5. ANALYTICS IN THE AREA OF SUPPLY AND PURCHASING

The chapter discusses procurement and purchasing strategy. One of the most important challenges in this area is the evaluation and selection of the right suppliers. The most important issues discussed in this chapter include:

- the role and importance of procurement and purchasing,
- division of procurement and purchasing strategies,
- selected methods of evaluating and selecting suppliers.

5.1. Introduction

Supply (supply logistics) is assigned to both basic and auxiliary functions. It contributes to gaining competitive advantage through, among others, selecting suppliers who:

- offer high-quality raw materials at the lowest possible price, contributing to increased customer satisfaction,
- guarantee innovative technologies, which translates into introducing new solutions and products to the market,
- apply sustainable practices that reduce waste and improve the company's image.

Supply allows for obtaining equipment, materials and components necessary for the production of one's own finished product or for selling goods to subsequent links in the supply chain. Supply logistics also connects participants in the supply chain and ensures the desired quality created by suppliers in this chain (Coyle, et al., 2002). Supply also includes activities related to the analysis of the available (current) stock of materials and components that are at the company's disposal. An equally important activity performed in the area of supply

logistics is the planning of material requirements based on production plans or orders from customers and on the basis of the structure (specification) of the product manufactured by the company. Supply also includes supervising and responding to changes in delivery conditions (changes in the date, assortment, quantity, etc.). Therefore, it means obtaining something in a planned manner.

Purchasing, on the other hand, is one of the stages of supply logistics. It means purchasing goods and services. However, this is a rather narrow perception of purchasing, which treats purchasing in a way that is separate from other functions performed in the company. The concept of purchasing should be understood as an exchange transaction that begins when material needs are known (Kowalska, 2005). It is preceded by the selection of the source of supply (supplier or subcontractor) and activities consisting in negotiating prices and the deadline for completing the order. Purchasing is a transaction in which a customer purchases a product or service, and the supplier receives payment for it. It therefore includes four stages: (1) specifying the type of purchase; (2) determining the necessary level of expenditure; (3) implementing the actual purchasing process; (4) assessing the effectiveness of the completed purchasing process.

The terms purchasing, supply and supply purchasing are often treated as synonymous terms. However, it should be remembered that these terms differ from each other – their scope is different. Purchases are a narrower concept than supply. Supply purchasing, on the other hand, concerns the acquisition of goods and services needed for the production process.

The role and importance of purchasing and supply in an enterprise largely depend on the availability of industrial and commercial goods. The greater the problem and difficulty in obtaining and purchasing goods (e.g. an unstable market subject to seasonal cycles, shortages and price instability), the more strategic the supply and purchase become. On the other hand, the more standard the type of goods and the generally high level of availability on the market, the less important the supply and purchase. This role is also different if the enterprise has a significant part of its capital tied up in material goods. The associated cost means that more effective management of supply and purchase will affect better management of the enterprise's capital and greater savings. This means that the role of supply and purchase will

increase in enterprises where the degree of capital intensity (the share of costs of material goods and related operations in the finished product) of this process is high.

5.2. Sourcing and purchasing strategies – division by supply sources

Due to the possible sources of supply, several different supply and purchasing strategies can be distinguished. They can be differentiated in terms of the number of supply sources. In such a situation, the following strategies can be indicated (Grzybowska, 2011):

- single source of supply (one supplier); (single sourcing) means that based on established criteria, one supplier is selected, who is responsible for the supply of a specific assortment item or assortment group. This solution ensures maintaining close contacts between the recipient and one supplier selected and preferred by the company. It allows for building lasting relationships and relations between business partners, often on the basis of a long-term partnership and agreement. Lasting relationships, stability of cooperation and collaboration, and uniform quality of delivered goods or services are the undoubted advantages of this solution. The disadvantage of the applied strategy is the risk associated with having only one supplier. This is primarily the risk that there will be a loss of continuity of supplies, which may be caused by disruptions in the supply chain and the risk of the buyer becoming dependent on one supplier. This is especially the case when the supplier is a monopolist. In special cases, a supplier monopoly may occur when there are no alternative sources of supply on the market.

- two sources of supply (two suppliers); (dual sourcing) which means purchasing from two equal suppliers who supply the same type of product range or group of products. Cooperation between the buyer and two suppliers is based on the 50-50 principle – the division of orders and purchases is evenly distributed between them. The dual purchase strategy may also take the form of uneven division and differentiation of cooperation between two selected suppliers. This is a see-saw strategy. As the name suggests, this strategy uses the see-saw principle of order

distribution. The division of purchases is uneven (e.g. 70% one supplier, 30% the other supplier). The proportions of orders allocated to suppliers may change depending on the proposed price of the purchase item and its quality. Although these companies have the same rights, there is competition between them for a larger share. This is undoubtedly the driving force of this strategy.

