The integration of LARG supply chain paradigms and supply chain sustainable performance (A case study of Iran)

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ABSTRACT
This research aims to conduct whether the lean, agile, resilience, green and sustainable paradigms are applied and combined in the actual environment (Petrochemical Industries) of Supply Chain Management (SCM). A structured literature review of theoretical foundations of manufacturing paradigms in SCM was carried out to achieve this aim. Then the conceptual model is extracted from reviewing theoretical research foundations and structure of ‘Lean, Agility, Resilience, Green’ (LARG) supply chain and sustainability. The novelty of this research is that a classification scheme of manufacturing paradigms in SCM was developed where previous studies were used to find how these paradigms were being integrated. The results indicated that paradigms in SCM, including; Lean, Agile, Resilience, Green, and Sustainable had an important role in the successful performance and competitive advantage. The Goodness of Fit was used to examine the verification model solution. The contribution of this research is an integrated model of LARG supply chain paradigms and sustainable supply chain performance. The proposed model is merged in academic literature for the first time. The integration model of LARG supply chain paradigms and supply chain sustainable performance

1. Introduction

Supply chain management (SCM) refers to relations between suppliers and customers to sustain the efficiency and effective flow of production resources to meet the stakeholders’ requirements (Azevedo et al., 2011). However, in the past few decades, supply chains and their various stages have been facing various internal operational, as well as external challenges. These external challenges may be associated with environment or nature and societies (Dahlmann & Roehrich, 2019; Dey et al., 2019; Tasdemir & Gazo, 2018); customers’ demand uncertainty (Lotfi & Saghiri, 2018; Singh & Vinodh, 2017); technological disruptions with a shorter product life cycle (Carvalho et al., 2012) and global sourcing (Parkouhi et al., 2019). These all challenges or problems make SC ineffective, instable, vulnerable, and turbulent (Azevedo et al., 2013; Centobelli et al., 2020; Lotfi & Saghiri, 2018). Also, SC faces various pressures from all stakeholders for sustainable business development (Chang et al., 2019).
Some researchers (Digalwar et al., 2020; Leon & Calvo-Amodio, 2017; Rajeev et al., 2017), suggested that SC should include the dimension of social and environmental performance measures into the conventional performance metrics. In addition to that, Luthra et al. (2016), Ciccullo et al. (2018), Zhan et al. (2018), and Orazalin (2020), discussed the relevance of sustainability. Abdollahi et al. (2015) discussed the need for dynamism in SC and their various stages to remain competitive and meet the stakeholders’ expectations effectively and efficiently.

Thus, all these related issues attract the scholar to consider how the various existing and emerging management philosophies or paradigms help avoid the aforementioned challenges and achieve their objectives to remain competitive in a SC.

Many research studies authored by Sayyadi Tooranloo et al. (2018), Mohammed et al. (2019), and Chavez et al. (2020) highlighted the importance of various evolving practices and theories and suggested to restructuring the traditional management philosophies such as lean and agile to survive. Azevedo et al. (2016), Luthra et al. (2016), Anvari (2017), Wong et al. (2018), and Dey et al. (2019), and Izadyar et al. (2020), discussed the role of various emerging paradigms or integration of paradigms such as lean, agile, resilient, and green (LARG), green with sustainability, and leanness, greenness with agility and resilience in this highly competitive environment for supply chains. In the past years, the research on integrating various combinations of lean, agile, resilient, green and sustainable (LARGS) paradigms in SC domain got enough attention from academic researchers and practitioners. However, no such research study was conducted that discusses how many integrations of the paradigms mentioned above are possible. Also, how research based on these paradigms was evolved in the supply chain domain? The previous research studies discussed the synergies and differences among these paradigms and their attributes, considering few at a time. Naylor et al. (1999), Bruce et al. (2004), and Agarwal et al. (2006); discussed linkage of lean and agile (LA) paradigms; Christopher and Peck (2004) discussed linkage of agile and resilient paradigms, and Lartey et al. (2020) discussed linkage between lean and green paradigms.

Carvalho and Cruz-Machado (2011) explain the linkage of LARG paradigms. However, no study considers sustainable standards in addition to their framework. Therefore, to fill this research gap, this study is a unique research study that seeks integration of LARGS paradigms in the domain of SCs. In LARGS, L stands for lean/leanness, A stands for agile/agility, R stands for resilient/resilience, G stands for green/greenness, and S stands for sustainable/sustainability.

Petrochemical Industries in Iran as a major industry that allocates a significant proportion of the country’s production directly or indirectly, has interacted with its environment (suppliers, consumers, social and environmental factors, etc.) in all parts of its life cycle from the exploitation of natural resources, manufacturing, production, consumption, and post-consumption. In addition, due to environmental conditions, domestic manufacturers should focus on regional and global markets. Considering the necessities such as joining the World Trade Organization (WTO), increased international law, and customers’ emphasis on products that are high quality, low cost, more service, and green environmentally friendly, creating a sustainable value chain management to provide products and services in the industry is indispensable. However, one of the fundamental problems besides environmental issues is high cost, low quality, and
time-consuming processes that necessitate the use of new methods and techniques (Bhagawati et al., 2019; Cabral et al., 2012).

