SUPPLIER SELECTION IN SUPPLY CHAIN USING CROSS-DOCKING SERVICES FOR BLENDING TECHNOLOGY-BASED PRODUCTION PROCESSES

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ABSTRACT*: In today's consumer society, there is a growing need for companies to optimise their sourcing processes, as without this, the performance of the entire supply chain can be severely compromised. An important step in this process is the integrated design of production and logistics processes to create an optimal value chain that lead to efficient operations. Conventional optimisation methods for blending technologies are focusing mainly on the optimisation of process parameters and neglect the logistics aspects that can further improve the efficiency of the overall system. Within the frame of this article, the author describes a novel model of supplier selection of production processes using blending technologies which makes it possible to analyse the impact of logistics constraints on the cost efficiency of the solution. The analysed supply chain is a multi-supplier, cross-docking facility based single user supply chain. As the numerical examples and computational results show, the new integrated approach makes it possible to increase the cost efficiency of the supply of blending technologies.*

KEYWORDS*: blending technology, production supply, logistics costs, optimisation*

1 INTRODUCTION

Due to the significant expansion of product structures, the optimization of logistics processes become more and more important. These logistics related optimization problems include a wide range of design aspects, for example the selection of appropriate packaging (Matyi &Tamás, 2022) or vehicle routing problems (Taghavi et al., 2023). In this field Industry 4.0 technologies represents suitable tools to improve performance (Akkad et al., 2022). The supplier selection is an integrated part of aggregate production planning, because in the computer integrated manufacturing (CIM) the computer aided process planning (CAPP), the computer aided manufacturing (CAM) and the production planning and scheduling (PPS) build an integrated unit (Mota et al., 2018). Supplier selection can significantly influence its environment including economic, social, environmental, and cultural pillars (Rasmi et al., 2019).

The optimisation of value chains, supply chains and logistics processes can be significantly influenced by the selection of suppliers, because supplier selection has a great impact on the purchasing portfolio, inventory management, material requirement planning, production planning and production scheduling. The supplier selection problems is especially important in the case of disrupted supply chains, where the uncertainties make the forecasting of system parameters and processes more unstable, therefore robust, reliable methodologies are needed to solve supplier selection problems. Disrupted supply chains try to smooth their processes using cross-docking facilities and consignment contracts. These solutions can smooth disruptions in value chains. Blending technologies represents a special sector of production processes, where the quality of the final product is significantly influenced by the components' quality parameters. The optimisation of blending technologies generally focuses on technological aspects. Within the frame of this article a novel approach of supplier selection is discussed. This approach focuses on both technological and logistics impacts of supplier selection in the case of production processes using blending technologies.

This paper is organized as follows. Section 2 presents a short literature review, which summarizes the research background of supplier selection problems in supply chain and logistics. Section 3 describes the model framework of supplier selection focusing on the potentials in integrated design. The model framework describes a supplier selection problem in supply chain using cross-docking services for blending technology-based production processes. Section 4 discusses the numerical results of scenario analyses, while Section 5 includes conclusions, future research directions and managerial impacts.

2 LITERATURE REVIEW

Within the frame of this section, a short review shows the main results in the field of supplier selection problems, focusing on the integrated approaches. This literature review includes the content analysis of the article. To find the suitable sources of supplier selection research results, the following search key was used in Web of Science Core Collection: "supplier selection" (ALL Fields) and "logistics" (ALL Fields) and "optimization" (ALL Fields) and "supply chain" (ALL Fields) refined by Documen Types: Article and Languages: English and Open Access. The search was conducted in March 2023; therefore, new articles may have been published since then in the field of supplier selection.