- multiple sources of supply (multiple suppliers), (multiple sourcing) means using the services of multiple suppliers and subcontractors. This strategy ensures high supply security. It is characterized by the triad: multiple suppliers – multiple relationships – multiple strategies. It usually concerns components for the finished product, which are not strategic. The multiple supplier strategy says that it is necessary to use and cooperate with a relatively large number of suppliers, with whom the company creates various types of relationships, levels of cooperation and different transactions. The strategy guarantees the continuity and reliability of supplies. It also allows not to become dependent on a single supplier. The competition existing between suppliers also ensures constant raising of the buyer's requirements and expectations. Problems may occur with maintaining an equal level of quality and technical parameters of both purchased goods and services provided. It is impossible to conduct joint research and development work with such a large number of alternative suppliers.

Another example of a supply and purchasing strategy is the division according to the subject of the purchase. The following strategies can be distinguished (Grzybowska, 2011):

- purchases of individual elements (unit sourcing), which is directed to manufacturing companies that purchase the subject of the purchase in the form of uncomplicated components (simple elements: parts, details, etc.), from which they then produce a finished product. In this solution, the degree of separation of production activities to the outside (outsourcing) is small. It assumes a high degree of vertical integration of production. There is a very high probability that a manufacturing company (buyer) will gather around itself many or very many suppliers of various material goods from which the finished product is manufactured.

- modular purchases (modular sourcing), which means moving away from acquiring individual elements in favour of ready-made assembly modules or complex components that are assembled into a final product.

5.3.   Supplier Evaluation and Selection Methods

The evaluation of candidate suppliers is based on criteria established for supplier selection. Experts conduct these evaluations using various decision-making methods. Supplier selection is one of the most critical activities related to purchasing management in the supply chain (Amid et al., 2006). Supplier selection is the basis for long-term supplier partnerships that can significantly contribute to the success or failure of a company (Ali et al., 2023). The decision-making process for supplier evaluation and selection is influenced by the following elements: (1) evaluation method used; (2) minimum order quantity; (3) sourcing strategy; (4) supplier production capacity; (5) product type; (6) type of supplier evaluation; (7) supplier location preferences; (8) supplier selection criteria; (9) production strategy; and (10) supplier production capacity (Nowakowski & Werbińska-Wojciechowska, 2012; de Boer, et al. 2001).

A number of methods and techniques are known for supplier evaluation and selection. Below are some of the classifications (Benyoucef et al., 2003):

- elimination methods, which help companies in the supplier selection process by gradually eliminating those who do not meet certain criteria. One of the elimination methods is the point method, in which each supplier is evaluated based on a set of criteria, such as price, quality, timeliness of delivery, etc. Suppliers who do not reach the minimum number of points are eliminated. A subcategory in this group is the weighted supplier evaluation method.
- optimization methods, which help companies make decisions regarding the selection of the best suppliers based on various criteria. One of the more popular optimization methods is the multi-criteria method (Analytic Hierarchy Process, AHP), which consists of hierarchically ordering criteria and evaluating suppliers based on these criteria. AHP allows for the inclusion of both quantitative and qualitative criteria.

- probabilistic methods, which take into account uncertainty and variability of data in the decision-making process. One of the methods of this group is the TOPSIS method with probabilistic information.

Much attention is currently paid to the problems related to supplier selection and supplier allocation, which are becoming increasingly difficult to solve over time (Khazaei et al., 2023). Supplier selection in today's competitive market is the most important function for the success of the overall cycle efficiency and supply chain organization (Dweiri et al., 2016).

5.4. Supplier evaluation criteria

Determining the right criteria for supplier evaluation enables the best possible choice to be made later. These criteria influence and determine the evaluation of subcontractors' offers. The detailed criteria for supplier evaluation (Fig. 5.1) and their expansion with important parameters (Tables 5.1-5.4) are worth noting.

Assessment criteria

Price/costs and payment terms

Delivery terms

Goods quality

Supplier potential
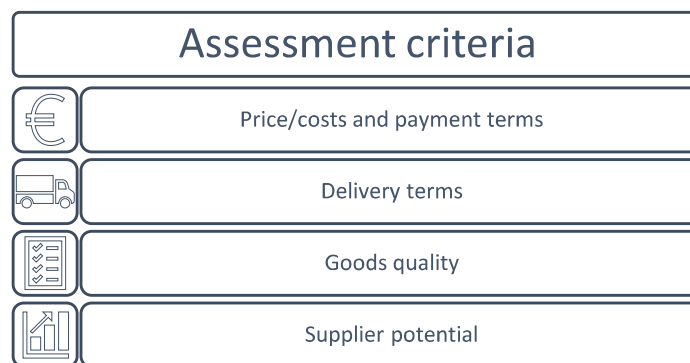
Figure 5.1. Selected supplier evaluation criteria

Source: (Midor & Biały, 2019)

For example, Ha and Krishnan (2008) mentioned that price, quality and delivery are the three most frequently used attributes. Similarly, Koul and Verma (2012) also considered price, quality, cost and service as the main criteria for supplier selection.

