DEVELOPING SUSTAINABLE SUPPLIER EVALUATION FRAMEWORK – THE 10 CS OF SUPPLIER EVALUATION

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Abstract

The purpose of this paper is to provide theoretically uniform, methodologically adherent and practically applicable framework for supplier evaluation, based on the principles of TBL sustainability. In order to identify a theoretically uniform sustainable supplier evaluation model, a comprehensive literature review was conducted. The outcome was the development of the new sustainable supplier evaluation approach, coupled with AHP methodology. The proposed model was empirically tested in paper wholesaling industry setting. The final outcome of the model's testing was the provision of suppliers' assessments and rankings. The paper also discusses implications regarding theoretical uniformity, methodological adherence and practical applicability of the developed model, and provides ideas for future research avenues.

Key words: supplier evaluation, sustainability, sustainable supplier evaluation, AHP methodology

INTRODUCTION

One of the key strategic challenges in supply chain management is choosing the right supplier. Suppliers have a vital role in contributing to company's capability to deliver value to its customers. To understand and manage a supply chain, data on suppliers` performances has to be adequately and comprehensively monitored, assessed, interpreted, and acted upon. Part of the supply chain management process, tasked with assessing suppliers' performances, is supplier evaluation (Gimenez & Sierra, 2013).

We are witnessing ever growing complexity and volatility of modern supply chains, permeated with rising ethical, environmental, and social challenges, conjoined as sustainability issues. This has been the driving force for establishing supply chain management practices, which incorporate sustainability aspect, embodied in the triple bottom line (TBL) principle (Elkington, 2004). The occurring shift from supplier evaluation process to sustainable supplier evaluation (SSE) process implies that supplier performance should be evaluated in all three domains of their business responsibility: economic, environmental, and social. Nevertheless, contemporary literature is often single-directional, focusing on the specific aspect of sustainability, neglecting the inter-dimensional relations, synergetic interactions and economic soundness of the remaining aspects (Morali & Searcy, 2013). Therefore, it is a common occurrence to see partial SSE models, such as green supplier evaluation models (Govindan et al., 2015). Similar situation occurs when only social aspect is taken into account ((Xu et al., 2013). To this day, the literature does not provide a universally accepted SSE framework, nor a dominant approach to modelling supplier KPIs.

This paper was inspired by the strategic potential that SSE possesses in modern business decision-making process, and driven by observed inconsistencies in theoretical considerations and research approaches to this topic. The main research aim of this paper is to identify a theoretically uniform SSE model, which overcomes afore mentioned knowledge gaps. To test

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the applicability of the model, AHP methodology is used, as one of the most common modelling techniques in SSE literature.

The outline of the paper is based around the research aim. In the next section a literature analysis of SSE literature is performed, in order to identify the theoretical foundation for SSE framework. Next, implemented methodology for model testing is explained, followed by empirical results. The discussion part interprets the findings and critically analyses operational and strategic implications of the proposed SSE model. The paper ends with concluding remarks and overview of future research avenues.

LITERATURE REVIEW

The origins of supplier evaluation can be traced to 1960s when it was referred to as vendor selection and evaluation. In the beginning cycle time and responsiveness were dominant assessment criteria. More recent supplier evaluation acknowledge the importance of supplier flexibility, as well as product and service quality (Chan & Chan, 2010). Contemporary literature has transitioned from assessing suppliers' performance through only economic criteria by recognizing the importance of many ecological and social business aspects (Brandenburg & Rebs, 2015). This shift towards triple-bottom line sustainability in business gave rise to sustainable supply chain management (C. R. Carter & Rogers, 2008), and consequently sustainable supplier evaluation.