The optimal supplier selection has a great impact on purchasing, production, distribution and inverse processes of value chains, as a multi-objective integrated closed-loop supply chain configuration shows focusing on supplier selection considering uncertain demand and different performance levels (Mohammadzadeh et al., 2017). This research describes an integrated model including supplier selection and facility location problems. The new approach of the researchers is a nonlinear multi-objective mixed integer model. Other integrated design approach is presented by (Taghavi et al., 2023) showing the potentials in the integration of supplier selection, order allocation and vehicle routing problem. In this approach, resilient strategies before disruption, including multiple sourcing, supplier fortification, prepositioned inventory at the protected supplier, and contract with third-party logistics providers are considered. It is also possible to focus on a special segment of supply chain, and select the optimal suppliers for only one segment of the supply chain, for example in reverse logistics (Tavana et al., 2021). This study shows, how Fuzzy models can be used to perform the evaluation of suppliers and make an optimal selection of them for green supply chains. The Fuzzy extension of the Shannon's entropy was integrated with other methods (fuzzy versions of complex proportional assessment, multi-objective optimization, multi-objective optimization by ratio analysis) for the evaluation of suppliers. Holistic approaches are also important to solve supplier selection problems. Conventional approaches take upstream and downstream processes separated into consideration, and it is not the best way, because supply chain disruption also significantly influences the stability of value chains. Therefore, it is important to integrate upstream and downstream processes and focus on both technological and logistics aspects of supplier selection related problems (Yoon et al., 2018). As the analysis of solution methods shows, the supplier selection problems are generally integrated into the design of global supply chain configuration, and the solution methods can include analytical and heuristic methods. A set-based robust optimization methodology shows an example to solve a supply chain configuration and supplier selection problems, where the supply chain involves an upstream from heterogeneous capacitated suppliers to customers, and also a downstream to distribution centers and production facilities (Kisomi et al., 2016). The supplier selection problems can use a wide range of objective functions including availability, flexibility, efficiency, sustainability and transparency. The models can use both single-criteria and multi-criteria optimization. Researchers proposed a new approach integrating four important objectives, such as the decrease purchasing costs, improve logistics service level, avoid supply risk and improve sustainability (Kellner t al., 2019). The evaluation of opportunities and limitations is especially important form supply chain risk point of view while selecting suppliers, because the selection of suppliers has a great impact on the performance of the whole supply chain including, technological, logistics, financial and social aspects. A Fuzzy Extended Analytic Hierarchy Process for supplier selection shows, how relevant risks can be considered using a suitable criteria and sub-criteria framework (Fagundes et al., 2021). Another optimization approach integrates transport discount and supplier capacity constraints in a multi-objective decision-making model for supplier selection and takes both the suppliers and the manufacturers into consideration. This problem uses a nested algorithm to solve the optimization problem, the model is a nonlinear mixed-integer model and a non-dominated sorting genetic algorithm is used to minimize the costs of logistics operations and the lead time (Eydi & Saedi, 2021). Other approaches also validated the usability of integrated multi-objective mixed-integer linear programming models (Tavana et al., 2022). Supplier selection is important not only in the field of automotive industry, but also in all fields of economy. Some interesting applications are discussed in the field of forestry (Baghizadeh et al., 2021), agrifood supply chain (Mateo-Fornes et al., 2023), construction road projects (Alazani et al., 2022), logistics services (Wang & Hu, 2020), cold chain logistics (Hien & Van Thanh, 2022), inbound logistics (Simic et al., 2015) or B2B business plattforms (Prajapati et al., 2022). As this short content analysis shows, the supplier selection problem is a state-of-the art research topic, especially in the field of integrated supply chain design.

3 MATERIALS AND METHODS

Supplier selection problems can be defined as complex optimisation problems, where different objective functions, decision variables and constraints can be taken into consideration. In the case of conventional blending optimisation, the objective function is the purchasing cost of required components, while the main constraints focuses on the quality of the final product. In this approach, a new model of supplier selection for production processes using blending technologies is described.

The input parameters of this approach are the followings: bill of materials for the final products (blending recipe in the case of blending technology), assignment of potential suppliers and potential components, quality parameters of final products and required components, layout of the supply chain including the facility location of suppliers, cross-docking facilities and production plant, transportation distances among facilities of the supply chain, specific purchasing, transportation and materials handling cost, availability of components.