One of the key criteria for evaluating suppliers is price (costs) and payment terms (Table 5.1). Price and delivery costs directly affect the total cost of production. The level of profit margin also depends on them. It is also worth remembering that payment terms, such

as payment terms and credit availability, affect the financial liquidity of the company. Therefore, flexible payment terms can help manage cash flow and avoid liquidity problems.

Table 5.1. Development of supplier evaluation criteria – Price/costs and payment terms

Evaluation criterion	Characteristic parameters
Price/costs and payment terms	- price competitiveness - price stability or variability over a longer period of time - payment terms - possibility of crediting the delivery - scope of discounts granted for larger orders - scope of discounts granted for long-term cooperation - willingness to negotiate prices - delivery costs; transport costs - hidden (additional) costs not directly visible in the price offer - quality-related costs related to complaints, returns, repairs

Source: own study

Table 5.2. Development of supplier evaluation criteria – Supplies

Evaluation criterion	Characteristic parameters
Deliveries	- timeliness of deliveries - regularity; frequency of deliveries - completeness of deliveries - accuracy/assortment consistency of deliveries - method of packaging and securing goods - quantitative flexibility; timely flexibility of deliveries - convenience of placing orders - possibility of managing the logistics of deliveries by the supplier (e.g. transport, storage) - reliability of deliveries

Source: own study

Table 5.3. Development of supplier evaluation criteria – Product quality

Evaluation criterion	Characteristic parameters
Product quality	- technical quality of the product - quality guarantees - product reliability - product safety - technical service - product compliance with norms and standards - product functionality - product durability - quality control system - ease of repair or maintenance of the product - impact of the product on the natural environment (ecological character)

Source: own study

Table 5.4. Development of supplier evaluation criteria – Supplier potential

Evaluation criterion	Characteristic parameters
Supplier potential	- production capacity - technological availability - availability of technical, human and material resources - innovation potential - logistic and operational efficiency - supplier experience - management and organisational capabilities - supplier's market position (market share; reputation) - possibilities of introducing new technologies, products or processes

Source: own study

However, price is not the only criterion for evaluating suppliers. Delivery terms are an equally important criterion (Table 5.2). The supplier's ability to deliver on time, regularly or flexibly is essential to avoid production downtime and ensure continuity of operations.

Another important criterion for evaluating suppliers is the quality of the goods delivered (Table 5.3). High quality goods (raw materials, materials, components) affect the quality of the manufactured product, and as a result leads to customer satisfaction. This in turn increases loyalty and repeatability of purchases and affects the reputation of the company that makes the purchase.

When evaluating and selecting a supplier, attention can also be paid to the supplier's potential for further development (Table 5.4). This criterion refers to parameters that help determine whether the supplier will be able to meet future challenges and market requirements in the short/long term.

5.5.   Weighted Point Method

The most commonly used quantitative supplier evaluation method is the evaluation method, which is based on a weighted evaluation (Burdzik, 2017). In this method, the order of selected supplier evaluation criteria is first determined and a weighted factor (weight) is assigned to them. The weighted factor refers to the importance of the selected evaluation criterion.

Companies often use the weighted point system because it is highly reliable and its implementation costs are moderate. In addition, it combines qualitative and quantitative performance factors into a common system. Because decision makers can change the weighted factors assigned to each criterion or change them independently depending on the strategic prioritiesof the company. Thus, the system is flexible (Arsan & Shank, 2011; Maláková, et al., 2020).

The supplier's evaluation is obtained by multiplying each criterion score by a predetermined weighted factor. Then, the obtained values are summed. The preference score (P_S) denotes the supplier's evaluation.

The above shows the formal model:

$P_S = \sum_{y=1}^{n}(O_i \bullet \varpi_i)$

Where

P_S – preference score

O – criterion evaluation

ϖ – weighted coefficient.

The weighted coefficient should:

- Be in the range $< 0,1 >$,
- Each subsequent weighted coefficient used is smaller than its predecessor $\varpi_i > \varpi_{i+1} > \varpi_{i+2}$,
- The sum of all weighted coefficients must be equal to 1: $\sum_1^n \varpi_i = 1$,
- The number of weighted coefficients depends on the number of criteria analyzed.