Early papers on sustainable supplier evaluation are oftentimes single-directional, focusing on the specific aspect of sustainability, neglecting the inter-dimensional relations, synergetic interactions and economic soundness of the other remaining aspects (C. R. Carter & Liane Easton, 2011; Seuring & Müller, 2008). Therefore, green supplier evaluation models were a common occurrence (Akman, 2015; Banaeian et al., 2015; Boutkhoum et al., 2016). These models focus on evaluating the environmental aspects of supplier activities, but in doing so, neglect or underestimate social, and only sporadically cover the economic aspect of the evaluation process. Proposed solutions are usually not economically sound, and thus unacceptable for the majority of companies.

Similar problem occurs when only environmental aspect is taken into account (Kannan et al., 2014; Qin et al., 2017), or a combination of just social and economic assessment criteria (Winter & Lasch, 2016; Xu et al., 2013). However, the majority of contemporary papers on the topic embraces the triple-bottom line business logic and evaluates suppliers' performance through all three sustainability dimensions simultaneously (Ahmadi et al., 2020; Keskin, 2022; Zhang et al., 2021).

Although predominantly based on TBL philosophy, contemporary literature fails to provide a single, theoretically uniform sustainable supplier evaluation framework. This is reflected by evaluation criteria used in existing studies, which are either too broadly defined, with vague, often overlapping classification boundaries, such as delivery, quality, cost, service, technology, environmental performance and environmental impacts (Akman, 2015; Azadnia et al., 2012; Banaeian et al., 2015; Govindan et al., 2016; Wang Chen et al., 2016; Yazdani et al., 2017), or too specific, problem-orientated criteria, without broader inter-industrial applicability (Boutkhoum et al., 2016; Kannan et al., 2014; Kusi-Sarpong et al., 2016; Qin et al., 2017). Additionally, criteria used to evaluate suppliers are oftentimes adapted to best adhere to the implemented analytical methodology (Petković et al., 2020). This limits the effectiveness and accuracy of derived results.

The majority of existing SSE frameworks are orientated at solving individual problems, related to specific companies, countries or industries. Building upon this research gap, the aim of this paper is to develop a TBL-based supplier evaluation framework which can be applied regardless of the business context, as well as be compatible with the majority of modelling techniques, rather than be the "best fit" to a specific one.

Similarly to the famous 4P marketing concept, in 1995 Ray Carter developed a supplier evaluation framework, which will later become known as *The seven Cs of supplier evaluation* (R. Carter, 1995). These criteria were: *Capacity* (ability to meet present and future demands); *Cash* (contractor's financial stability); *Commitment* (contractor's possession of quality policy, and commitment to its success); *Competency* (ability of the contractor to perform the contract); *Consistency* (contractor's ability to provide consistent levels of quality and services); *Control* (contractor's ability to manage key business processes); *Cost* (analysis of key financial indicators).

These seven key elements formed the rigid backbone for every supplier performance effort, regardless of the contextual business elements (Mishra, 2009). This original set of criteria was later expanded by Carter and DPSS Consultants, and incorporated three additional criteria: *Clean* (contractors and their products/services should satisfy legislative and other environmental requirements); *Communication* (means, efficiency and effectiveness of communication with the contractors); *Culture* (contractors and client should share similar values) (R. Carter et al., 2012; R. J. Carter & Kirby, 2006). Continuous improvement and innovation has also been mentioned as a potential criteria.

Carter's model provides a general evaluation framework, with intuitive and balanced criteria, derived from main business performance aspects of every company (R. Carter et al., 2012). Evaluation criteria can be used as top-tier categories in a weighted point rating system, balanced scorecard, or a similar strategic assessment tool, or as primary criteria in a more complex, methodological analysis (Mishra, 2009). However, Carter`s model is exclusively economically orientated and lacks TBL sustainability consideration. Building upon the findings from the literature review, this paper proposes a set of ten modified supplier evaluation primary criteria, based on Carter's 10 Cs model.