The objective function of the supplier selection problems is the minimisation of cost, which can defined as follows:

$$C = C^P + C^{P*} + C^T + C^{T*} + C^H + C^{H*} \rightarrow min. \quad (1)$$

where C^P defines the purchasing cost taking only technological constraints into consideration, C^{P*} defines the additional purchasing cost taking both technological and logistics constraints into consideration, C^T defines the transportation cost taking only technological constraints into consideration, C^{T*} defines the additional transportation cost taking both technological and logistics constraints into consideration, C^H defines the materials handling cost taking only technological constraints into consideration, C^{H*} defines the additional materials handling cost taking both technological and logistics constraints into consideration. These costs can be defined as follows:

$$C^P = \sum_{i=1}^{\alpha} \sum_{j=1}^{\beta} \sum_{k=1}^{\gamma} q_{ijk} \cdot c_{jk}^P, \quad (2)$$

$$C^{P*} = \sum_{i=1}^{\alpha} \sum_{j=1}^{\beta} \sum_{k=\gamma}^{\gamma^{max}} \left(q_{jk}^{max} - q_{ijk}\right) \cdot c_{ijk}^{P*} \quad (3)$$

$$C^T = \sum_{p \in \Theta} l_{p,p+1} \cdot (q_{p+1}^{CUM} + krb) \cdot f \cdot c^{FU} \quad (4)$$

$$C^{T*} = \sum_{p \in \Psi} l_{p,p+1} \cdot (q_{p+1}^{CUM} + krb) \cdot f \cdot c^{FU} \quad (5)$$

$$C^H = \sum_{i=1}^{\alpha} \sum_{j=1}^{\beta} \sum_{k=1}^{\gamma} q_{ijk} \cdot c_{ijk}^H, \quad (6)$$

$$C^{H*} = \sum_{i=1}^{\alpha} \sum_{j=1}^{\beta} \sum_{k=\gamma}^{\gamma^{max}} \left(q_{jk}^{max} - q_{ijk}\right) \cdot c_{ijk}^{H*} \quad (7)$$

where q_{ijk} is the required amount of component j from supplier k for final product i in [pcs], c_{jk}^P is the specific purchasing cost of component j from supplier k in [EUR], α is the total number of products to be produced using blending technology, β is the total number of components required for final products, γ is the number of supplier, q_{jk}^{max} is the upper limit of component j available at supplier k, $l_{p,p+1}$ is the transportation route between station p and $p+1$ of the collection route, q_{p+1}^{CUM} is the cumulated loading of transportation truck [kg], *krb* is the kerb weight of the truck [kg], f is the fuel consumption depending on length and load, c^{FU} is the specific fuel consumption in [l/100km], c_{ijk}^H is the specific materials handling cost in [EUR/pcs], Θ is the set of segments of collection routes including normal suppliers, Ψ is the set of segments of collection routes including additional suppliers required by the logistics constraints.

The first constraint it the conventional technological constraint defining, that it is not allowed to exceed the lower and upper limit of the quality parameters of the final product:

$$\forall i, w: p_{iw}^{min} \le \sum_{j=1}^{\beta} \sum_{k=1}^{\gamma} q_{ijk} \cdot p_{jkw} \le p_{iw}^{max}, \quad (8)$$

where p_{iw}^{min} is the lower limit of quality parameter w of final product i, p_{iw}^{max} is the upper limit of quality parameter w of final product i, p_{jkw} is quality parameter w of component j purchased from supplier k.

The second constraint focuses on the availability of individual components:

$$\forall j, k: \sum_{i=1}^{\alpha} q_{ijk} \le q_{jk}^{max1}, \quad (9)$$

where q_{jk}^{max1} is the upper limit of available component j from supplier k.

The third constraint described, that the total number of components to be purchased has also an upper limit:

$$\forall k: \sum_{i=1}^{\alpha} \sum_{j=1}^{\beta} q_{ijk} \le q_k^{max2}, \quad (10)$$

where q_k^{max2} is the upper limit of available components from supplier k. It is important to note that the sum of the upper limits for each component is not necessarily the same as the limit for the suppliers.