The above is explained by the formula used in Excel

for a weighted average with five selected supplier evaluation criteria:

preference score(supplier 1) = (rating(criterion 1) * ω(1)) + (rating(criterion 2) * ω(2)) + (rating(criterion 3) * ω(3)) + (rating(criterion 4) * ω(4)) + (rating(criterion 5) * ω(5))

The proposed procedure and description of the calculation process are presented below.

Task content

Evaluate suppliers for the selected assortment item.

[1] Preparing a data sheet; Listing the criteria and assigning weighted coefficients.

[2] Establishing a scale of assessment of individual criteria.

[3] Establishing a set of suppliers subject to assessment; Assigning assessments to individual criteria and suppliers.

[4] Calculating a weighted average for each supplier subject to assessment.

[5] Drawing a graph containing the criteria and their assessment by suppliers.

[6] Performing an analysis and, on its basis, selecting the best supplier; determining which supplier will receive the best assessment

The selected criteria are:

- Quality of the bicycle part (parts do not break, are durable, no complaints),
- Price of the bicycle part (the lower the better),
- Timeliness of deliveries (deliveries are delivered on time),
- Reliability of deliveries (products arrive intact, without damage),
- Compliance of the goods with expectations (the goods arrive exactly as ordered),
- Ordering procedure (simple and intuitive ordering).

The assigned weighted coefficients are as follows:

- Quality of the bicycle part – 30%,
- Price of the bicycle part – 25%,
- Timeliness of deliveries – 15%,
- Reliability of deliveries – 10%,
- Compliance of the goods with expectations – 10%,
- Ordering procedure – 10%.

It was indicated that the assessment of individual criteria will be made on the basis of a 10-point assessment (1-10), where:

- 10 – Very good (perfect fulfillment of the criterion),
- 7–9 – Good (minor problems),
- 4–6 – Average (partial fulfillment, a few problems),
- 2–3 – Poor (numerous problems),
- 1 – Very bad (no fulfillment of the criterion).

It was indicated that five companies supplying bicycle parts were selected for the supplier assessment. These are companies coded: A1, B2, C3, D4, E5.

Excel example:

[1] Prepare a spreadsheet with data; list the criteria and assign weighted coefficients.

Assessment ctiteria	Criterion weight	Supplier assessment				
		A1	B2	C3	D4	E5
Quality	30%					
Price	25%					
Punctuality	15%					
Reliability	10%					
Compatibility	10%					
Ordering procedure	10%					

[2] Define the scale of evaluation of individual criteria according to the established scale and assign them to each supplier who is subject to evaluation.

Assessment ctiteria	Criterion weight	Supplier assessment				
		A1	B2	C3	D4	E5
Quality	30%	9	4	6	10	8
Price	25%	7	9	6	9	7
Punctuality	15%	8	9	7	8	8
Reliability	10%	9	8	4	9	9
Compatibility	10%	10	8	7	10	5
Ordering procedure	10%	8	7	6	10	8

[3] Calculate the weighted averages for each supplier being assessed; The formula for calculating the weighted average for a single supplier is shown below.

fx =D4*C4+D5*C5+D6*C6+D7*C7+D8*C8+D9*C9

Assessment ctiteria	Criterion weight	Supplier assessment				
		A1	B2	C3	D4	E5
Quality	30%	9	4	6	10	8
Price	25%	7	9	6	9	7
Punctuality	15%	8	9	7	8	8
Reliability	10%	9	8	4	9	9
Compatibility	10%	10	8	7	10	5
Ordering procedure	10%	8	7	6	10	8
	Preference score	8,35	7,1	6,05	9,35	7,55

For each supplier, calculate the weighted average, which takes into account the ratings and the weights for a given criterion. To do this, calculate the sum of the products of the rating and the weight for each criterion for each supplier. Copy the formula with absolute addresses for the remaining suppliers;

To copy the formula, it is worth using absolute addresses for the cells that contain the weight of a given criterion.

[4] Draw a chart containing the criteria and their assessment by suppliers;

To visualize the result, it is worth making a radar chart that will show the assessment of each criterion (chart axes) by supplier (colored lines).
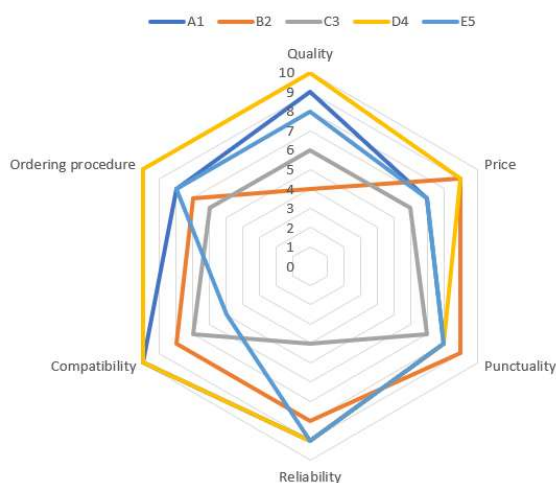
The perfect state of the supplier's selected criteria will be the "circle" figure, while the imperfect state will be point 0 "the center".