Contribution – Suppliers' capacity to fulfil present and future demands in short- and long-term;

Capital – Supplier's influence on buyer's finances, goodwill, brand equity, market perception, as well as internal and external structures (social, green and human capital);

Credibility – Displayed, as well as certified, commitment to TBL excellence;

Character – Supplier's specificities which contribute to value creation within the supply chain through unique value proposition;

Continuity – Capacity for long-term business relationships, viewed as suppliers' capacity to deliver desired product and service quality, over a longer period of time;

Clarity –Transparency level reflected in open access to important data, understandable and standardized measurement and assessment procedures which allows for a wider, easier, and more constructive external and internal audit'

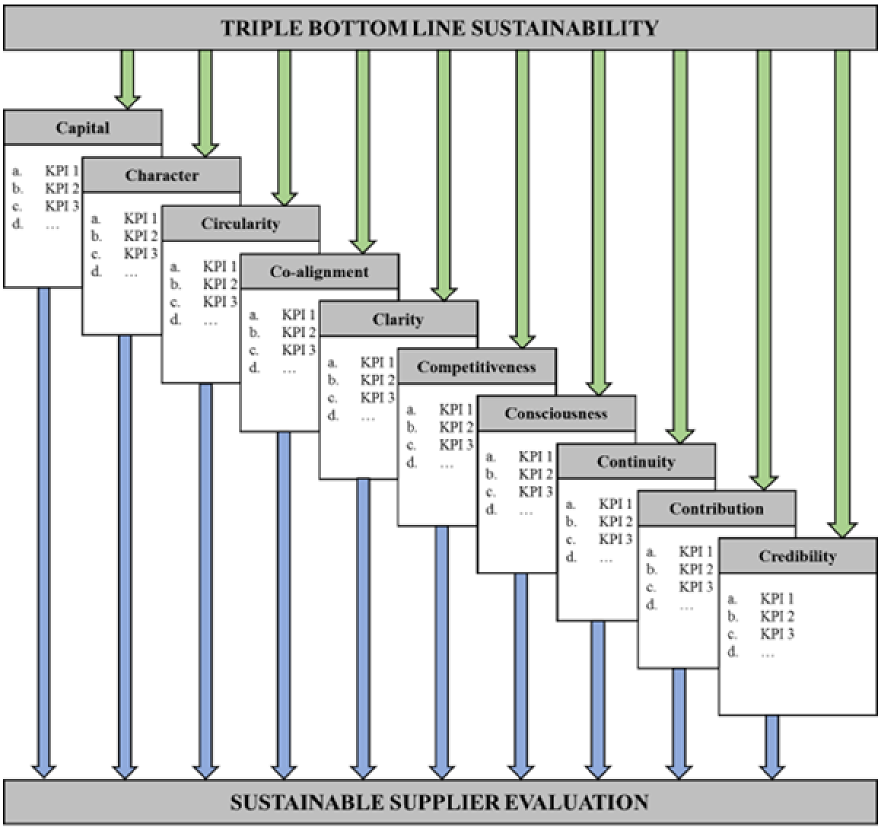
Competitiveness –Competitive position of a supplier is determined by a synergetic set of strategic value propositions, aimed at communicating the best customer solutions conveniently, at the lowest costs for customers;

Consciousness – Supplier's ability and willingness to notice, understand, analyze and tackle sustainability challenges, both internally and externally, through proactive approach to innovation;

Circularity – Long-term synchronization with the suppliers regarding all supply chain flows, and establishment of a productive feedback system (recycling, reverse logistics, joint employee training programs, joint community service and product development based on design for environment);

Co-alignment –Similarity of corporate cultures, as well as long-term goal alignment potential for creating lasting, value adding, win-win situation.

Figure 1. Graphical presentation of the modified 10 Cs model



These ten criteria form the main evaluation level of the proposed SSE model. Flexibility of the model is assured by choosing the appropriate key performance indicators (KPIs) for each of the ten defined supplier performance dimensions (**Figure 1**). These KPIs, which can be both qualitative and quantitative, are determined by the companies implementing the evaluation model, and depend on the company's capacity to determine, measure, control and interpret certain internal or external procurement activities.

