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Enhancing supplier management strategies: integrating purchasing and supplier potential matrices in furniture manufacturing

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ABSTRACT

Supplier segmentation is one of the most important supply chain activities for most companies that collaborate with many suppliers such as PT. XYZ is engaged in furniture manufacturing. Purchasing Portfolio Matrix (PPM) is a segmentation method that considers two dimensions (supply risk and profit impact) which are the basis for classifying materials to be purchased by the company. Supplier Potential Matrix (SPM) is a new supplier segmentation approach that includes two dimensions (capabilities and willingness). These two approaches are important because they have different focuses, namely PPM on suppliers while SPM on relationships. Therefore, the main objective of this research is to classify suppliers using a combination of PPM and SPM and determine the appropriate relationship management strategy. Data collected from PT. XYZ works with 74 raw material suppliers. Best Worst Method (BWM) is used to determine the criteria weights in both segmentation approaches. So from the 74 suppliers, the results were 7 suppliers in PPM1, 43 suppliers in PPM2, 5 suppliers in PPM3, and 19 suppliers in PPM4 and different strategies were obtained so that this combined PPM-SPM approach was able to improve supplier management.

1. Introduction

The In the last few decades, purchasing activities have progressed from traditional operational functions to strategic functions. As a result, purchasing contributes more significantly to overall organizational performance (Arantes et al, 2022). Companies realize that the key to implementing supply chains in the manufacturing industry is through proper production and purchasing planning (Aditya et al, 2019). Therefore, to remain competitive, companies need to develop a good network of relationships with suppliers. So purchasing strategies need to be adapted to each purchasing situation (Bildsten, 2021). One of these strategies includes Supplier Relationship Management (SRM). SRM is defined as relationships with suppliers that are built, developed and maintained to achieve sustainable competitive advantage due to the demand uncertainty faced by the Company (Gyampah et al, 2019). SRM is an opportunity to build on success and involves developing strategic sourcing partnerships and initiatives with key suppliers aimed at reducing costs, innovating new products (Putra et al, 2020) and building mutually beneficial relationships between both parties (Kimwaki et al, 2022).

A company certainly has quite a large number of suppliers with different characteristics and needs. Like PT. XYZ is a manufacturing company engaged in wooden furniture, its main business activity is making furniture products with custom designs according to consumer demand. There are various types of furniture products with different functions and specifications, so that making them requires various types of raw materials with certain qualities and quantities which will be fulfilled if the company purchases raw materials from several suppliers. As in Fig. 1, where the number of raw material

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suppliers PT. XYZ fluctuates every year. Moreover, the company has not implemented an organized management strategy, which will have an impact on relationships with suppliers in the future.

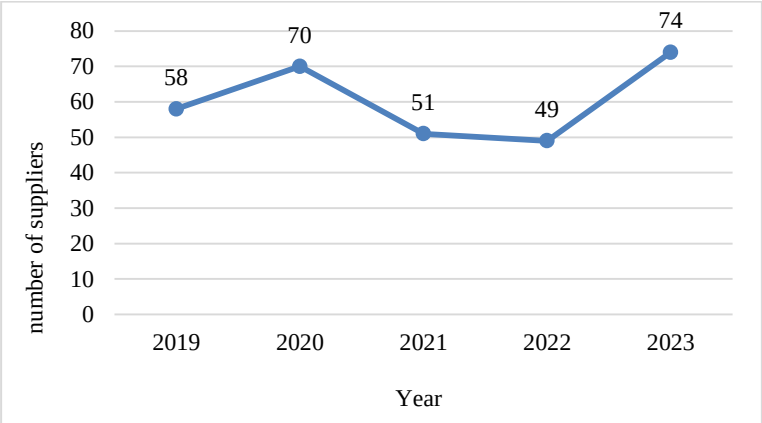

Fig. 1 Number of raw material suppliers of PT. XYZ for 2019-2023 period.

Based on the problems described above, this research aims to provide the main solution, namely by segmenting suppliers. With supplier segmentation, the best suppliers will be obtained so that this will also have a significant influence on the quality of the products produced. This providing large profits for the company (Rivaldi et al, 2023), increasing company effectiveness, and increasing customer confidence in the quality of the products produced (Putri et al, 2022). Purchasing Portfolio Matrix (PPM) is a supplier segmentation method that is obtained by selecting and giving weight to different parameters, which influence the supplier's position in the matrix in relation to the company's strategy and needs (Bianchini et al, 2019). PPM is based on two dimensions, namely supply risk and profit impact with low and high values for each dimension, divided into four segments, namely bottleneck, non-critical, leverage, and strategic commodities (Rezaei et al, 2019). Apart from that, the Supplier Potential Matrix (SPM) is a new segmentation method for integrating supplier assessment criteria into two dimensions, namely supplier capabilities and supplier willingness (Lajimi et al, 2021). PPM focuses on supply characteristics, while SPM focuses on the characteristics of relationships with suppliers, where both elements are equally important (Rezaei et al, 2019).

