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Optimizing Supply Chains: A Grey-DEMATEL Approach to Implementing LARG Framework

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Abstract: The performance of supply chains is directly impacted by overarching strategies and management paradigms. Success in the contemporary business landscape necessitates a comprehensive perspective that caters to the diverse needs of the market. The LARG (Lean-Agile-Resilient-Green) paradigm stands out as a versatile solution capable of addressing various concerns within the supply chain. This study introduces an innovative integrated framework for the implementation of the LARG supply chain, drawing upon insights from literature and expert knowledge, and encompassing 14 key factors. Subsequently, employing the grey-DEMATEL (decision-making trial and evaluation laboratory) method, we quantitatively measure the interrelations among these factors, culminating in the development of a structural model. The research findings underscore the significance of a technological approach as the most impactful factor in facilitating the LARG paradigm within the supply chain.

Keywords: Grey-DEMATEL Method; LARG Paradigm; supply chain performance; technological approach

1 INTRODUCTION

In the rapidly intensifying business landscape, the adoption of diverse strategies is imperative for gaining a competitive edge. Consequently, businesses are integrating various paradigms into their processes to enhance overall performance. Nevertheless, conflicts arising from the interplay of paradigms and strategies can disrupt planning and hinder performance. Furthermore, numerous global companies recognize the significance of effectively managing the linkages between supply sources and demand points. The escalating degree of globalization and interdependence among businesses has firmly entrenched the supply chain as an integral component of the business environment [1]. Consequently, upcoming competition is poised to shift from an organizational level to a supply chain level [2]. Hence, the application of a comprehensive perspective that addresses diverse concerns within a supply chain becomes imperative.

To formulate effective strategies aligning with the requirements of organizations and supply chains, the LARG (Lean - Agile - Resilient - Green) philosophy is suggested [3]. While intriguing, the multifaceted nature of the LARG paradigm within a supply chain introduces intricate trade-offs [4]. Consequently, navigating this complexity stands as a noteworthy accomplishment in supply chain management. Subsequently, this paper delves into a review of the four pillars of the LARG philosophy.

Lean: The concept of leanness originates from economic considerations within the production environment, with the primary objective of eliminating activities, resources, and processes that do not contribute to benefit. The overarching goal of the lean paradigm within a supply chain is to minimize the total costs across the entire supply chain [5]. The significance of this paradigm has been underscored in recent years, particularly during economic crises and their aftermath, prompting numerous businesses to embrace leanness as a survival strategy in the market [6]. Consequently, leanness assumes a pivotal role in organizational strategies and supply chain policies.

Agile: The ability to respond adeptly to unforeseen changes while maintaining consistent and acceptable performance is a crucial attribute in today's marketplace, referred to as agility [7]. Supply chain agility confers significant competitive advantages, given the escalating pace of changes in the business environment [8]. Nonetheless, supply chain agility is a multi-faceted concept that demands a comprehensive perspective [9].

Resilient: The response of a system, encompassing resistance and recovery, to the occurrence of disruptions, with the aim of preserving or restoring its original condition, defines resilience within that system [10]. The resilience engineering process, which involves designing or redesigning systems in line with resilience factors, plays a pivotal role in achieving supply chain resiliency [11]. However, the concept of resilience is not confined to specific guidelines; rather, it represents a widespread culture that endeavors to minimize the vulnerability of systems. Therefore, supply chain resiliency emerges as a contemporary and effective approach for safeguarding the supply chain against disruptions [12].

Green: The environmental and ecological challenges stand as among the most pressing issues faced by human societies, significantly influencing the business environment. Consequently, numerous studies have directed their attention to this domain, presenting various environmentally friendly approaches [13, 37]. Nevertheless, the intricate challenge of balancing economic benefits with environmental concerns persists globally. The emergence of diverse environmental crises has compelled decision-makers to intensify their focus on this realm [14, 38, 45].

The pursuit of integrating diverse paradigms to harness their respective advantages has been a focal point of research. While many previous studies have explored the integration of pairs of paradigms, the integration of Lean and Agile paradigms has garnered significant attention over an extended period [15, 16].