The fourth constraint defines, that it is not allowed not exceed the available capacities of materials handling resources

$$\forall k: \sum_{i=1}^{\alpha} \sum_{j=1}^{\beta} q_{ijk} \le MHC_k^{max}, \quad (11)$$

where MHC_k^{max} is the upper limit of available materials handling capacity at supplier k.

The fifth constraint defines, that it is not allowed not exceed the available capacities of transportation resources

$$\forall k: \sum_{i=1}^{\alpha} \sum_{j=1}^{\beta} q_{ijk} \leq TC_k^{max}, \qquad (12)$$

where T_k^{max} is the upper limit of available transportation capacity at supplier k.

The optimisation of the supplier selection problem can take process quality related aspects into consideration. For example, the reliability of the supplier can be defined based on fulfilled supply demands, and based on this reliability it is possible to forecast the future expected reliability. As a sixth constraint we can defines a lower limit for the weighted reliability factor of the optimised supplier cluster, and it is not allowed to exceed this predefined value.

As the above mentioned literature review showed, it is possible to use both analytical or heuristic methods to solve the supplier selection problem in the case of simple blending problems. In this case the optimisation integrates technological and logistics aspects as constraints, therefore analytical methods are not suitable to solve this problems, therefore this model was solved using the evolutive Excel Solver.

4 RESULTS

Within the frame of this chapter two different scenarios will be analysed. The first scenario demonstrates the results of supplier selection problem focusing on predefined technological parameters, which is a conventional optimisation problems of blending technology-based production. The second scenario integrates technological and logistics aspects, including availability, capacity, fuel consumption, transportation and materials handling. The input parameters of the above-mentioned scenarios are the followings: assignment matrix of components and suppliers; quality parameters of required components; specific purchasing cost of required components, availability of components at the suppliers (see Table 1).

Table 1. Input parameters of scenarios

CID[1]	QP1[2]	QP2[2]	QP3[2]	SPC[3]	AVA[4]	SU[5]	W[6]
C124	49.35	39.54	55.19	4.1	103	S1	25.2
C127	69.41	35.65	30.12	3.8	80	S2	32.1
C131	66.25	27.45	47.51	2.2	74	S3	26.1
C136	14.51	29.21	34.53	0.9	83	S4	18.7
CID[1]	**QP4[2]**	**QP5[2]**	**QP6[2]**	**SPC[3]**	**AVA[4]**	**SU[5]**	**W[6]**
C141	54.24	13.13	26.04	3.9	88	S2	27.1
C143	39.55	34.27	13.09	2.9	84	S1	35.2
C155	17.72	54.87	29.75	5.1	110	S4	21.3
C156	27.64	58.23	67.51	3.7	114	S3	54.4
CID[1]	**QP7[2]**	**QP8[2]**	**QP9[2]**	**SPC[3]**	**AVA[4]**	**SU[5]**	**W[6]**
C161	23.23	56.56	14.43	2.1	97	S3	21.8
C162	22.29	64.15	37.02	3.3	57	S2	23.7
C163	64.54	11.11	15.62	4.6	64	S1	23.6
C166	57.91	43.84	31.20	4.0	155	S4	29.5

[1] CID=Component ID number. [2] QPi=Quality parameter *i*. [3] SPC=Specific purchasing cost [EUR/pcs]. [4] AVA=Availability of component at the supplier within the analyzed time window [pcs]. [5] SU=Supplier. [6] W=Weight of the final product per pieces [kg/pcs].

The quality of final products defined by lower and upper limit of quality parameters influenced by the quality of the components and the demands are shown in Table 2.