Supplier segmentation in this case is a Multi-Criteria Decision-Making (MCDM) problem which is solved using the Best-Worst Method (BWM). In making this decision, predetermined criteria are used in accordance with the dimensions of the PPM and SPM. However, the existing criteria in the supply risk dimension are still deemed to be less effective when used in furniture companies such as PT. XYZ. Therefore, in this research, in addition to the eight existing supply risk criteria, namely geographical location, product availability, delivery time, possibility of substitution, product storage costs, official requirements, ease of supplier substitution in the event of failure, logistics proximity to the supplier's market, number of suppliers availability, quality, and guarantees or guarantees, new criteria have been added, namely "Accuracy of Payment Criteria" on the grounds that the accuracy of payments made by the company must be in accordance with the initial agreement with the supplier because it will affect the existing supply in the company and also affect the supplier's trust in the company in the future. Therefore, it is hoped that the combination of PPM and SPM will be able to provide convenience for companies, especially PT. XYZ in determining strategies for dealing with different suppliers and also encouraging increased company profits based on appropriate criteria.

2. Methods

Determination of Criteria

This criteria determination stage is the stage of identifying several criteria in the PPM-SPM obtained from literature studies to determine the criteria that are most relevant to PT. XYZ. At this stage, the author conducted interviews and discussions with company representatives related to suppliers, namely purchasing manager, HR manager and quality manager.

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Table 1 Criteria for the PPM-SPM dimensions

Supply Risk	Profit Impact
Geographic Location	Total amount purchased
Product availability	Estimated growth in company demand
Delivery time	Perceived bargaining power of purchasing firms
Possible Substitutions	Product Price
Product storage costs	The importance of the product in the project sequence
Official Requirements Ease of Supplier	
Substitution in the event of failure	
Logistical proximity to supplier markets	
Number of suppliers available	
Quality Guarantee/Guarantee	
Capabilities	**Willingness**
Price/Cost	Commitment to quality
Delivery	Honest and frequent communication
Quality	Openness of communication
Reserve Capacity	Attitude
Industry Knowledge	Closeness of relationship
Supplier process capabilities	Open for site Evaluation
Geographic location/proximity	Commitment to continuous improvement in products and processes
Design capabilities	Compliance with bidding procedures
Technical capabilities	Mutual arrangement
Technology monitoring	Previous experience with suppliers
Management and organization	Ethical standards
Production, Manufacturing/transformation facilities, and capacity	Impression
	Willingness to design together
Reputation and position in the industry	Willingness to participate in new product development
Financial position	Willingness to integrate supply chain management relationships
Performance awards	Mutual respect and honesty
Performance history	Willingness to share information
Cost control	Willingness to share ideas
Technology development	Willingness to share technology
Repair service	Willingness to share cost savings
After sales support	Consistency and no follow up
Packaging capabilities	Willingness to eliminate waste
Product reliability	Willingness to promote JIT Principles
Operational control	Dependency
Training aids	Willingness to invest in certain equipment
Labor relations records	Long term relationship
Impact on energy utilization	
Ease of maintenance design	
Communication system	
Desire for business	
Human Resource Management	
Number of past businesses	
Warranty and claims	
Market sensing	
Customer link	
Environmental health and safety	
Innovation	
Order entered	
Invoicing system including EDI	

Source: Rezaei & Lajimi, 2019

Pairwise Comparison and Criteria Weighting

Best Worst Method (BWM) is a newly developed Multi Criteria Decision Making (MCDM) method that uses the ratio of relative importance of criteria in pairwise comparisons given by the decision maker, based on two evaluation vectors, namely the best criteria (best) against the criteria others, and other criteria towards the worst criteria (Kaya et al, 2019). The steps taken in implementing the BWM method are as follows:

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Step 1. The decision maker needs to provide and consider a series of decision criteria C = {c1, c2, ..., cn} that must be used to arrive at a decision.

Step 2. The decision maker chooses the best (CB) and worst (CW) criteria from the criteria determined in the first step. The selection of the best criteria (Best) is the most important or most desired, while the selection of the worst criteria (Worst) is the least important or least desired among the other criteria.

Step 3. Make a pairwise comparison between the best criteria (CB) and the other criteria from C. In this step, the decision maker calibrates his preference for the best criteria against the other criteria with a number between one and nine, where one means the same importance and nine means very more important. Pairwise comparison yields the A_B "Best-to-Others" vector as:

$$A_B = (a_{B1}, a_{B2}, a_{B3}, \ldots\ldots, a_{Bn}) \quad (1)$$

where a_{Bj} represents the preference of the best criterion (C_B) against criterion $C_j \in C$

Step 4. Carry out pairwise comparisons between the worst criteria (CW) and the other criteria from C. In this step the decision maker calibrates his preferences for the other criteria against the worst criteria with a number between one and nine, where one means the same importance and nine means very more important. Pairwise comparison yields the "Others-to-Worst" AW vector as:

$$A_W = (a_{1W}, a_{2W}, a_{3W}, \ldots\ldots, a_{nW})^T \quad (2)$$

where a_{jW} represents the preference of criterion $C_j \in C$ over the worst criterion (C_W)

Table 2 Best Worst Method (BWM) rating scale

Scale	Explanation
1	Both criteria are equally important
3	One criterion is slightly more important than the other criteria
5	One criterion is more important than the other criteria
7	One criterion is clearly more important than the other criteria
9	One criterion is absolutely more important than the other criteria
2, 4, 6, 8	The values between two adjacent considerations

Source: Rahayu et al (2022)