In this context, Agarwal et al. [17] conducted separate examinations of the outcomes associated with Lean and Agile paradigms. Subsequently, they delved into investigating the outcomes stemming from the integration of Lean and Agile, referred to as the Leagile paradigm. They then proposed a comprehensive framework for achieving a Leagile Supply Chain (SC), encompassing various considerations relevant to SCs. The integration of Lean and Agile paradigms within an SC was scrutinized through the lens of strategic supplier partnerships by Qrunfleh and Tarafdar [18]. Their study underscored the pivotal role of SC strategies and practices in influencing the responsiveness and performance of the focal firm. To assess the level of Leagility in an SC, Rahiminezhad Galankashi and Helmi [19] introduced a novel measurement tool. Taking into account primary SC drivers, particularly logistic and cross-functional drivers, they outlined operational activities tailored for a Leagile SC and categorized them. The measurement tool was subsequently formulated based on these operational activities [35].

Presenting a comprehensive conceptual model that outlines the interrelations among Lean, Agile, Resilient, and Green paradigm practices in SCM, Carvalho et al. [20] position themselves as pioneers in integrating these four paradigms. Their emphasis lies in identifying efficient LARG practices and appropriate performance measures. Additionally, Cabral et al. [4] concentrated on LARG SCM to enhance supply chain competitiveness, recognizing it as a necessity in contemporary business environments. To this end, they introduced specific practices and utilized the Analytic Network Process method for optimal practice selection. However, it is noteworthy that the aspect of uncertainty in decision-making problems was overlooked in their approach.

A holistic framework for a Lean-Agile-Resilient-Green (LARG) supply chain amalgamates four pivotal paradigms in the supply chain, fortifying their interactions to align with the primary concerns of supply chain management. This paper presents a conceptual framework encompassing 14 factors aimed at facilitating the implementation of the LARG paradigm within the supply chain. These factors, derived from existing literature, have been prominently featured in prior studies. Subsequently, we employ the grey-DEMATEL (Decision-Making and Trial Evaluation Laboratory) method to discern and scrutinize the relationships between these factors, relying on expert judgment for a comprehensive analysis.

The subsequent sections of this paper are structured as follows: Section 2 conducts a thorough literature review and outlines a comprehensive framework for a Lean-Agile-Resilient-Green (LARG) supply chain. Section 3 details the grey-DEMATEL evaluation method proposed in this study. Section 4 consolidates and presents a summary of the obtained results. In Section 5, we delve into discussions and outline the managerial implications derived from the findings. Finally, Section 6 offers a synthesis of the paper's key discoveries and proposes potential directions for future research endeavors.

1.1 Literature Review

The exploration of integrating diverse paradigms to capitalize on their respective advantages has been a focal point of research. While many previous studies have examined the integration of a couple of paradigms, the combination of Lean and Agile paradigms has garnered considerable attention over an extended period [15-16].

Another well-explored pairing of paradigms for integration is Lean-Green Supply Chains (SCs) [20]. The integration of Lean and Green has gained considerable attention as a means to enhance both financial and environmental performance in SCs. Kainuma and Tawara [21] put forward a method for evaluating managerial and environmental performance in SCs, specifically considering re-use and recycling. Additionally, they delve into the significance of information sharing within a Lean-Green SC. A succinct review of prior research concurrently addressing Lean and Green SC management revealed its practical applicability. Dues et al. [22] specifically focused on trade-offs between Lean and Green practices in SCs, identifying potential synergies between the two paradigms. They introduced Lean and Green as complementary strategies in SCs. Carvalho et al. [23] put forth a strategic framework with a mathematical model to facilitate the integration of Lean and Green practices in SCs, emphasizing eco-efficiency. The proposed model was implemented in an automotive SC. Furthermore, Thanki and Thakkar [24] presented a qualitative assessment framework for Lean and Green SCs, based on Balanced Score Card perspectives. The proposed framework, anchored in causal relations between relevant factors, was implemented in a textile SC.

The integration of Lean, Green, and Resilient paradigms to improve the performance of an automotive SC has been explored by Govindan et al. [25]. Their study concentrates on specific practices and performance measures associated with each paradigm, employing the Interpretive Structural Modeling approach to analyze their interrelations. Additionally, Ruiz-Benitez et al. [26] investigated Lean, Green, and Resilient SC practices in the aerospace industry. They utilized the Interpretive Structural Modeling approach to scrutinize the interactions between these paradigms, complemented by the application of Importance-Performance Analysis to validate the results.