Table 2. Predefined quality and quantity parameters of products

PID[1]		PAR01[2]	PAR02[2]	PAR03[2]	DEM[3]
P011	min	19.51	32.45	35.12	180
	max	64.41	34.54	50.19	
PID[1]		**PAR04[2]**	**PAR05[2]**	**PAR06[2]**	**DEM[3]**
P012	min	22.72	18.13	18.09	200
	max	49.24	53.23	62.51	
PID[1]		**PAR07[2]**	**PAR08[2]**	**PAR09[2]**	**DEM[3]**
P014	min	27.29	16.11	19.43	176
	max	59.54	59.15	32.02	

1 PID=Product ID number. 2 PARi=Quality parameter i of the final product. [3] DEM=Demand of final products [pcs].

The lower and upper limit of components to be transported from the suppliers to the user, the specific material handling cost of components at the suppliers and the reliability factors based on the analysis of historic data are shown on Table 3.

Table 3. Supplier related input parameters

SU1	TAVAMIN 2	TAVAMAX 3	SHANC 4	RELI 5
S1	26	226	1.23	95%
S2	23	225	0.95	94%
S3	29	285	1.38	97%
S4	35	348	1.55	92%

[1] SU=Supplier. [2] TAVAMIN=Minimal quantity to be transported from the supplier to the user [pcs]. [3] TAVAMAX=Maximum quantity to be transported from the supplier to the user [pcs]. [4] SHANC=Specific material handling cost at the supplier [EUR/pcs]. [5] RELI=Reliability of the supplier based on the analysis of historic supplies [%].

The layout of the supply chain includes the location of four suppliers, the cross-docking facility and the production plant. The location of the production plant could be irrelevant in the case of optimisation, because the required component demand must be supplied from the cross-docking facility to the production plant, and this transportation cost is constant; it has no impact on the optimal solution. Despite of this fact, the transportation between cross-docking facility and the production plant is taken into consideration, because it influences the value of the objective function. In these scenarios, Volvo FH trucks are taken into consideration as available transportation resources, with the following parameters: kerb weight is 9610kg, plated weight (gross combination weight) is 44000 kg, fuel consumption is 28 l/100km. The fuel price is 1.734 EURO/litre. In the following two sub-chapters the main results of the two mentioned scenarios are discussed, while the third sub-chapter focuses on the comparison of the results of the scenarios.

4.1 Scenario 1: supplier selection focusing on technology

In this scenario, the optimisation takes only the technological parameters into consideration, which means, that the supplier selection is based only on technological parameters of components. This is a conventional optimisation methodology for blending technology-based production processes. The results of the optimisation shows Table 4, including the amount of components to be ordered.

Table 4. Optimal value of decision variables in Scenario 1

PID1=P011		PID1=P012		PID1=P014	
CID2	DV3	CID2	DV3	CID2	DV3
C124	56	C141	0	C161	130
C127	1	C143	181	C162	25
C131	0	C155	0	C163	2
C136	123	C156	19	C166	19

[1] PID=Product ID number. [2] CID=Component ID number. [3] DV=Decision variable.

In this scenario, the upper limit of available components is not taken into consideration, because of the third constraint, therefore additional orders must be initialised, which lead to additional purchasing costs. Table 5 shows the purchasing portfolio including the optimal assignment of components and suppliers and the additional orders to be placed.

Table 5. Optimal purchasing portfolio in Scenario 1

CID1	S12	S22	S32	S42	SA3
C124	56	0	0	0	0
C127	0	1	0	0	0
C131	0	0	0	0	0
C136	0	0	0	83	404
C141	0	0	0	0	0
C143	84	0	0	0	974
C155	0	0	0	0	0
C156	0	0	19	0	0
C161	0	0	97	0	334
C162	0	25	0	0	0
C163	2	0	0	0	0
C166	0	0	0	19	0

[1] CID=Component ID number. [2] Si=Supplier *i*. [3] SA=Additional supplier to supply required components not available at contracted suppliers. [4] Si=Components to be ordered from additional supplier.