Step 5. Obtain the optimal weight $w^* = (w^*_1, w^*_2, w^*_3, \ldots\ldots, w^*_n)$

Given A_B dan A_W, the weight vector w^* must be calculated. The weight vector should be around the equations $w_B / w_j = a_{Bj}$ and $w_j / w_w = a_{jW}$ for j = 1, 2, …., n. This, the maximum absolute difference $\left|\frac{w_B}{w_j} - a_{Bj}\right|$ and $\left|\frac{w_j}{w_w} - a_{jw}\right|$ for all j = 1, 2, …., n can be minimized. In addition, the non-negative and summation properties of the weight vectors must be satisfied. As a result, the following optimization problem can find the optimal weight vector w^*.

$$\min_{w} \max_{j} \left\{ \left|\frac{w_B}{w_j} - a_{Bj}\right|, \left|\frac{w_j}{w_w} - a_{jw}\right| \right\}$$

$$s.t. \sum_{j=1}^{n} w_j = 1, \quad w_j \geq 0 \quad \forall j = 1,2,\ldots,n \quad (3)$$

Similarly, the weight vector can also be calculated with the following problem:

$$\min_{\xi, w} \quad \boldsymbol{\xi}$$

$$s.t. \left|\frac{w_B}{w_j} - a_{Bj}\right| \leq \boldsymbol{\xi} \quad \forall j = 1,2,\ldots,n$$

$$\left|\frac{w_j}{w_w} - a_{jw}\right| \leq \boldsymbol{\xi} \quad \forall j = 1,2,\ldots,n$$

$$\sum_{j=1}^{n} w_j = 1, \quad w_j \geq 0 \; \forall j = 1,2,\ldots,n \quad (4)$$

To check the reliability of the optimal weights, the correctness between the pairwise comparison inputs and their associated output weights is checked using the following Consistency Ratio (CR):

$$CR = \frac{\xi^*}{CI} \quad (5)$$

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Where ξ^* is the objective value of equation (4) and CI (consistency index) is a fixed value per a_{Bw} which can be read from Table 3

Table 3 CI (consistency index) table

a_{Bw}	1	2	3	4	5	6	7	8	9	6
consistency index	0.00	0.44	1.00	1.63	2.30	3.00	3.73	4.47	5.23	3.00

Source: Mohammadi & Rezaei, 2020

Determining the Score for Each Supplier Based on Criteria

The score for each supplier is determined by a company representative based on each criterion that has been identified using a Likert scale. The Likert scale is a psychometric scale for evaluating questionnaires which is assessed on an n-point scale, which generally consists of 5 scales, namely a scale of 1 to 5 (Improta et al, 2019).

Table 4 Likert scale rating numbers

Score	Explanation
5	Very good
4	Good
3	Enough
2	Not enough
1	Very less

Source: Agustina et al, 2023

PPM-SPM Combination Supplier Segmentation

Supplier segmentation is carried out by grouping each supplier in the PPM - SPM quadrant which is explained as in Fig. 2.

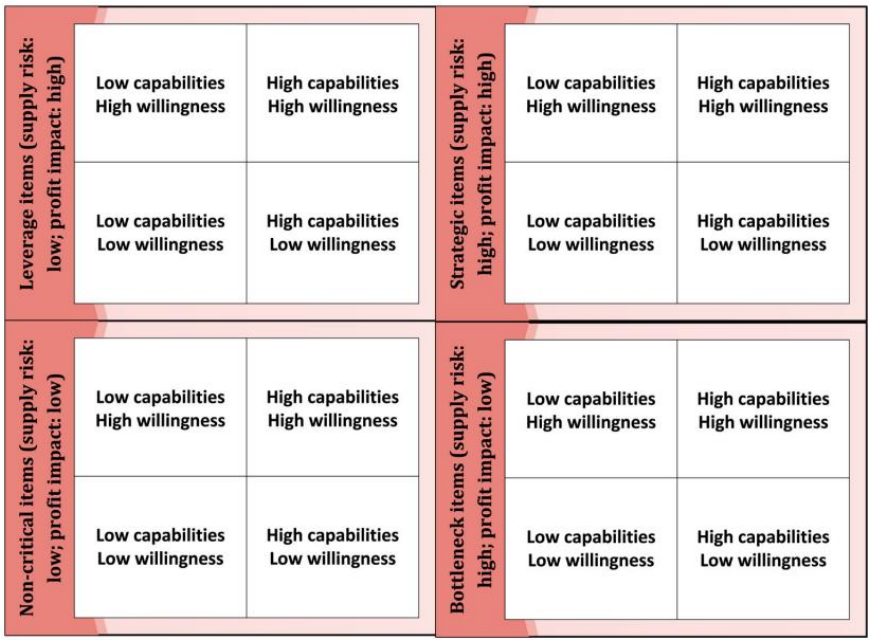

Fig. 2 Combined PPM-SPM approach.
Source: Rezaei & Lajimi, 2019

To determine the overall score for each supplier on each dimension in the two approaches, the criteria weight W_j and the score of each supplier with respect to each criterion, X_{ij}, are required. The final aggregate score of each dimension for supplier i is then calculated as follows:

$$S_i = \sum_{j=1}^{n} w_j X_{ij}, \ \forall i \tag{6}$$

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Next, the S_i value is normalized in the following way:

$$\hat{S}_p = \frac{S_p - \min\{s_i\}}{\max\{s_i\} - \min\{s_i\}} \quad (7)$$

3. Results and Discussion

Determination of Criteria

The following are the results of identifying the criteria for each PPM and SPM dimension for suppliers at PT. XYZ uses data collection resulting from interviews and has been combined with Rezaei & Lajimi (2019).