Ghazvinian et al. [3] proposed a comprehensive conceptual model elucidating the relationships among Lean, Agile, Resilient, and Green paradigm practices in supply chain management, asserting their leadership in integrating these four paradigms with suitability. They highlight the importance of identifying efficient LARG practices and appropriate performance measures. Additionally, Cabral et al. [4] concentrated on LARG Supply Chain Management (SCM) to enhance supply chain competitiveness, deeming it essential in contemporary business environments. To this end, they introduced specific practices and employed the Analytic Network Process (ANP) to select optimal practices. However, it is worth noting that their approach overlooked uncertainties in decision-making problems.

Additionally, Azevedo et al. [27] directed their attention to the LARG concept as a benchmarking tool for evaluating supply chain performance. In this regard, they employed the Delphi technique to assign weights to corresponding practices. Subsequently, they introduced a linear aggregated method tailored for automotive companies and their associated supply chains. Moreover, the application of LARG paradigms extends beyond the scope of supply chains. do Rosário Cabrita et al. [28] explored the integration of LARG principles into the Business Model Canvas as a strategy to enhance organizational business performance. Their objective was to refine the business model by incorporating LARG principles, striving to achieve an ideal business model for the organization.

2 RESEARCH METHODOLOGY

This study employs the grey–DEMATEL approach to uncover the relationships among LARG supply chain factors and identify the pivotal elements within this framework. DEMATEL is widely acknowledged as a comprehensive method for constructing and scrutinizing a structural model that unveils intricate causal relationships among diverse factors. Recognized for determining groups of influencing and influenced factors, DEMATEL has been frequently utilized in numerous articles where factors are considered as interconnected components [29-31]. This method was initially introduced by The Battelle Memorial Institute through its Geneva Research Centre. The DEMATEL technique relies on digraphs, which effectively illustrate the directed relationships among factors. Fig. 1 illustrates steps of current research.

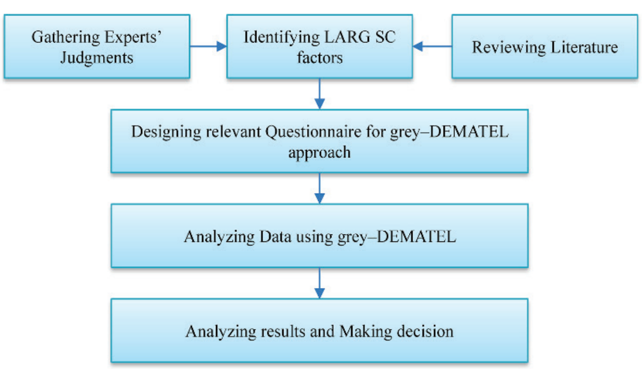

Figure 1 Research steps

The present research utilizes DEMATEL methodology to establish causal relationships among the alignment enablers that were identified, and to measure the magnitude of their impact. Nevertheless, the proposed framework relies on subjective factors, emphasizing the need to mitigate ambiguity arising from linguistic expression and the limited dataset used to evaluate factor relationships, as well as the inherent uncertainty in subjective assessments.

To address the inherent ambiguity in decision-making, the Grey System Theory or fuzzy sets theory could be employed [32, 38]. Grey numbers, forming the foundation of Grey systems, do not specify an exact value but rather determine an interval that contains the value. The primary advantage of grey systems lies in their capacity to generate plausible outcomes with incomplete information [33]. Consequently, numerous studies have applied grey systems theory across various domains.

The necessity for expressing results in precise numerical terms is evident. Therefore, we employ the modified CFCS method [34]. In the case of having a group of K evaluators, and $\otimes x_{ij}^{k} = \left[\underline{\otimes} x_{ij}^{k}, \bar{\otimes} x_{ij}^{k}\right]$ representing a grey number used for evaluating the impact of the i^{th} factor on the j^{th} factor by the k^{th} evaluator, we can derive the crisp value through the following steps.

2.1 Modified CFCS Method

Step 1: The normalization process utilizing Eqs. (1) and (2).

$$\underline{\otimes}\bar{x}_{ij}^{k} = (\underline{\otimes} x_{ij}^{k} - \min_{j} \underline{\otimes} x_{ij}^{k}) \Big/ \Delta_{\min}^{\max} \tag{1}$$

$$\bar{\otimes}\bar{x}_{ij}^{k} = (\bar{\otimes} x_{ij}^{k} - \min_{j} \underline{\otimes} x_{ij}^{k}) \Big/ \Delta_{\min}^{\max} \tag{2}$$

Where $\Delta_{\min}^{\max} = \max_{j} \underline{\otimes} x_{ij}^{k} - \min_{j} \underline{\otimes} x_{ij}^{k}$.