Based on this optimised purchasing portfolio, it is possible to calculate the quality parameters of the final products, depending on the assignment of components and the final products. As Figure 1 shows, the optimised purchasing portfolio and the optimal assignment of components and final products lead to acceptable quality parameters, which take quality related constraint (8) into consideration.

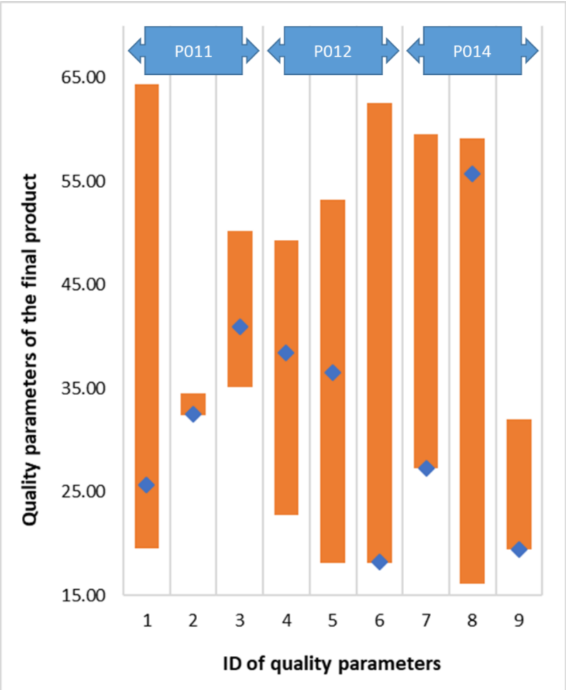

Fig. 1 Predefined quality parameters of the three products and their computed value in the case of the optimal solution of Scenario 1

The conventional supplier selection of the blending technology-based production systems resulted a total cost of 4325 EUR. Figure 1 shows the structure of the optimised purchasing portfolio based on the supplier selection.

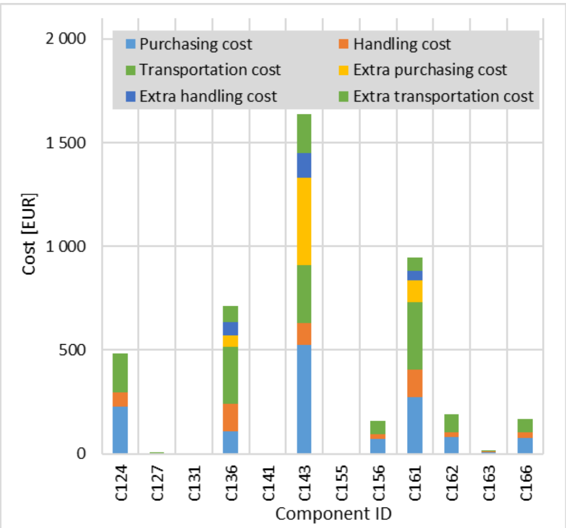

Fig. 2 Cost structure of the optimised purchasing portfolio in Scenario 2

As Figure 2 shows, due to the non-compliance with logistics related constraints, all three logistics related costs are increased. These extra costs can be eliminated using and integrated optimisation approach taking not only technological, but also logistics related constraints into consideration.

4.2 Scenario 2: supplier selection integrating technological and logistics aspects

In this scenario, the optimisation takes not only the technological parameters, but also the logistics aspects into consideration, including availability of components at the suppliers, lower and upper limit of total amount of components to be purchased, materials handling cost, reliability of suppliers based on statistical analysis of supply data, capacity utilisation of truck transporting components among suppliers, cross-docking facilities and production plants. The results of the optimisation shows Table 6, including the amount of components to be ordered for each final products.

Table 6. Optimal value of decision variables in Scenario 2

PID1=P011		PID1=P012		PID1=P014	
CID2	**DV3**	**CID2**	**DV3**	**CID2**	**DV3**
C124	40	C141	88	C161	97
C127	33	C143	84	C162	57
C131	24	C155	0	C163	1
C136	83	C156	28	C166	21

[1] PID=Product ID number. [2] CID=Component ID number. [3] DV=Decision variable.