Table 5 Selected criteria for each PPM-SPM dimension

Supply Risk	*Profit Impact*
Geographic Location	Total amount purchased
Product availability	Estimated growth in company demand
Delivery time	Perceived bargaining power of purchasing firms
Official Requirements	Product Price
Number of suppliers available	
Quality	
Guarantee	
Payment Accuracy	
Capabilities	*Willingness*
Price/Cost	Commitment to quality
Delivery	Openness of communication
Quality	Attitude
Industry knowledge	Compliance with bidding procedures
Technical capabilities	Previous experience with suppliers
Technological capabilities	Mutual respect and honesty
production, manufacturing/transformation facilities, and capacity	Willingness to share information
Financial position	Long Term Relationships
Technology development	
Desire for business	
Warranty and claims	

Pairwise Comparison and Criteria Weighting with the Best Worst Method

After obtaining the criteria that are relevant to the company. Next, a pairwise comparison is carried out between the best criteria (Best) and the worst criteria (Worst), determining weights, and consistency ratios by solving linear programming problems based on equations (4) and (5) using Solver in Excel. So the results obtained were the average consistency ratio and weight values of the three experts for each criterion as in Table 6 to Table 9 which show the results for PPM and Table 7 to Table 8 show the results for SPM.

Table 6 Weighting results and consistency ratio for supply risk criteria

consistency value (ξ^*)	*Supply Risk Criteria*							
0.097	Geographic Location	Product availability	Delivery time	Official Require-ments	Number of suppliers available	Quality	Guarantee	Payment Accuracy
Weight	0.069	0.143	0.144	0.073	0.125	0.212	0.073	0.161

Table 7 Weighting results and consistency ratio for profit impact criteria

Consistency value (ξ^*)	*Profit Impact Criteria*			
0.277	Total amount purchased	Estimated growth in company demand	Perceived bargaining power of purchasing firms	Product Price
Weight	0.231	0.166	0.353	0.250

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Table 8 Weighting results and consistency ratio for capabilities criteria

consistency value (ξ^*)	*Capabilities Criteria*					
0.128	Price/Cost	Delivery	Quality	Industry knowledge	Technical capabilities	Technological capabilities
Weight	0.127	0.108	0.192	0.098	0.082	0.086
0.128	Production, manufacturing/ transformation facilities, and capacity	Financial position	Technology development	Desire for business	Warranty and claims	
Weight	0.103	0.112	0.093	0.033	0.059	

Table 9 Weighting results and consistency ratio for willingness criteria

consistency value (ξ^*)	*Willingness Criteria*							
0.160	Commitment to quality	Openness of communication	Attitude	Compliance with bidding procedures	Previous experience with suppliers	Mutual respect and honest	Willingness to share information	Long Term Relationships
Weight	0.149	0.117	0.167	0.117	0.114	0.163	0.085	0.089

As shown in Table 6, Quality Criteria are by far the most important criteria in relation to supply risk, followed by the criteria of Accuracy of Payment and Time of Delivery. The profit impact dimension in Table 7, the criterion of Perceived Bargaining Power of the Buying Company is the most important criterion. Product Price Criteria is the next important criterion. In Table 8, the quality criterion is the most important criterion in the capabilities dimension, followed by the Price/Cost and Financial Position criteria. The willingness dimension in Table 9, the attitude criterion is the most important criterion followed by the criteria of mutual respect and honesty, as well as commitment to quality.

Determining the Score for Each Supplier Based on Criteria

After obtaining the weighting results and consistency ratios for the criteria in the PPM-SPM dimensions. So the company representative determines the score for each supplier using a Likert scale of 1 to 5.

PPM-SPM Combination Supplier Segmentation

Supplier segmentation begins by determining the overall score for each supplier (score aggregation). The results of the aggregation score calculation for each supplier are calculated using equation (6).

$$\boldsymbol{S_i = \sum_{j=1}^{n} w_j X_{ij}},\ \forall i$$

$S_{SR1} = (W_1 x_{11}) + (W_2 x_{12}) + (W_3 x_{13}) + (W_4 x_{14}) + (W_5 x_{15}) + (W_6 x_{16}) + (W_7 x_{17}) + (W_8 x_{18})$
$S_{SR1} = (0.069 \times 3) + (0.143 \times 3) + (0.144 \times 4) + (0.073 \times 3) + (0.125 \times 3) + (0.212 \times 4) + (0.073 \times 3) + (0.161 \times 3)$
$S_{SR1} = 3.356$