Step 2: The computation of a total normalized crisp value, as outlined in Eq. (3).

$$Y_{ij}^{k} = \frac{\underline{\otimes}\bar{x}_{ij}^{k}(1 - \underline{\otimes}\bar{x}_{ij}^{k}) + \bar{\otimes}\bar{x}_{ij}^{k} \times \bar{\otimes}\bar{x}_{ij}^{k}}{1 - \underline{\otimes}\bar{x}_{ij}^{k} + \bar{\otimes}\bar{x}_{ij}^{k}} \tag{3}$$

Step 3: Computing the final crisp value by employing Eq. (4).

$$z_{ij}^{k} = \min_{j} \underline{\otimes} x_{ij}^{k} + Y_{ij}^{k} \Delta_{\min}^{\max}. \tag{4}$$

Step 4: Aggregating the crisp scores resulting from the defuzzification of K evaluations and generating an averaged score as illustrated in Eq. (5).

$$c_{ij} = \frac{1}{K} \sum_{i=1}^{k} z_{ij}^{k}. \tag{5}$$

2.2 DEMATEL

Step 1: Generating the normalized direct-influence matrix $\boldsymbol{D}$, denoted as $[d_{ij}]_{n\times n}$

$$\boldsymbol{D} = k \times \boldsymbol{A} \tag{6}$$

$$k = \min\left\{1/\max_{i} \sum_{j=1}^{n} a_{ij},\ 1/\max_{j} \sum_{i=1}^{n} a_{ij}\right\},\quad i, j \in \{1, 2, \ldots, n\} \tag{7}$$

Step 2: Computing the total-influence matrix $\boldsymbol{T}$, denoted as $[t_{ij}]_{n\times n} \times \boldsymbol{I}$, where $\boldsymbol{I}$ is an $n \times n$ identity matrix.

$$\boldsymbol{T} = \boldsymbol{D}(\boldsymbol{I} - \boldsymbol{D})^{-1} \quad (8)$$

Step 3: Calculate *R* as the sum of rows and *J* as the sum of columns.

$$R = [r_i]_{n\times 1} = \left[\sum_{j=1}^{n} t_{ij}\right]_{n\times 1} \quad (9)$$

$$C = [c_j]_{n\times 1} = \left[\sum_{i=1}^{n} t_{ij}\right]_{1\times n} \quad (10)$$

Step 4: Creating a causal diagram by plotting (R+J, R–J).

3 RESULTS

In this study, following an extensive review of existing literature, we formulated a grey-DEMATEL questionnaire, which was then distributed to five experts in the petrochemical supply chain domain. In crafting the questionnaire and addressing potential uncertainties in judgments, we incorporated the term "influence" with five linguistic descriptors: Very High, High, Low, Very Low, and No. These descriptors were represented using grey numbers, as detailed in Tab. 1.

Table 1 The grey linguistic scale

Linguistic terms	Gery numbers
No Influence (NI)	(0 , 0)
Very Low influence (VL)	(0 , 0.25)
Low influence (L)	(0.25 , 0.5)
High influence (H)	(0.5 , 0.75)
Very High influence (VH)	(0.75 , 1)

Applying Grey system theory, we processed the data collected from the questionnaire. The transformation of Grey-DEMATEL values is elucidated in Tab. 2. Employing the specified equations, we implemented the DEMATEL method. The input data for the DEMATEL technique is presented in Tab. 3, and the resultant outcomes are detailed in Tab. 4.