A significant portion of contemporary studies used AHP methodology for modelling sustainable supplier evaluation solutions (Bruno et al., 2013; Luthra et al., 2017; Rajesh & Malliga, 2013; Secundo et al., 2017). AHP has several advantages in comparison to other MCDA techniques, in the context of SSE. AHP is clearly related to the research goal, capable of managing large number of criteria, combining both qualitative and quantitative data intuitive to users (Chan & Chan, 2010). AHP is also easier to use than more complicated methods, such as TOPSIS and VIKOR (Opricovic & Tzeng, 2004). For these reasons, the proposed 10Cs framework was tested using AHP methodology.

METHODOLOGY

AHP, which stands for analytic hierarchy process, was developed by Thomas Saaty in 1977 (Żak, 2015). This is a multi-criteria decision making tool, which is used for presenting, assessing, evaluating, and comparing differences in importance of multi-level criteria, relative to the research goal (Govindan et al., 2015). In this paper, a procedure by Xu et al. (2013) is used.

The AHP model is depicted by criteria ($C_{1\dots}C_n$) and corresponding sub criteria ($S_{1\dots}S_n$), which are used for deriving scores and ranking order of observed alternatives ($A_{1\dots}A_n$). The relative importance of every primary criterion, and corresponding sub criteria, is determined through pairwise comparison technique. Quantification of assessment judgements is formulated in accordance to Saaty's 1-9 scale (T. L. Saaty, 2004), presented in **Table 1**.

Table 1. Pairwise comparison scale

Relative importance in numerical variable	Relative importance in linguistic variable
1	Equal importance
3	Moderate importance
5	Strong importance
7	Very strong importance
9	Extreme importance
2, 4, 6, 8	Intermediate values

Source: Saaty (2004)

After conducting the pairwise comparison, the comparison values for every criterion element are inserted into a matrix. By establishing comparison matrices, local weights of criteria can be calculated. Local weights are derived by the normalization of all limit weights, within the comparison cluster.

For every comparison matrix inconsistency must be calculated in order to assess consistency and precision of the research (R. W. Saaty, 2003). Consistency ratio (C.R) is calculated using consistency index (C.I) and random index (R.I) value (Mawuntu, 2014), which is a function of the number of compared elements within a cluster, and is determined from the Table of Random Indices (**Table 2**).

Table 2. Random indices (R.I), relative to the number of criteria constituting the analyzed matrix

n	1	2	3	4	5	6	7	8	9	10
Random Index	0	0	0.52	0.89	1.11	1.25	1.35	1.40	1.45	1.49

Source: Saaty (2004)

If $C.R \leq 0.1$ the comparison is considered consistent, and no additional improvement actions are required. If $C.R \geq 0.1$ the comparison is considered inconsistent and data revision is needed.

Final weights of analyzed alternatives represent their overall weighted scores for observed assessment criteria. Alternatives' priorities are derived through comparison matrix, which consists of alternatives' normalized weights, relative to every corresponding comparison sub criterion.

EMPIRICAL FINDINGS

Primary data were gathered using in-depth interviews (Morita & Yamaoka, 2012). Company that was analyzed is one of the biggest paper wholesaling companies in Serbia, as well as in Europe. Paper wholesaling industry has a long tradition of high market concentration, leading to the introduction of comprehensive supply-chain management practices, including key supplier management, which covers certain environmental and social aspects, making it a good context for testing the proposed model.

In total, three interviews were conducted with the Business unit director of paper & print for the entire Group, co-owner and CEO of the Serbian division, and sales director of the Serbian division. All interviews were conducted separately, so that the interviewees would not be influenced by the answers of their colleagues. First, the AHP model was finished, by inputting the KPIs, which were determined by the interviewees. After that, relevance judgments were inputted for every comparison cluster, using afore mentioned Saaty's scale. Finally, after inputting the relevance judgements, preliminary data consistency analysis was performed. SuperDecisions 2.8.0 software was used for calculations.