[5] Perform the analysis and select the best supplier based on it; determine which supplier received the best rating.

Assessment criteria	Criterion weight	Supplier assessment				
		A1	B2	C3	D4	E5
Quality	30%	9	4	6	10	8
Price	25%	7	9	6	9	7
Punctuality	15%	8	9	7	8	8
Reliability	10%	9	8	4	9	9
Compatibility	10%	10	8	7	10	5
Ordering procedure	10%	8	7	6	10	8
	Preference score	8,35	7,1	6,05	9,35	7,55

In order to determine the supplier that best meets the criteria adopted during the analysis, the supplier with the highest preference score is selected.

After performing the analysis, it is possible to indicate which supplier best meets the criteria indicated in the company. Cooperation should be established with this supplier. In the event that the purchasing strategy indicates that there should be two suppliers for a given purchase item, the next supplier with the highest preference score should be selected.

The results of the obtained analysis of the supplier evaluation using the weighted average method can be presented in a clear way on a graph. The highest preference score also means the highest sum of weighted scores of the selected criteria.

5.6.   Multi-criteria method

The Analytic Hierarchy Process (AHP) is a commonly used procedure for solving problems related to strategic decisions, also for evaluating and selecting suppliers (Ossadnik & Lange, 1999). AHP is a common multi-criteria decision-making method. It was developed to help solve complex decision-making problems. It takes into account both subjective and objective evaluation measures (Dweiri et al., 2016). AHP uses a pairwise comparison of evaluation criteria with respect to an objective. This pairwise comparison allows determining the relative importance of criteria with respect to the main objective. If quantitative data is available, comparisons can be easily made based on a defined scale. This makes the analysis result guarantee an excellent evaluation. The AHP method is an intuitive method for formulating and

analyzing decisions. It is based on a subjective methodology. It consists of three main principles: (1) hierarchical structure, (2) priority analysis, and (3) consistency verification (Cheng et al., 2007).

The proposed procedure and description of the calculation process are presented below.

Task content

Evaluate suppliers for the selected assortment item.

[1] Preparation of data sheet; Listing of criteria.

[2] Compare criteria in pairs (scale 1, 2, 3, 4, 5).

[3] Calculate the sum for each criterion.

[4] Calculate the share of each cell in the sum for each criterion.

[5] Calculate global preferences for each criterion.

[6] Show global preferences for each criterion.

[7] Indicate suppliers (A1, B2, C3, D4).

[8] Calculate local preferences for each criterion and supplier.

[9] Calculate the share of each cell in the sum for each criterion and supplier.

[10] Calculate local preferences for each criterion and supplier.

[11] Show local preferences for each supplier for a given criterion.

[12] Establish a ranking of suppliers.

[13] Select a supplier.

The selected criteria are:

- Quality of the bicycle part (parts do not break down, are durable, no complaints),
- Price of the bicycle part (the lower the better),
- Timeliness of deliveries (deliveries are delivered on time),
- Reliability of deliveries (products arrive intact, without damage).

The scale of comparison of criteria was selected:

- 1 – just as good / important,

- 2 – slightly better / more important,
- 3 – definitely better / more important,
- 4 – much better / more important,
- 5 – extremely better / more important.

It was indicated that five companies supplying bicycle parts were selected for the assessment of suppliers. These are companies coded: A1, B2, C3, D4.

Excel example:

[1] Prepare a data sheet; list the criteria.

[2] Compare criteria in pairs (scale 1, 3, 5).

Comparing criteria in pairs allows you to determine which of them is more important. The comparison is made according to the adopted scale.

For example: quality is extremely more important than price, which means choosing a rating of 5. To compare the criteria in the order price and quality, the inverse of the previous rating is taken, i.e. 1/5.

	Quality	Price	Punctuality	Reliability
Quality	1	5	3	2
Price	1/5	1	3	1
Punctuality	1/3	1/3	1	1/5
Reliability	1/2	1	5	1

[3] Calculate the sum for each criterion in the column.

Then sum the scores awarded from the pairwise comparison of criteria in the columns.

✓ : ✗ ✓ fx	=SUM(C12:C15)			
B	C	D	E	F
	Quality	Price	Punctuality	Reliability
Quality	1,00	5,00	3,00	2,00
Price	0,20	1,00	3,00	1,00
Punctuality	0,33	0,33	1,00	0,20
Reliability	0,50	1,00	5,00	1,00
Sum	=SUM(C12:C15)	7,33	12,00	4,20

[4] Count the share of each cell in the total for each criterion.