Hence, this research aims to understand the development and integration of LARGS research fields over the years to identify the unexplored areas and propose future research directions. In this sense, this study addresses the three research questions:

The main research questions are as follows:

**Question 1**: What are the basic requirements, effective factors and performance indicators to achieve a competitive supply chain? In other words, to achieve a competitive advantage in the supply chain; What is the role of the LARGS paradigms in meeting the basic requirements as effective factors in performance outcomes?

**Question 2**: Which sustainable LARG supply chain parameters are of greater importance for achieving a supply chain with competitive advantage? What are the current trends in the relationships of LARGS paradigms, among themselves, to achieving supply chain with competitive advantage?

**Question 3**: What SCM model is more effective in achieving the competitive advantage of the company’s supply chain? For this, it is important to study which types of LARGS techniques have been targeted in the literature? In addition, In addition, which paradigm was more important?

Thus, responding to these questions provides a path for standardizing the constructs of each type of paradigms with integrating SCM for future researchers, practitioners, and especially strategy developers. This article is structured into four sections. The major gap of existing frameworks of LARG supply chain is discussed in the literature review. Section two focuses on the identification of frameworks from the extant literature. The survey methodology, the survey results, and analysis are presented in Section three, followed by discussion and conclusions on survey results in Section four.

### 2. Theoretical foundations and literature

SCM involves coordination in production, inventory, positioning, and transportation among the participants to achieve the best combination of response and performance for the success of the market in a supply chain (Arzu Akyuz & Erman Erkan, 2010; Bhagawati et al., 2019; Cabral et al., 2011). The supply chain consists of all activities associated with the flow and transformation of products from the raw materials to delivery to the final consumer as well as their relevant information flows. Generally, a supply chain is a chain that includes all activities associated with the flow of goods and transformation of materials from raw material procurement to the final product delivery to the consumer (Laouden, 2011). The structure, organization, and integration are crucial to improving global supply chains performance and help them to achieve strategic and operational goals (Rolo et al., 2014). A large part of the literature on sustainable development in SCM is focused on the environmental aspect of sustainable development. Bhagawati et al. (2019) identified Key Success Factors of Sustainability in Supply Chain Management. In a study, Zhu and Sarkis (2006) investigated the relationship between
operational practices and the performance of companies that worked in the green supply chain. Srivastava (2007) has suggested the integration of environmental thinking in SCM as green SCM that encompasses the processes of product design, selection and procurement, manufacturing processes, product delivery to the customer, and end of lifecycle product management. Holt and Ghobadian (2009) have made an experimental study of UK manufacturers’ green SCM. Arif et al. (2009) have examined Indian green SCM challenges. Kumar et al. (2012) have revealed that a green supply chain is an essential tool for corporate profitability. In green supply chain evaluation modeling, Falatoonittoosi et al. (2013) have addressed issues such as organizational performance, green organizational activities, green suppliers, environmental factors, and green logistics. While sustainable development affects the various components of main supply chain activities, Linton et al. (2007) have proposed five modules, including product design, reduced waste, increased product lifecycle, product end-of-life, and recovery processes in the supply chain that strongly affect sustainability.

Koplin et al. (2007) studied sustainability in the supply chain. They identified five alternatives including the use of less materials and energy, replacing the input raw materials, reduced unwanted outputs, changing outputs into inputs, and the restructuring of supply chain for the sustainable production of a product according to the product life cycle (Koplin et al., 2007). Büyüközk and Berkol (2011) are among those who have worked in sustainable supply chain and they have proposed a model. With the integration of ANP and goal programming techniques in a QFD model, they have developed a sustainable supply chain. In this model, factors such as economic, social, and environmental factors have been studied (Büyüközk & Berkol, 2011). Carter and Rogers (2008) provided an appropriate framework for sustainable green chain management. Soni and Kodali (2012) and Sukwadi et al. (2013) assessed supply chain performance based on agile operations. Literature suggests that agile, resilience, and sustainable supply chains strategies enable them to be more competitive in order to adapt to the dynamic and unstable scenario (Rolo et al., 2014).