Comparison starts with the highest level of the model, and continues downwards. After establishing intra-hierarchical relations between three sustainability dimensions, the next hierarchical level, containing modified 10 Cs criteria is analyzed.

Eigenvectors for first two hierarchical levels were determined, according to Saaty & Vargas (2012) The eigenvectors for analyzed 10 Cs criteria, with respect to three sustainability dimensions, were also calculated and joined together, in order to derive a combined Eigen matrix. Multiplying combined Eigen matrix with eigenvector sustainability dimension weights, we derive the eigenvector, containing weighted priorities of 10 Cs criteria.

Next, each of the ten Cs criteria were analyzed individually, using pairwise comparison of corresponding KPIs. The final summary of this calculation step is provided in **Table 3**, where 10 Cs criteria are depicted together with corresponding KPIs, and their calculated priorities.

Table 3. Summary of evaluated 10 Cs criteria, with corresponding KPIs and their priorities

10 Cs criteria	Weighted criteria weights	KPIs	Local sub criteria weights	Global sub criteria weights	Limited sub criteria weights
Capital	0.2076				
		▪ Data from the central	0.6667	0.1384	0.0346
		▪ Financial reports	0.3333	0.0692	0.0173
Character	0.0894				
		▪ Exclusivity of business conduct	0.5000	0.0447	0.0112
		▪ Possibility of PL brand registration	0.5000	0.0447	0.0112
Circularity	0.0568				
		▪ Communication flows	0.5396	0.0306	0.0077
		▪ Reclamation	0.2970	0.0169	0.0042
		▪ Recycling efforts	0.1635	0.0093	0.0023

10 Cs criteria	Weighted criteria weights	KPIs	Local sub criteria weights	Global sub criteria weights	Limited sub criteria weights
Clarity	0.0585				
		▪ Long term information	0.2000	0.0117	0.0029
		▪ Predictability	0.2000	0.0117	0.0029
		▪ Project cooperation	0.6000	0.0351	0.0088
Co-alignment	0.0778				
		▪ Joint market performance	0.3333	0.0259	0.0065
		▪ Long term goal orientation	0.6667	0.0519	0.0130
Competitiveness	0.1488				
		▪ Discounts	0.2493	0.0371	0.0093
		▪ Prices	0.5936	0.0883	0.0221
		▪ Quality	0.1571	0.0234	0.0058
Consciousness	0.0834				
		▪ CO2 footprint	0.5000	0.0417	0.0104
		▪ Recycling effort	0.5000	0.0417	0.0104
Continuity	0.0479				
		▪ Improved organizational efforts	0.2500	0.0120	0.0030
		▪ New product features	0.7500	0.0359	0.0090
Contribution	0.0407				
		▪ Increased competitiveness	0.3333	0.0136	0.0034
		▪ Value through cooperation	0.6667	0.0271	0.0068
Credibility	0.1891				
		▪ Certificates ISO 9001, 14001, 16001, FSC, PFSC	0.2500	0.0473	0.0118
		▪ Recommendations from others	0.7500	0.1418	0.0355

After calculating criteria priorities, the next step is consistency check of conducted comparisons. This calculation procedure is conducted for every comparison matrix, and follows the hierarchical levels of the assessed SSE model. Calculated consistency levels for all hierarchical levels were below 0.1, indicating no need for further model modifications.

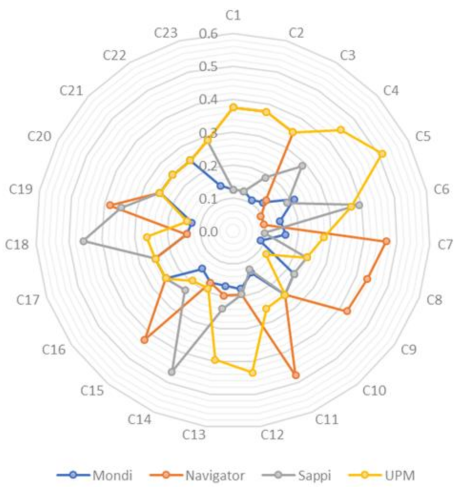
The final step in AHP model implementation is the calculation of alternatives' priorities. Here, priorities of the alternatives are calculated by multiplying the comparison matrix, which consists of alternatives' normalized weights relative to every KPI, with the eigenvector containing KPI weights, resulting in eigenvector depicting importance weights of four evaluated suppliers. Calculated values are normalized, and show the relative importance of each supplier alternative, within the evaluation process (**Table 4**).