Table 7 shows the optimised purchasing portfolio including the optimal assignment of components and suppliers. This optimised purchasing portfolio takes the predefined upper and lower limits of components to be purchased (as a constraint based on the consignment contract), and the available amount of components.

Table 7. Optimal purchasing portfolio in Scenario 2

CID1	S12	S22	S32	S42
C124	40	0	0	0
C127	0	33	0	0
C131	0	0	24	0
C136	0	0	0	83
C141	0	88	0	0
C143	84	0	0	0
C155	0	0	0	0
C156	0	0	28	0
C161	0	0	97	0
C162	0	57	0	0
C163	1	0	0	0
C166	0	0	0	21

[1] CID=Component ID number. [2] Si=Supplier *i*.

Based on this optimised purchasing portfolio it is possible to calculate the quality parameters of the final products, depending on the assignment of components and the final products. As Figure 3 shows, the optimised purchasing portfolio and the optimal assignment of components and final products lead to acceptable quality parameters, which take quality related constraint (x) into consideration.

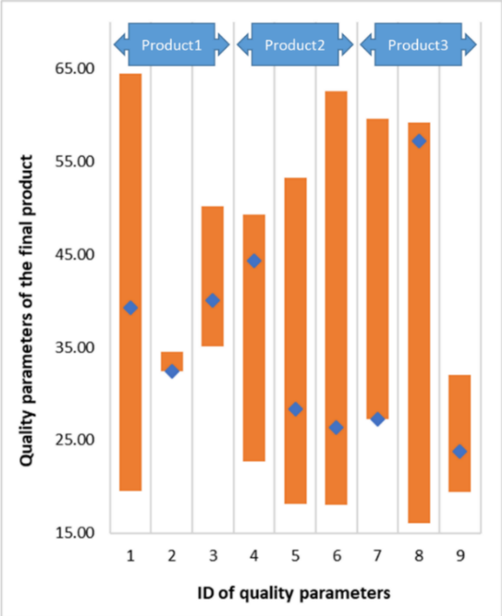

Fig. 3 Predefined quality parameters of the three products and their computed value in the case of the optimal solution of Scenario 2

The integrated supplier selection of the blending technology-based production systems resulted a total cost of 3748 EUR. Figure 4 shows the structure of the optimised purchasing portfolio based on the supplier selection taking both technological and logistics aspects into consideration.

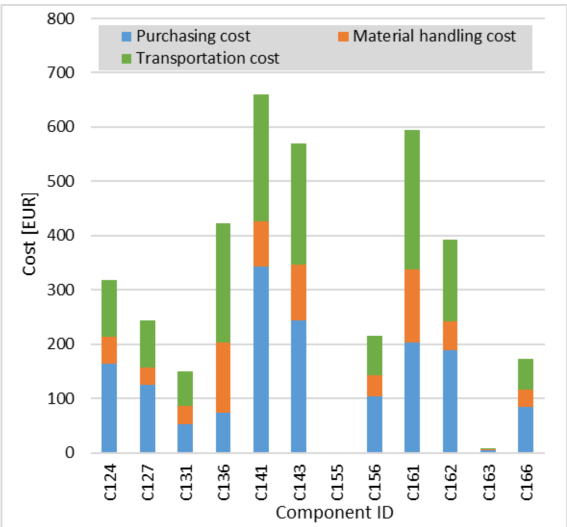

Fig. 4 Cost structure of the optimised purchasing portfolio in Scenario 2

The next sub-chapter shows the comparison of the above-mentioned two scenarios and demonstrates the efficiency of the integrated supplier selection methodology in the case of blending technology-based production.