Next, you need to count the share of a given criterion in the total for that criterion. The example shows the appropriate cells in the formula bar, the values look like this for the quality criterion: 1: 2.03 = 0.49; 0.20: 2.03 = 0.10; 0.33: 2.03 = 0.16; 0.50: 2.03 = 0.25. The sum of the shares must be 1.

C21		fx	=C12/C16		
	A	B	C	D	E	F
10						
11			Quality	Price	Punctuality	Reliability
12		Quality	1,00	5,00	3,00	2,00
13		Price	0,20	1,00	3,00	1,00
14		Punctuality	0,33	0,33	1,00	0,20
15		Reliability	0,50	1,00	5,00	1,00
16		Sum	2,03	7,33	12,00	4,20
17						
18						
19						
20			Quality	Price	Punctuality	Reliability
21		Quality	0,49	0,68	0,25	0,48
22		Price	0,10	0,14	0,25	0,24
23		Punctuality	0,16	0,05	0,08	0,05
24		Reliability	0,25	0,14	0,42	0,24
25		Sum	1,00	1,00	1,00	1,00

[5] Calculate global preferences for each criterion.

Calculating global preferences for each criterion is a row-wise calculation of the average shares for each criterion. This calculation allows us to determine the global share of this criterion in the entire evaluation to which the suppliers will be subjected.

	fx	=average(C21:F21)			
	B	C	D	E	F	G
		Quality	Price	Punctuality	Reliability	W (average)
	Quality	0,49	0,68	0,25	0,48	=average(
	Price	0,10	0,14	0,25	0,24	0,181
	Punctuality	0,16	0,05	0,08	0,05	0,085
	Reliability	0,25	0,14	0,42	0,24	0,259
	Sum	1,00	1,00	1,00	1,00	1,00

[6] Show global preferences for each criterion.

The graphical form allows for a better presentation of the preferences of a given criterion in relation to the selection of the supplier.
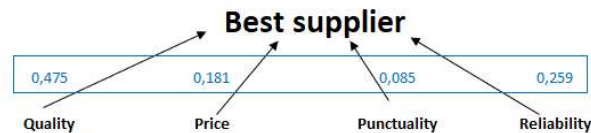
[7] Indicate suppliers (A1, B2, C3, D4).

[8] Compare suppliers in pairs according to each criterion (scale 1-7).

Comparing suppliers in pairs allows you to determine which of them meets a given criterion better. The comparison is performed according to the adopted scale. The adopted scale for comparing suppliers is 1-7, where 1 means that the suppliers are equally good, 7 - the supplier is extremely better, the remaining values are in between.

The comparison of suppliers is performed for each criterion separately.

For example: for the quality criterion, supplier A1 is as good as supplier B2 (score 1), supplier A1 is slightly better than suppliers C3 and D4 (score 3). To compare suppliers in the reverse order (B2 and A1, C3 and A1, D4 and C3), the inverse of the previous score is taken (i.e., 1/1, 1/3, 1/3, respectively).

Then, the scores awarded from the pairwise comparison of suppliers are summed up in the columns.

Quality	A1	B2	C3	D4
A1	1,00	1,00	3,00	3,00
B2	1,00	1,00	0,20	3,00
C3	0,33	5,00	1,00	0,33
D4	0,33	0,33	3,00	1,00
Sum:	2,66	7,33	7,20	7,33

Punctuality	A1	B2	C3	D4
A1	1,00	3,00	0,33	3,00
B2	0,33	1,00	0,20	3,00
C3	3,00	5,00	1,00	5,00
D4	0,33	0,33	0,20	1,00
Sum:	4,66	9,33	1,73	12,00

Price	A1	B2	C3	D4
A1	1,00	5,00	7,00	4,00
B2	0,20	1,00	3,00	1,00
C3	0,14	0,33	1,00	0,33
D4	0,25	1,00	3,00	1,00
Sum:	1,59	7,33	14,00	6,33

Reliability	A1	B2	C3	D4
A1	1,00	0,20	3,00	5,00
B2	5,00	1,00	5,00	5,00
C3	0,33	0,20	1,00	0,33
D4	0,20	0,20	3,00	1,00
Sum:	6,53	1,60	12,00	11,33

[9] Calculate the share of each cell in the total for each criterion and supplier.

The share of a given supplier in the total for this supplier with respect to each criterion should be calculated.