Table 4. Overview of ranked supplier alternatives, with corresponding priorities

	Priorities			
Alternatives	**Ideal**	**Normalized**	**Limited**	**Rank**
Mondi	0.5401	0.1662	0.0416	**IV**
Navigator	0.9132	0.2811	0.0703	**II**
Sappi	0.7956	0.2449	0.0612	**III**
UPM	1.0000	0.3078	0.0769	**I**

Calculated suppliers' weights can be analyzed in more detail graphically, by determining the contribution of each KPI score to the final supplier priority rank (**Figure 2**).

Figure 2. Graphical depiction of every KPI contribution to suppliers' final priority scores



Normalized priorities of four analyzed suppliers are disseminated into corresponding KPIs' contributions, regarding alternatives' final weights. Every supplier's weight, depicted by a single line, consist of 23 KPI points, graphically marking the contribution of each KPI.

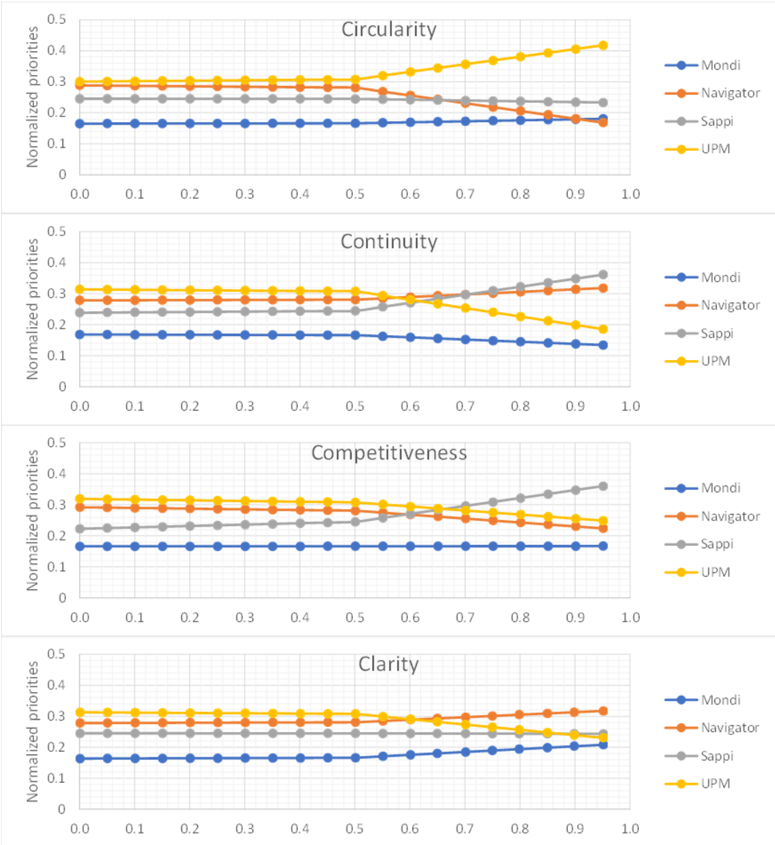
DISCUSSION

The proposed 10 Cs model provided a theoretically uniform framework when tested using AHP methodology. The model also demonstrated contextual flexibility through changeable lower hierarchical comparison levels. Flexible KPIs allow for model's modification, depending on specific industry's challenges, national market specifics, as well as reflections of certain internal organizational tendencies. This is especially apparent in situations where close competitors have different market strategies, in which one focuses on product price as a main indicator, whereas the other focuses more on the overall "package" value.