After score normalization, apart from the score aggregation data, data on the maximum (max) and minimum (min) score values for each PPM-SPM dimension is also needed. In Table 10, you can see the results of calculating the normalization score for each supplier which is calculated using equation (7). So from this normalized score, supplier segmentation can then be carried out by grouping each supplier into quadrants as in Figure 2 based on the value (low and high) of each dimension with a Cutoff Point of 0,5. The following is an example of calculating the normalization score for supplier 1 (SPK1) on the supply risk dimension in PPM:

$$\hat{S}_{\boldsymbol{p}} = \frac{\boldsymbol{S_p - \min\{s_i\}}}{\boldsymbol{\max\{s_i\} - \min\{s_i\}}}$$
$$\hat{S}_{\boldsymbol{SR1}} = \frac{\boldsymbol{S_{SR1} - \min\{S_{SR}\}}}{\boldsymbol{\max\{S_{SR}\} - \min\{S_{SR}\}}}$$
$$\hat{S}_{\boldsymbol{SR1}} = \frac{\boldsymbol{3{,}356 - 2{,}839}}{\boldsymbol{3{,}697 - 2{,}839}}$$
$$\hat{S}_{\boldsymbol{SR1}} = 0.603$$

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Table 10 Normalize scores for each supplier

Supplier Code	*Purchasing Portfolio Matrix* (PPM)		PPM Segment	*Supplier Potential Matrix* (SPM)		SPM Segment
	Supply Risk	*Profit Impact*		*Capabilities*	*Willingness*	
SPK1	0.603	0.500	PPM4	0.546	0.310	SPM3
SPK2	0.768	0.984	PPM4	0.454	0.403	SPM1
SPK3	0.607	0.692	PPM4	0.487	0.403	SPM3
SPK4	0.355	0.692	PPM2	0.360	0.616	SPM2
SPK5	0.273	0.500	PPM2	0.345	0.528	SPM2
SPK6	1.000	0.793	PPM4	0.471	0.496	SPM1
SPK7	0.790	0.500	PPM4	0.353	0.403	SPM1
SPK8	0.273	0.500	PPM2	0.454	0.659	SPM2
SPK9	0.435	0.638	PPM2	0.454	0.628	SPM4
SPK10	0.436	0.500	PPM2	0.123	0.225	SPM1
SPK11	0.627	0.500	PPM4	0.651	0.566	SPM4
SPK12	0.253	0.793	PPM2	0.454	0.403	SPM1
SPK13	0.854	0.500	PPM4	0.401	0.663	SPM4
SPK14	0.585	0.500	PPM4	0.579	0.756	SPM4
SPK15	0.273	0.638	PPM2	0.475	0.791	SPM4
SPK16	0.273	0.500	PPM2	0.577	1.000	SPM4
SPK17	0.420	0.500	PPM2	0.140	0.271	SPM1
SPK18	0.205	0.500	PPM2	0.536	0.275	SPM3
SPK19	0.441	0.500	PPM2	0.651	0.531	SPM4
SPK20	0.128	0.500	PPM2	0.577	0.679	SPM4
SPK21	0.354	0.500	PPM2	0.374	0.776	SPM2
SPK22	0.769	0.692	PPM4	0.000	0.403	SPM1
SPK23	0.273	0.500	PPM2	0.349	0.659	SPM2
SPK24	0.460	0.500	PPM2	0.483	0.528	SPM4
SPK25	0.188	0.308	PPM1	0.412	0.403	SPM1
SPK26	0.000	0.793	PPM2	0.333	0.306	SPM1
SPP1	0.248	0.500	PPM2	1.000	0.493	SPM3
SPP2	0.103	0.692	PPM2	0.348	0.586	SPM2
SPP3	0.441	0.829	PPM2	0.236	0.562	SPM2
SPP4	0.333	0.845	PPM2	0.936	0.691	SPM4
SPP5	0.355	0.692	PPM2	0.808	0.528	SPM4
SPP6	0.435	0.930	PPM2	0.544	0.586	SPM4
SPP7	0.268	0.500	PPM2	0.550	0.431	SPM3
SPP8	0.545	1.000	PPM4	0.042	0.275	SPM1
SPP9	0.103	0.500	PPM2	0.462	0.612	SPM2
SPP10	0.354	0.793	PPM2	0.213	0.446	SPM1
SPP11	0.188	0.793	PPM2	0.020	0.706	SPM2
SPP12	0.333	0.707	PPM2	0.456	0.478	SPM1
SPP13	0.105	0.500	PPM2	0.477	0.403	SPM1
SPP14	0.188	0.308	PPM1	0.477	0.000	SPM1
SPP15	0.042	0.345	PPM1	0.804	0.566	SPM4
SPP16	0.622	0.707	PPM4	0.468	0.400	SPM1
SPP17	0.333	0.707	PPM2	0.397	0.306	SPM1
SPP18	0.435	0.500	PPM2	0.493	0.721	SPM2
SPP19	0.375	0.308	PPM1	0.597	0.403	SPM3
SPP20	0.355	0.655	PPM2	0.591	0.593	SPM4
SPP21	0.273	0.984	PPM2	0.566	0.628	SPM4
SPV1	0.268	0.293	PPM1	0.721	0.403	SPM3
SPV2	0.273	0.500	PPM2	0.780	0.373	SPM3
SPV3	0.520	0.293	PPM3	0.244	0.575	SPM2
SPV4	0.936	0.500	PPM4	0.123	0.403	SPM1
SPV5	0.580	0.500	PPM4	0.122	0.496	SPM1
SPV6	0.600	0.793	PPM4	0.577	0.263	SPM3
SPV7	0.666	0.500	PPM4	0.357	0.388	SPM1
SPV8	0.540	0.707	PPM4	0.341	0.350	SPM1
SPV9	0.333	0.692	PPM2	0.686	0.403	SPM3
SPV10	0.188	0.500	PPM2	0.667	0.221	SPM3