Table 2 The initial direct-relation matrix

Grey value	Normalized value	Total normalized crisp value	Final crisp value
[0, 0]	[0,0]	0	0
[0.5, 0.75]	$[\frac{0.5-0}{1-0}, \frac{0.75-0}{1-0}]$	$(\frac{0.5\times(1-0.5)+0.75\times0.75}{1-0.5+0.75})$	0 +0.65
[0.25, 0.5]	$[\frac{0.25-0}{1-0}, \frac{0.5-0}{1-0}]$	$(\frac{0.25\times(1-0.25)+0.5\times0.5}{1-0.25+0.5})$	0 +0.35
[0, 0.25]	$[0, \frac{0.25-0}{1-0}]$	$(\frac{0\times(1-0)+0.25\times0.25}{1-0+0.25})$	0 +0.05
[0.25, 0.5]	$[\frac{0.25-0}{1-0}, \frac{0.5-0}{1-0}]$	$(\frac{0.25\times(1-0.25)+0.5\times0.5}{1-0.25+0.5})$	0 +0.35
[0, 0.25]	$[0, \frac{0.25-0}{1-0}]$ر	$(\frac{0\times(1-0)+0.25\times0.25}{1-0+0.25})$	0 +0.05
[0, 0.25]	$[0, \frac{0.25-0}{1-0}]$	$(\frac{0\times(1-0)+0.25\times0.25}{1-0+0.25})$	0 +0.05
[0, 0]	[0 , 0]	0	0
[0, 0]	[0 , 0]	0	0
[0, 0.25]	$[0, \frac{0.25-0}{1-0}]$	$(\frac{0\times(1-0)+0.25\times0.25}{1-0+0.25})$	0 +0.05
[0, 0.25]	$[0, \frac{0.25-0}{1-0}]$	$(\frac{0\times(1-0)+0.25\times0.25}{1-0+0.25})$	0 +0.05
[0, 0]	[0 , 0]	0	0
[0, 0.25]	$[0, \frac{0.25-0}{1-0}]$	$(\frac{0\times(1-0)+0.25\times0.25}{1-0+0.25})$	0 +0.05
[0.5, 0.75]	$[\frac{0.5-0}{1-0}, \frac{0.75-0}{1-0}]$	$(\frac{0.5\times(1-0.5)+0.75\times0.75}{1-0.5+0.75})$	0 +0.65

Table 3 The initial direct-relation matrix

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14
C1	0	0.95	0.275	0.35	0.187	0.262	0.71	0.175	0.187	0.25	0.425	0.337	0.262	0.725
C2	0.725	0	0.5	0.5	0.187	0.425	0.425	0.187	0.262	0.187	0.337	0.425	0.425	0.275
C3	0.35	0.262	0	0.475	0.562	0.425	0.25	0.35	0.1	0.575	0.325	0.65	0.337	0.375
C4	0.1	0.275	0.262	0	0.412	0.425	0.412	0.575	0.087	0.5	0.5	0.875	0.175	0.18
C5	0.1	0.012	0.337	0.575	0	0.725	0.35	0.204	0.187	0.8	0.337	0.637	0.325	0.725
C6	0.35	0.426	0.575	0.65	0.5	0	0.337	0.337	0.487	0.35	0.65	0.412	0.725	0.65
C7	0.2	0.5	0.25	0.65	0.65	0.575	0	0.325	0.575	0.575	0.175	0.575	0.487	0.4
C8	0.012	0.112	0.65	0.65	0.487	0.575	0.725	0	0.637	0.725	0.8	0.725	0.575	0.175
C9	0.1	0.337	0.425	0.575	0.575	0.575	0.425	0.725	0	0.5	0.725	0.5	0.725	0.325
C10	0.1	0.337	0.637	0.725	0.725	0.412	0.637	0.337	0.262	0	0.65	0.875	0.575	0.35
C11	0.175	0.275	0.487	0.725	0.8	0.5	0.5	0.412	0.425	0.5	0	0.8	0.5	0.4
C12	0.175	0.187	0.187	0.725	0.65	0.35	0.237	0.325	0.4	0.875	0.8	0	0.5	0.25
C13	0.35	0.5	0.575	0.425	0.725	0.725	0.8	0.637	0.575	0.725	0.875	0.502	0	0.575
C14	575	0.65	0.487	0.25	0.8	0.8	0.875	0.337	0.325	0.8	0.725	0.65	575	0

C1: Green design, C2: Environmental management, C3: Supplier relationship, C4: Customer relationship, C5: Just in time, C6: Quality integration, C7: Flexibility, C8: Information sharing, C9: Visibility, C10: Velocity, C11: Information management, C12: Responsiveness, C13: Internal management, C14: Technological approaches