Proposed SSE framework has both operational and strategic merit. Developed model can be used as a supplier performance measuring tool. However, neglecting the long-term aspect of SSE is a serious strategic error. In modern markets, things change on a daily basis. A business must monitor and control all internal and external changes, affecting its current and future performances. In this sense, being able to continuously reevaluate suppliers' performance plays a key role in attaining and maintaining significant competitive market advantage. Use of the 10 Cs framework allows for a proactive approach to determining and modifying relevant KPIs, and developing a sustainable procurement strategy.

To depict how market changes can influence supplier short- and long-term performance, a sensitivity analysis was conducted (**Figure 3**). Horizontal axes depict the values of the observed criterion, whereas the vertical axis depicts normalized priority values of evaluated supplier alternatives. The 0.5 value marks the calculated (realized) scenario. Values lower than 0.5 depict decreasing relevance of the criterion, whereas values higher than 0.5 depict increasing criterion significance.

Figure 3. Graphical depiction of selected criteria sensitivity analysis



By analyzing the ten SSE dimensions, four stood out as the ones mostly affected by the changing weight relevance. These criteria are related to suppliers' circularity, continuity, competitiveness and clarity. For these criteria, an increase in criteria weight causes significant changes in supplier ranking. This means that these criteria represent opportunities for suppliers with highest potential for creating competitive advantage. These aspects should be in the short-term and long-term focus of the suppliers, in order to significantly improve their customer's perception of the overall offer quality. Furthermore, sensitivity analysis highlights procurement aspects which, if their market importance increases, should trigger a reevaluation of chosen suppliers.

However, prolonged use of the presented framework could potentially lead to contamination of supplier alternatives' priorities, a phenomenon known as rank reversal (T. L. Saaty & Vargas, 2012). To avoid this, Saaty (2005) proposes the use of ideal alternatives' priorities rather than the normalized ones for the purposes of comparison, ranking, and future computations. Another approach is by Wang & Elhag (2006) which states that adaptation of criteria weights' normalization approach prevents rank reversal occurrence. The issue of rank reversal is important because in business situation companies can change their supplier evaluation criteria almost on a daily basis. Therefore, any alterations of the previously explained evaluation model require either the adoption of rank reversal prevention techniques, or reevaluation of new evaluation criteria priorities.

CONCLUSION

The aim of this paper was to identify a theoretically uniform model for sustainable supplier evaluation. The conducted literature review showed that sustainability principles are present in many contemporary studies, albeit in a narrow, contextual manner. A wide diapason of used evaluation criteria, as well as different approaches to sustainability dimensions dilute theoretical uniformity of SSE literature. Therefore, this paper explored the existing 10 Cs model by Carter, further modifying it to encompass the triple-bottom line sustainability principles. Innovated evaluation criteria reflect ten key segments in supplier-procurer interactions, incorporating the findings derived from the literature review. The proposed SSE framework was tested using AHP methodology, one of the most common methodologies used in supplier evaluation literature.

The analysis showed that the developed SSE model possesses theoretical uniformity, providing a solid evaluation framework. Also, the model was well suited to AHP methodology, providing a very accurate, easily quantifiable set of evaluation criteria, with high results' benchmarking potential. The model also showed that it can respond to various modern business challenges, such as differences in companies' size, international market specificities and specific industry-related challenges. This was achieved by providing a flexible, lower hierarchical structure of the model, with changeable KPIs, reflecting specific requirements of the company implementing the model. Finally, performed sensitivity analysis showed that it can be used as a tool for developing strategic responses within the procurement process.

This paper could provide a theoretical point for future research in the area. Proposed 10 Cs model could be further studied in a different capacity, either in a different industry, thus expanding the use of different KPIs in SSE process, or using different modelling techniques, such as MCDA methodology. In the latter regard, implementation of fuzzy logic or methodologies such as TOPSIS, DEA, DRSA, etc. could provide new research directions.

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