In the example in the first table for the quality criterion, the formula bar shows the appropriate cells, in the values it looks like this for supplier A1: 1:

2.66 = 0.38; 1: 2.66 = 0.38; 0.33: 2.66 = 0.12; 0.33: 2.66 = 0.12. The sum of the shares must be 1.

	f_x	=C3/C7									

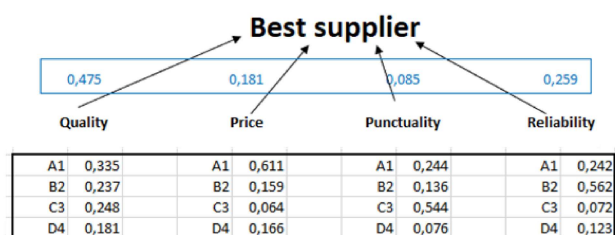| B	C	D	E	F	G	H	I	J	K	L
Quality	A1	B2	C3	D4		**Quality**	A1	B2	C3	D4
A1	1,00	1,00	3,00	3,00		A1	0,38	0,14	0,42	0,41
B2	1,00	1,00	0,20	3,00		B2	0,38	0,14	0,03	0,41
C3	0,33	5,00	1,00	0,33		C3	0,12	0,68	0,14	0,05
D4	0,33	0,33	3,00	1,00		D4	0,12	0,05	0,42	0,14
Sum:	2,66	7,33	7,20	7,33		Sum:	1,00	1,00	1,00	1,00
Price	A1	B2	C3	D4		**Price**	A1	B2	C3	D4
A1	1,00	5,00	7,00	4,00		A1	0,63	0,68	0,50	0,63
B2	0,20	1,00	3,00	1,00		B2	0,13	0,14	0,21	0,16
C3	0,14	0,33	1,00	0,33		C3	0,09	0,05	0,07	0,05
D4	0,25	1,00	3,00	1,00		D4	0,16	0,14	0,21	0,16
Sum:	1,59	7,33	14,00	6,33		Sum:	1,00	1,00	1,00	1,00
Punctuality	A1	B2	C3	D4		**Punctuality**	A1	B2	C3	D4
A1	1,00	3,00	0,33	3,00		A1	0,21	0,32	0,19	0,25
B2	0,33	1,00	0,20	3,00		B2	0,07	0,11	0,12	0,25
C3	3,00	5,00	1,00	5,00		C3	0,64	0,54	0,58	0,42
D4	0,33	0,33	0,20	1,00		D4	0,07	0,04	0,12	0,08
Sum:	4,66	9,33	1,73	12,00		Sum:	1,00	1,00	1,00	1,00
Reliability	A1	B2	C3	D4		**Reliability**	A1	B2	C3	D4
A1	1,00	0,20	3,00	5,00		A1	0,15	0,13	0,25	0,44
B2	5,00	1,00	5,00	5,00		B2	0,77	0,63	0,42	0,44
C3	0,33	0,20	1,00	0,33		C3	0,05	0,13	0,08	0,03
D4	0,20	0,20	3,00	1,00		D4	0,03	0,13	0,25	0,09
Sum:	6,53	1,60	12,00	11,33		Sum:	1,00	1,00	1,00	1,00

[10] Calculate local preferences for each criterion and supplier.

Calculating local preferences for each supplier for each criterion is a matter of calculating the average shares for each supplier in the rows. This calculation allows us to determine the local share of this supplier for a given criterion in the evaluation.

| fx | =average(I3:L3) | | | | |

	H	I	J	K	L	M
	Quality	A1	B2	C3	D4	**U(Quality)**
	A1	0,38	0,14	0,42	0,41	=average(I3:L3)
	B2	0,38	0,14	0,03	0,41	0,237
	C3	0,12	0,68	0,14	0,05	0,248
	D4	0,12	0,05	0,42	0,14	0,181
	Sum:	1,00	1,00	1,00	1,00	1,00
	Price	A1	B2	C3	D4	**U(Price)**
	A1	0,63	0,68	0,50	0,63	0,611
	B2	0,13	0,14	0,21	0,16	0,159
	C3	0,09	0,05	0,07	0,05	0,064
	D4	0,16	0,14	0,21	0,16	0,166
	Sum:	1,00	1,00	1,00	1,00	1,00
	Punctuality	A1	B2	C3	D4	**U(Punctuality)**
	A1	0,21	0,32	0,19	0,25	0,244
	B2	0,07	0,11	0,12	0,25	0,136
	C3	0,64	0,54	0,58	0,42	0,544
	D4	0,07	0,04	0,12	0,08	0,076
	Sum:	1,00	1,00	1,00	1,00	1,00
	Reliability	A1	B2	C3	D4	**U(Reliability)**
	A1	0,15	0,13	0,25	0,44	0,242
	B2	0,77	0,63	0,42	0,44	0,562
	C3	0,05	0,13	0,08	0,03	0,072
	D4	0,03	0,13	0,25	0,09	0,123
	Sum:	1,00	1,00	1,00	1,00	1,00

[11] Show local preferences for each supplier with respect to a given criterion. The graphical form allows for a better presentation of the preferences of a given supplier with respect to each criterion.