Table 4 The total-relation matrix

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14
C1	0.076	0.212	0.155	0.197	0.180	0.176	0.145	0.127	0.119	0.188	0.206	0.211	0.163	0.199
C2	0.160	0.108	0.185	0.225	0.190	0.202	0.186	0.137	0.134	0.191	0.205	0.231	0.189	0.157
C3	0.118	0.140	0.135	0.235	0.245	0.212	0.177	0.161	0.122	0.250	0.215	0.271	0.188	0.174
C4	0.083	0.133	0.161	0.174	0.222	0.204	0.189	0.182	0.119	0.235	0.228	0.288	0.165	0.144
C5	0.096	0.121	0.188	0.262	0.199	0.262	0.204	0.157	0.143	0.292	0.234	0.288	0.202	0.225
C6	0.143	0.192	0.242	0.303	0.290	0.211	0.231	0.197	0.199	0.275	0.303	0.299	0.275	0.243
C7	0.115	0.186	0.190	0.286	0.286	0.260	0.173	0.182	0.197	0.281	0.231	0.296	0.233	0.200
C8	0.103	0.158	0.260	0.323	0.307	0.289	0.285	0.168	0.227	0.334	0.333	0.352	0.272	0.196
C9	0.112	0.179	0.230	0.303	0.305	0.282	0.246	0.245	0.147	0.298	0.317	0.316	0.280	0.208
C10	0.111	0.178	0.248	0.318	0.319	0.261	0.264	0.198	0.175	0.239	0.303	0.355	0.259	0.209
C11	0.118	0.169	0.229	0.314	0.323	0.268	0.246	0.204	0.191	0.294	0.226	0.343	0.248	0.213
C12	0.105	0.143	0.179	0.289	0.282	0.227	0.198	0.178	0.172	0.308	0.294	0.226	0.228	0.177
C13	0.163	0.229	0.282	0.333	0.368	0.341	0.325	0.264	0.243	0.369	0.376	0.366	0.236	0.272
C14	0.188	0.245	0.265	0.305	0.367	0.342	0.325	0.222	0.209	0.368	0.350	0.371	0.296	0.202

Table 5 The impacts exerted and received by each factor.

	R	J	R+J	R–J
C1	2.362	1.699	4.061	0.663
C2	2.507	2.399	4.906	0.108
C3	2.648	2.955	5.604	-0.307
C4	2.531	3.873	6.405	-1.342
C5	2.879	3.888	6.768	-1.008
C6	3.409	3.544	6.953	-0.135
C7	3.121	3.200	6.322	-0.078
C8	3.614	2.629	6.243	0.985
C9	3.476	2.402	5.878	1.073
C10	3.443	3.928	7.372	-0.485
C11	3.393	3.828	7.221	-0.435
C12	3.013	4.220	7.234	-1.206
C13	4.173	3.239	7.413	0.933
C14	4.061	2.825	6.886	1.236

The prominence of each factor is indicated by its (R+J) value, which denotes its significance. In addition, the (R–J) value is assigned as the relation value and classifies factors into two categories: cause group and effect group. The cause group includes factors with positive (R–J), such as (C1), (C2), (C8), (C9), (C13), and (C14), while the effect group comprises factors with negative (R–J), including (C3), (C4), (C5), (C6), (C7), (C10), (C11), and (C12). A detailed summary of the cause group and effect group is presented in Tab. 5. The causal diagram illustrated in Fig. 2 is generated based on the (R+J) and (R–J) values. This graphical representation effectively illustrates the distinctions between the cause group and the effect group.

