Agile Purchasing Portfolio Model." *Supply Chain Management: An International Journal* 18(1): 3–20.

Hallikas, Jukka, Kaisu Puumalainen, Toni Vesterinen, and Veli Matti Virolainen. 2005. "Risk-

Based Classification of Supplier Relationships." *Journal of Purchasing and Supply Management* 11(2–3): 72–82.

Lee, Dong Myung, and Paul R. Drake. 2010. "A Portfolio Model for Component Purchasing Strategy and the Case Study of Two South Korean Elevator Manufacturers." *International Journal of Production Research* 48(22): 6651–82.

Montgomery, Robert T., Jeffrey A. Ogden, and Bradley C. Boehmke. 2018. "A Quantified Kraljic Portfolio Matrix: Using Decision Analysis for Strategic Purchasing." *Journal of Purchasing and Supply Management* 24(3): 192–203.

Muhammad, Ihsan, Mutawali Syarawy, and Mohamad Rifky Fahreza. 2024. "Pentingnya Teori Etika Deontologi Dalam Membangun Hubungan Dengan Pemasok Bisnis 1." 42: 137–47.

Olsen, Rasmus Friis, and Lisa M. Ellram. 1997. "A Portfolio Approach to Supplier Relationships." *Industrial Marketing Management* 26(2): 101–13.

Rahayu, Siti, Tri Ngudi Wiyatno, and Ikhsan Romli. 2021. "Segmentasi Supplier Mempertimbangkan Kombinasi Purchasing Portfolio Matrix (PPM) - Supplier Portfolio Matrix (SPM) Pada Perusahaan Manufaktur." *Jurnal Teknik Industri* 2(1): 51–57.

Rezaei, Jafar. 2015. "Best-Worst Multi-Criteria Decision-Making Method." *Omega (United Kingdom)* 53: 49–57. http://dx.doi.org/10.1016/j.omega.2014.11.009.

Rezaei, Jafar, and Hamidreza Fallah Lajimi. 2019. "Segmenting Supplies and Suppliers: Bringing Together the Purchasing Portfolio Matrix and the Supplier Potential Matrix." *International Journal of Logistics Research and Applications* 22(4): 419–36. https://doi.org/10.1080/13675567.2018.1535649.

Rezaei, Jafar, and Roland Ortt. 2012. "A Multi-Variable Approach to Supplier Segmentation." *International Journal of Production Research* 50(16): 4593–4611.

Rezaei, Jafarac, Jing Wang, and Lori Tavasszy. 2015. "Linking Supplier Development to Supplier Segmentation Using Best Worst Method." *Expert Systems with Applications* 42(23): 9152–64. http://dx.doi.org/10.1016/j.eswa.2015.07.073.

Valipour Parkouhi, Sahar, Abdolhamid Safaei Ghadikolaei, and Hamidreza Fallah Lajimi. 2019. "Resilient Supplier Selection and Segmentation in Grey Environment." *Journal of Cleaner Production* 207: 1123–37. https://doi.org/10.1016/j.jclepro.2018.10.007.

Wu, Chong, Chuanlin Lin, David Barnes, and Yi Zhang. 2020. "Partner Selection in Sustainable Supply Chains: A Fuzzy Ensemble Learning Model." *Journal of Cleaner Production* 275: 123165. https://doi.org/10.1016/j.jclepro.2020.123165.