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Supplier Code	*Purchasing Portfolio Matrix* (PPM)		PPM Segment	*Supplier Potential Matrix* (SPM)		SPM Segment
	Supply Risk	*Profit Impact*		*Capabilities*	*Willingness*	
SPV11	0.501	0.308	PPM3	0.451	0.318	SPM1
SPV12	0.520	0.207	PPM3	0.326	0.403	SPM1
SPV13	0.268	0.500	PPM2	0.330	0.310	SPM1
SPV14	0.375	0.362	PPM1	0.328	0.764	SPM2
SPV15	0.520	0.638	PPM4	0.356	0.586	SPM2
SPV16	0.188	0.500	PPM2	0.236	0.499	SPM1
SPV17	0.603	0.500	PPM4	0.612	0.528	SPM4
SPV18	0.273	0.500	PPM2	0.891	0.403	SPM3
SPV19	0.414	0.707	PPM2	0.485	0.505	SPM1
SPV20	0.435	0.500	PPM2	0.475	0.473	SPM3
SPV21	0.666	0.000	PPM3	0.561	0.531	SPM4
SPV22	0.520	0.500	PPM4	0.699	0.616	SPM4
SPV23	0.355	0.692	PPM2	0.573	0.628	SPM4
SPV24	0.354	0.500	PPM2	0.326	0.531	SPM2
SPV25	0.273	0.500	PPM2	0.136	0.636	SPM2
SPV26	0.353	0.308	PPM1	0.600	0.691	SPM4
SPV27	0.545	0.345	PPM3	0.561	0.310	SPM3

Table 11 Supplier segmentation for the PPM model

Segment	Description	Number of suppliers	%
PPM1	*low supply risk & low profit impact*	7	9
PPM2	*low supply risk & high profit impact*	43	58
PPM3	*high supply risk & low profit impact*	5	7
PPM4	*high supply risk & high profit impact*	19	26
	TOTAL	74	100

Table 12 Supplier segmentation for the SPM model

Segment	Description	Number of suppliers	%
SPM1	*low capabilities & low willingness*	25	34
SPM2	*low capabilities & high willingness*	15	20
SPM3	*high capabilities & low willingness*	14	19
SPM4	*high capabilities & high willingness*	20	27
	TOTAL	74	100

From the supplier segmentation results, Table 11 shows that the majority of suppliers are segmented as PPM2 (low supply risk & high profit impact) followed by PPM4, PPM 1 and PPM3 with the following results, there are 7 suppliers in the PPM1 segment, 43 suppliers in the PPM2 segment, 5 suppliers in the PPM3 segment, and 19 suppliers in the PPM4 segment. Then in Table 12 the results show that the number of suppliers in each segmentation is not much different, but the majority of suppliers are segmented in SPM1 (low capabilities & low willingness) followed by SPM4, SPM2, and, SPM3 with the results as follows, there are 25 suppliers in the SPM1 segment, 15 suppliers in the SPM2 segment, 14 suppliers in the SPM3 segment, and 20 suppliers in the PPM4 segment.

Based on the Fig. 3 of the results of the Combined PPM-SPM model, it is explained that the 74 Raw Material suppliers are classified into the PPM and SPM categories, namely there are 7 suppliers in PPM1 (low supply risk & low profit impact) with 2 suppliers in SPM1 (low capabilities and low willingness), 1 Suppliers in SPM2 (low capabilities and high willingness), 2 Suppliers in SPM3 (high capabilities and low willingness), and 2 Suppliers in SPM4 (high capabilities and high willingness); 43 suppliers in PPM2 (low supply risk & high profit impact) with 11 Suppliers in SPM1 (low capabilities and low willingness), 12 Suppliers in SPM2 (low capabilities and high willingness), 8 Suppliers in SPM3 (high capabilities and low willingness), and 12 Suppliers in SPM4 (high capabilities and high willingness). 5 suppliers in PPM3 (high supply risk & low profit impact) with 2 Suppliers in SPM1 (low capabilities and low willingness), 1 Supplier in SPM2 (low capabilities and high willingness), 1 Supplier in SPM3 (high capabilities and low willingness), and 1 Supplier in SPM4 (high capabilities and high willingness); and 19 suppliers in PPM4 (high supply risk & high profit impact) with 10 Suppliers in SPM1 (low capabilities and low willingness), 1 Supplier in SPM2 (low capabilities and high willingness), 3 Suppliers in SPM3 (high capabilities and low willingness), and 5 Suppliers in SPM4 (high capabilities and high willingness).