4.3 Comparison of Scenarios

Within the frame of this sub-chapter, the above described two different approaches, the conventional supplier selection focusing on technological parameters, and the integrated supplier selection focusing on both technological and logistics aspects are compared from purchasing portfolio, quality parameters and cost structure point of view. As the comparison of the optimal decision variables shows, in the case of scenario 1 the purchasing portfolio includes less components, while in the case of scenario 2 the purchasing portfolio is more diversified. This diversification of the purchasing portfolio is impacted by the capacity-related constraints. The comparison of the two discussed scenarios validated, that the conventional supplier selection leads to an optimal solution, which does not take logistics constraints into consideration, therefore in the case of higher, than available component request additional suppliers must be involved, which can lead to the significant increase of the purchasing, transportation and material handling cost. The analysis of the quality parameters shows, that there is a significant difference between the solutions of the analysed scenarios. In the case of Scenario 1, the average deviance of the quality parameters from the average of the lower and upper limit of the quality parameters is -12.1%, while in the case of scenario 2, this value is 15.9%. The comparison of the absolute value of the deviance of the quality parameters does not highlighted a significant difference between the solutions of the analysed scenarios (see Figure 5).

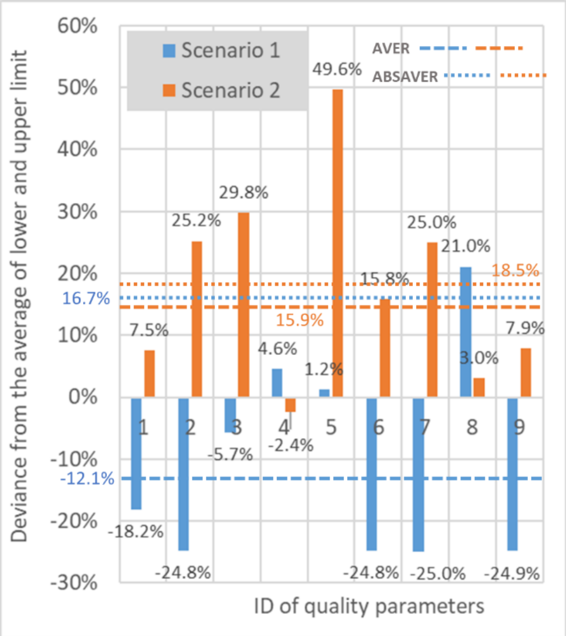

Fig. 5 Comparison of quality parameters of the analysed scenarios

The most important conclusions can be drawn on costs from the comparison of the scenarios. As Figure 1 and Figure 2 shows, there is a significant cost reduction taking not only technological but also logistics constraints into consideration. The calculation shows, that the cost reduction is about 15 percent. This cost reduction includes both purchasing, transportation and materials handling costs.

5 CONCLUSIONS

An important prerequisite for the optimal operation of supply chains is the development of a suitable supplier selection methodology that is capable of selecting the optimal suppliers and defining an optimal purchasing portfolio, taking into account company-specific conditions. This is particularly difficult for production companies using blending technology, where the quality parameters that influence the quality of the finished product are usually the main factors in the selection of suppliers. In this research work a new methodology was developed which is suitable for the optimal solution of the supplier selection tasks of production companies based on blending technology, taking into account both technological and logistics constraints. The case study presented in this paper investigates the effectiveness of the integrated planning approach in a supply chain using cross-docking services for blending technology-based production processes. The described approach analyses the impact of two different optimisation approach focusing on the supplier selection, purchasing portfolio, quality of final products and focuses on the cost efficiency from purchasing, transportation and materials handling costs. The analysis of the scenarios shows, that the integration of more design aspects (mainly in the field of technology and logistics) can increase the efficiency of the optimisation, because it leads to a more efficient supplier selection and purchasing portfolio, while technological and logistics constraints (capacities and times) are also taken into consideration.

The described methodology can support managerial decisions, because the results of the optimisation is an important input parameter for data-based decision, which is especially important in the case of strategic decisions of purchasing and procurement managers.

Potential future research direction is to extend the described methodology to take uncertain market environment into consideration. It is important if the customer demands and the availability of logistics resources are given as stochastic variable. In this case a Fuzzy model can help to model uncertainties of suppliers, users, resources and demands.

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