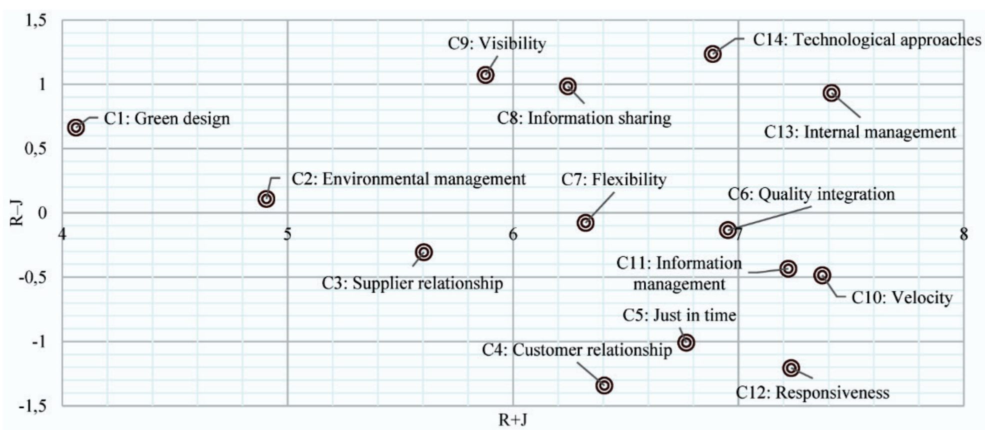

Figure 2 DEMATEL casual diagram

As depicted in Fig. 2, the disparity in the (R+J) index among factors is not highly significant. However, internal management exhibits the most substantial interconnections with the entire system, while green design displays fewer relationships.

In contrast to the previous index, the (R–J) index reveals notable differences among some factors. A detailed examination of the (R–J) index underscores the significance of cause group and effect group factors. Illustrated in Fig. 2, cause group factors encompass green design, environmental management, information sharing, internal management, and technological approaches [46]. Notably, technological approaches emerge as the pivotal factor for enhancing the LARG concept. Conversely, the effect group factors comprise supplier relationship, customer relationship, just in time, quality integration, flexibility, velocity, information management, and responsiveness.

4 MANAGERIAL IMPLICATIONS

Factors in the cause group act as catalysts for improvement since they instigate changes. Therefore, they demand heightened attention due to their significant impact on other factors. This paper underscores the importance of prioritizing focus on green design, environmental management, information sharing, velocity, quality integration, flexibility, internal management, and technological approaches as key elements in the cause group.

These factors are instrumental in facilitating the LARG concept within a supply chain. However, Fig. 2 highlights variations in the influence levels of each factor within this group, emphasizing the need for appropriate prioritization.

Firstly, the integration of modern technologies tailored to the particular requirements of the commercial setting has the potential to significantly enhance overall supply chain performance. The increasing complexities within the business landscape further underscore the paramount importance of adopting technological approaches. Thus, prioritizing a focus on technological advancements is deemed essential for all business entities, with managers playing a unique and pivotal role as drivers of business success.

Secondly, succeeding in today's dynamic business environment necessitates an accurate understanding of the situation and informed decision-making. In this context, information sharing emerges as a critical enabler, expediting the dissemination of information and enhancing the supply chain's capabilities to navigate challenges. The strategic emphasis of managers on fostering information sharing through infrastructure improvement and cultural development becomes imperative.

Thirdly, while paradigms and strategies are employed in supply chains to enhance overall performance, incorrect implementation poses a significant threat to the relationships across different layers in a supply chain. The relationships with customers and suppliers remain perpetual concerns in the supply chain domain. Therefore, during the initial stages of implementing new paradigms, managers must safeguard these crucial relationships from vulnerability.

Fourthly, all the interrelations prove to be effective for implementing the LARG paradigm in supply chains.

5 CONCLUSION

This paper endeavors to present a conceptual framework aimed at facilitating the implementation of a Lean-Agile-Resilient-Green supply chain and exploring the intricate interactions among its components. A comprehensive review of the literature culminated in the development of a reference framework comprising 14 factors. Subsequently, the grey-DEMATEL approach was employed to pinpoint critical factors and scrutinize their causal relationships. Given the inherent nature of our data, the grey system theory emerged as the most suitable method for deriving meaningful results. The findings highlight technological approaches as the most influential factor in the context of LARG supply chain implementation. Additionally, factors such as green design, environmental management, information sharing, and internal management are identified within the cause group, warranting heightened attention. Extensive exploration of the interactions among these enablers has been conducted and the results are thoroughly discussed. In conclusion, future research endeavors may involve the application of these findings across diverse industries in the new digital era [41], tailoring those to specific contexts and requirements. Future research on the LARG supply chain paradigm can be improved by combining qualitative [47, 48] and quantitative data analysis techniques. Interviews with supply chain professionals can give insights on implementing the LARG framework, while statistical methods and machine learning [36, 49] can identify trends and correlations among key factors. Data mining [39, 43], deep learning [44], and Artificial Intelligence [40, 42, 48, 50] techniques can further extract valuable information from supply chain data, providing actionable insights for optimization. By integrating these approaches, research can offer a comprehensive understanding of the LARG framework's effectiveness in different industries.

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