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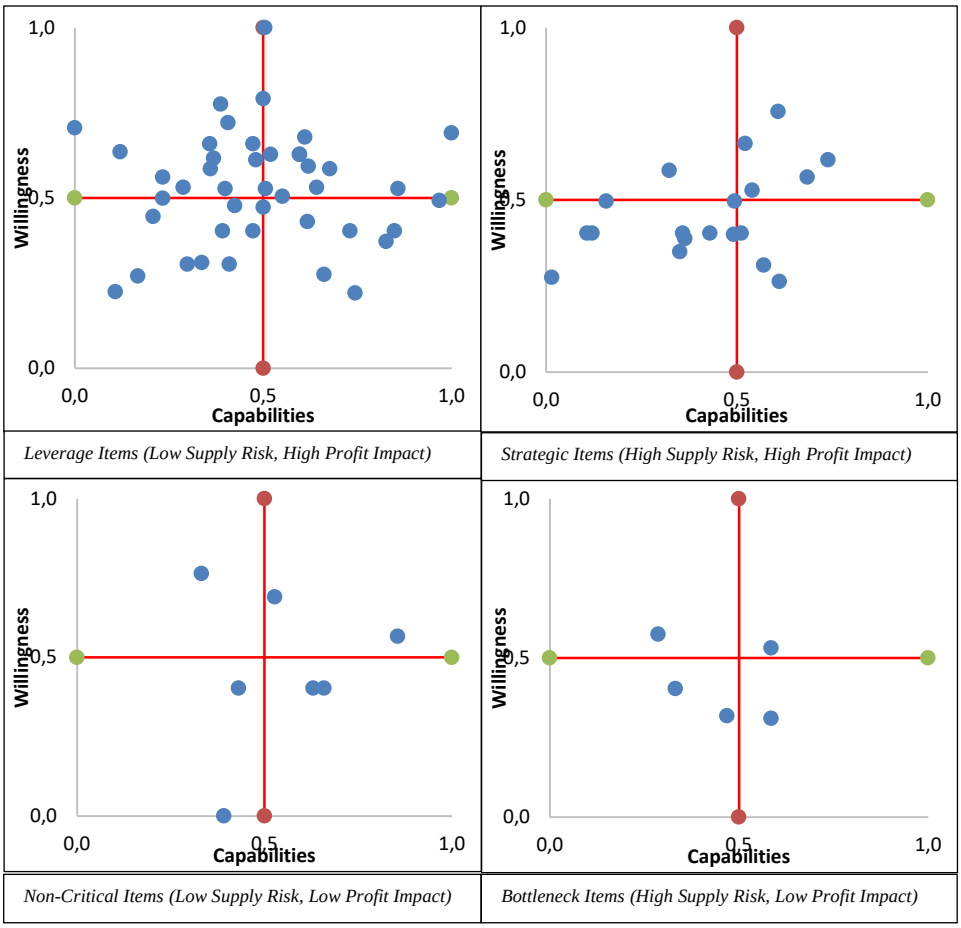

Fig. 3 PPM-SPM combined model results.

Non-Critical Supplier Management Strategy or PPM1 (N=7)

From 7 of the 74 suppliers in the PPM1 segment are suppliers of goods/products that are characterized by low supply risk and low profit impact, in other words, this product has low value and many suppliers provide it. A general strategy that can be carried out is 'Bundling Purchasing Requirements' or combining purchasing requirements.

- Suppliers with low capabilities and low willingness (n=2)
  If the buying company is able to easily find a better alternative supplier, then the best strategy is replacement. If not, it is better to retain the supplier so that the supplier portfolio is more spread out which makes it possible to get price offers and thus obtain higher profits.
- Suppliers with low capabilities and high willingness (n=1)
  The large number of suppliers with the same supply will make it easier for purchasing companies to choose suppliers who are more capable so that the best strategy is replacement. However, if not, other strategies can be carried out to maintain and develop their abilities.
- Suppliers with high capabilities and low willingness (n=2)
  The supplier market for this product is very competitive, so that some capable suppliers have low willingness due to the supportive nature of the market. The best strategy is to develop relationships with suppliers, including increasing the level of supplier willingness and purchasing the majority of the supplier's annual sales.
- Suppliers with high capabilities and high willingness (n=2)
  Suppliers in this segment are the best suppliers for these products, so the best strategy is to maintain good quality relationships and try to expand relationships by purchasing other items. If this supplier is able to supply other products, it could be a good alternative choice for suppliers in the PPM2, PPM3 and PPM4 segments.

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Supplier Leverage Management Strategy or PPM2 (N=43)

From 43 of the 74 suppliers in the PPM2 segment are suppliers of goods/products that are characterized by low supply risk and high profit impact, in other words, there are many suppliers in the market but the product prices are relatively high. The general strategy that can be implemented is 'Adobt Development Strategies' or implementing development strategies.

- Suppliers with low capabilities and low willingness (n=11)
  Because there are many suppliers for this product in the market and the product also has a big impact on the profits of the Buying company. So the best strategy is replacement
- Suppliers with low capabilities and high willingness (n=12)
  As with SPM 1, in SPM2 this is because there are many suppliers for this product on the market and the product also has a big impact on the Buyer's company's profits. So the best strategy is replacement
- Suppliers with high capabilities and low willingness (n=8)
  The high capability of this supplier can provide the expected benefits from the product. However, low supplier willingness is an indication of the supplier's attractiveness in the eyes of the buying company. So the best strategy is to develop relationships with suppliers, including long-term commitment, two-way communication, and building trust
- Suppliers with high capabilities and high willingness (n=12)
  The best supplier for these products, so the best strategy is to maintain a good relationship with this supplier

Supplier Bottleneck Management Strategy or PPM3 (N=5)

From 5 of the 74 suppliers in the PPM2 segment are suppliers of goods/products that are characterized by high supply risk and low profit impact, in other words, even though the product does not have a large profit impact, the supply risk vulnerability of this product is very high. The general strategy that can be implemented is to accept dependence on suppliers, reduce negative impacts, and move towards non-critical segments by looking for alternative suppliers.