Best supplier

	0,475		0,181		0,085		0,259

Quality		**Price**		**Punctuality**		**Reliability**	
A1	0,335	A1	0,611	A1	0,244	A1	0,242
B2	0,237	B2	0,159	B2	0,136	B2	0,562
C3	0,248	C3	0,064	C3	0,544	C3	0,072
D4	0,181	D4	0,166	D4	0,076	D4	0,123

[12] Establish a supplier ranking. Establishing a supplier ranking involves calculating for each supplier the sum of the products of the weight for each criterion and the supplier's rating for that criterion.

	Global Preference	W		Quality		Price		Punctuality		Reliability	
	Quality	0,475		A1	0,335	A1	0,611	A1	0,244	A1	0,242
	Price	0,181		B2	0,237	B2	0,159	B2	0,136	B2	0,562
	Punctuality	0,085		C3	0,248	C3	0,064	C3	0,544	C3	0,072
	Reliability	0,259		D4	0,181	D4	0,166	D4	0,076	D4	0,123

*Formula bar: =K3*N3+K4*P3+K5*R3+K6*T3*

supplier 1	A1	0,353
supplier 2	B2	0,299
supplier 3	C3	0,194
supplier 4	D4	0,154

[13] Select a supplier.

The results obtained can be presented graphically. In the analyzed example, the highest evaluation result was received by supplier A1.

5.7.　Resilient Suppliers

Suppliers and subcontractors are considered to be the main sources of risk that cause massive disruptions in supply chains (Pramanik et al., 2017). Moreover, many supply chain processes are dependent on the supplier. Therefore, selecting resilient suppliers can significantly reduce purchasing costs, delay times, and increase the company's competitiveness and customer satisfaction (Davoudabadi et al., 2020). Supplier resilience assessment is therefore one of the most important ways to enter the world of supply chain resilience, as suppliers are one of the main sources of vulnerability in supply chains.

According to Sheffi and Blayney Rice (2005), resilience in companies and supply chains can be built in three general ways: (1) creating redundancy throughout the supply chain (e.g., additional inventory, low capacity utilization, multiple sourcing), (2) increasing supply chain flexibility (e.g., flexible means of transportation in the event of disruptions, parallel processes instead of sequential, sourcing strategies tailored to supplier relationships), and (3) changing corporate culture (e.g., continuous communication between informed employees, preparation for disruptions).

Table 5.5. Resistance criterion

Resistance Criterion	Explanation
Pollution Control Initiatives	Effort related to pollution minimization initiatives regarding solid waste, water wastage, air emissions etc.
Investment in transmission capacity	A level of safety stock taken into account to minimize the risk of stock-outs due to uncertainty.
Speed of response	The ability of suppliers to respond to market fluctuations in the shortest time possible.
Ability to maintain strategic stockpiles for emergencies	It shows zero availability, losses, replenishment and stock rotation. Strategic stocks must be at a certain level because there are always uncertain demands.
Concluding contracts with backup suppliers	Backup supplier contracting is the process by which a company contracts with suppliers who can provide products or services when primary suppliers are unable to do so. It is a strategy to increase the resilience of the supply chain to disruptions and minimize the risk of supply disruptions.
Mitigation Strategy	Mitigation strategies are actions taken to reduce the negative consequences of supply chain disruptions.
Reserved stock	Reserved inventory is an inventory management strategy in which a company maintains a certain level of inventory that is intended to be used in emergencies or when there are sudden increases in demand.

Source: (Davoudabadi et al., 2020; Suryadi & Rau, 2023)

Hosseini et al. (2019) also pointed out that in supplier assessment, it is worth introducing elements of analysis based on the supplier's resilience capability, which includes three levels of capability:

- absorptive (e.g., excess inventory increases the resilience of the entire supply network to disruptions),
- adaptive (e.g., alternative backup suppliers to quickly adjust the supply network),
- corrective (e.g., rapid recovery of the supplier's lost supply capacity at minimal cost).

Davoudabadi et al. indicated and extended the supplier selection criteria to include sustainable aspects (for example: environmentally friendly materials; technology based on eco-friendly technology; compliance with environmental protection policy; green R&D projects) and resilient ones (Table 5.5).

Thus, resilient suppliers should (1) have the ability to return to an equilibrium state, (2) have the strength and provide some buffering capacity for the system before a disturbance brings the system from stable to unstable conditions, and (3) have the ability to respond to a disturbance.

Chapter Questions

1. What supplier evaluation criteria do you consider to be the most important in the context of managing the financial liquidity of the enterprise and why?
2. What are the main advantages of using the AHP method in the supplier evaluation and selection process?
3. What are the main disadvantages of using the AHP method in the supplier evaluation and selection process?

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