- Suppliers with low capabilities and low willingness (n=2)
  This product has very low profits but has high risks, which means that suppliers with low ability and willingness will make it untrustworthy, so the best strategy is replacement. But on the other hand, because the supply market for these products is not very competitive, suppliers have great power, which means purchasing companies are also considering adopting them. The best strategy is development that can increase capabilities and willingness which includes 'supplier assessment and feedback', 'financial and physical investment', 'knowledge transfer', and 'supplier incentives'
- Suppliers with low capabilities and high willingness (n=1)
  The best strategy is to develop supplier capabilities because their willingness can reduce supply risks. The vulnerability of these products is high, so it is necessary to develop technical capabilities and product quality.
- Suppliers with high capabilities and low willingness (n=1)
  The profitability of these products is low, making it difficult for some suppliers to collaborate. A high level of risk can persuade the purchasing company to develop a relationship with the supplier. The best strategy is to build trust, take joint action, and conduct factory visits to suppliers.
- Supplier with high capabilities and high willingness (n=1)
  The best supplier for these products, the best strategy apart from maintaining good relationships, the buying company can try to buy other products and also accept dependence from this supplier.

Strategic Supplier Management Strategy or PPM4 (N=19)

From 19 of the 74 suppliers in the PPM2 segment are suppliers of goods/products that are characterized by high supply risk and high profit impact, in other words, these products are the most important goods and require more attention. General strategies that can be carried out are 'maintain a strategic partnership', 'accept a locked-in partnership', or 'terminate a partnership'.

- Suppliers with low capabilities and low willingness (n=10)
  Because the impact of these suppliers is so large on both profits and supply risk, the best strategy is replacement. If this does not work, because the number of suppliers is limited, the buying company is advised to implement strategies, namely financial and physical investment, knowledge transfer, conducting mutual assessments with suppliers, and providing incentives to suppliers.

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- Suppliers with low capabilities and high willingness (n=1)
  A high level of supplier willingness can reduce the level of risk because they are willing to work together. So the best strategy is to develop the technical and product quality of this supplier.
- Suppliers with high capabilities and low willingness (n=3)
  A high level of supplier capability has a positive impact on the profits of the purchasing company, which means the supplier is valuable. So the best strategy is long-term commitment and building trust.
- Suppliers with high capabilities and high willingness (n=5)
  The high level of supplier ability and willingness means that the purchasing company does not need to worry about the high level of product risk involved. So the best strategy is for buyers to develop strategies designed to continue developing relationships with this supplier, because it is likely that other buying companies will find this supplier very attractive.

Based on the results of data collection and processing obtained from this research, the limitation is that this research only focuses on supplier segmentation and strategy design. It is hoped that the results of the two supplier segmentation approaches, namely the Purchasing Portfolio Matrix (PPM) and the Supplier Potential Matrix (SPM), will provide a significant contribution to companies that previously still implemented traditional strategies where new problems were handled so that by designing this strategy, it is hoped that the company can be responsive with strategy and segmentation recommendations resulting from this research. From the 74 supplier data collected, processed using the Best Worst Method (BWM) with Solver Excel, we obtained a weighting for each criterion so that strategies could be formulated for different segments.

4. Conclusion

By integrating the PPM and SPB matrices, 74 raw material suppliers in the case of furniture companies were successfully classified into four supplier segments. The most dominant are in the PPM2 (low supply risk & high profit impact) with 43 suppliers, followed by the PPM4 (high supply risk & high profit impact) with 19 suppliers, PPM 1 (low supply risk & low profit impact) with 7 suppliers, and the fewest are PPM3 (high supply risk & low profit impact) with 5 suppliers. The best strategy that can be applied in each dimension, in PPM1 (Non-Critical) is bundling purchasing requirements, replacement suppliers, developing technical capabilities of suppliers, purchasing most of the supplier's annual sales and purchasing other items sold by the supplier; in PPM2 (Leverage) are adopt development strategies, supplier replacement, long-term commitment by making supplier cooperation contracts, two-way communication with suppliers to share information, and building supplier trust; in PPM3 (Bottleneck) is accepting dependence on suppliers by accepting repeated purchasing cooperation within a certain time, reducing negative impacts that will occur, moving towards non-critical segments by looking for alternative suppliers, making supplier assessments and feedback, financial and physical investment in suppliers, knowledge transfer to suppliers, providing supplier incentives, developing technical capabilities and product quality, building supplier trust, joint action, and conducting factory visits to suppliers; and in PPM4 (Strategic) are maintain a strategic partnership, accept a locked-in partnership, terminate a partnership, financial and physical investment in suppliers, transfer knowledge to suppliers, carry out mutual assessments with suppliers, and provide incentives to suppliers, long-term commitment long with making supplier cooperation contracts, and developing relationships with suppliers.

From these results, it is hoped that future research can use a combination of methods with other MCDM methods such as AHP so that the results are more accurate and implemented directly in companies to assess the effectiveness of the strategies implemented.

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