Govindan et al. (2015) using an interpretive structural modeling approach, proved integrated Lean, green, and resilient practices influence on supply chain performance. Azevedo et al. (2016) demonstrated LARG index can be as a benchmarking tool for improving the leanness, agility, resilience and greenness of the automotive supply chain. Azfar et al. (2017) showed that the application of Lean Agile Resilient Green Paradigms Framework Can play an effective role on China Pakistan Economic Corridor. Ruiz-Benitez et al. (2017) showed that the combination of lean, green, and resilient supply chain management there are environmental benefits in the aerospace sector. Ciccullo et al. (2018), in a review studying, demonstrated that integration of environmental and social sustainability pillars into the lean and agile supply chain management paradigms makes synergy. Lotfi and Saghir (2018) proposed a conceptual development mode using disentangling resilience, agility, and leanness. Suifan et al. (2019) investigated trade-off among lean, agile, resilient, and green paradigms in on pharmaceutical industry in Jordan, and the result of this research shows LARG paradigms have a synergy of each other. In this regard, the lean and resilient management of the supply chain affects performance (Ruiz-Benitez et al., 2018); it is also possible to achieve sustainability through the lean and resilient management of the supply chain (Ruiz-Benitez et al., 2019).
LARG- SCM is trying to put together lean, agile, resilience, and green approaches in SCM in order to benefit from the advantages of each one of them and simultaneously to cover up their shortcomings (Cabral et al., 2012). For the first time, Duarte and Machado (2011) determined whether the lean, agile, resilience, and green paradigms provide a comprehensive understanding of supply-chain management. They showed to find how these paradigms were being integrated. Azevedo et al. (2011) have proposed LARG supply chain. They have improved the LARG – SCM model based on a performance measurement system. In this study, four factors of LARG’s model have been studied based on a performance measurement system. By investigating LARG supply chain factors (lean, agile, resilience, and green) separately, Cabral et al. (2012) have developed the relevant model based on a series of performance indicators such as cost, waiting time, and service level. In this study, in addition to the verification and application of LARG’s supply chain factors (Azevedo et al., 2011), they have identified and studied competitive advantage factors. Azevedo et al. (2016) demonstrated LARG index could be a benchmarking tool for improving the leanness, agility, resilience, and greenness of the automotive supply chain. Imani and Ahmadi (2009) have carried out a study ‘green SCM as a new strategy to achieve competitive advantage.’ Cabral et al. (2011) have identified four basic criteria (cost, quality, time, and service) to create a competitive advantage.

Four key factors of LARG model, together with their sub-criteria that are designed by Azevedo et al. (2011) and supported by Cabral et al. (2012), are considered as a basis for this study, and sustainable supply chain factors are determined using Büyüközkan and Berkol’s model as ‘sustainable supply chain’. On the other hand, Cabral et al. model (Cabral et al., 2012) is used to achieve competitive advantage i.e. in this study, LARG supply chain factors (Cabral et al., 2012; Azevedo et al., 2011) are combined with sustainable supply chain factors (Büyüközkan & Berkol, 2011) to achieve competitive advantage (Cabral et al., 2012). Table 1 shows a summary of differentiation among LARGS paradigms in SC Features.

According to the previous supply chain studies, it was revealed that separate research contributions had been conducted such as supply chain, lean supply chain, agile supply chain, green supply chain, resilience supply chain, sustainability supply chain, and newly LARG supply chain. Therefore, dealing with this topic (The integration of LARG supply chain paradigms and supply chain sustainable performance) seems to be a necessary component of academic and industrial research activities that includes innovation. Therefore, the conceptual model (Figure 1) is the result of reviewing theoretical research foundations and identifying existing models of sustainable and LARG supply chain (Büyüközkan & Berkol, 2011; S. G. Azevedo et al., 2011; Cabral et al., 2012; Ruiz-Benitez et al. 2019). Both sustainable and LARG supply chain models’ dimensions and criteria are extracted, and by modifying the existing criteria, the model’s criteria are selected. Then, experts examine the selected dimensions and criteria, and high-priority criteria from the experts’ view are selected as models’ criteria.

3. Research method and data analysis

This study is an applied and descriptive survey research. The study population consists of seven experts (census sampling method) of Petrochemical Industries.
Table 1. Differentiation among LARGS paradigms.

| SC Features | LARGS Paradigms | LARGS Criterions based on SC Features |
|-------------|-----------------|--------------------------------------|
| Purpose     | lean            | cost, lead time, defects reduction & increasing value (Anvari et al., 2014a), increasing Accountability, Competency, Flexibility, Speed, Cost effectiveness (Shiri et al., 2015). |
|             | agility         |                                      |
|             | resilience      | increasing resilience to capacity shortage, materials shortage & unexpected disruption (Anvari, 2017). |
|             | green           | Minimization of the ecological impact & environmental risks by SC activities (Dües et al., 2013). |
|             | sustainability  | Cost, fuel, greenhouse gases, waste reduction, high profitability; Health, safety, law & regulation promotion & inventory (Schaltegger & Burritt, 2014). |
| Supply chain structure | lean            | Static structure (Vonderembse et al., 2006; Dües et al., 2013). |
|             | agility         | Virtual organisations that change frequently to offer different products 'mass customisation' or dynamic structure (Christopher, 2000; Vonderembse et al., 2006). |
|             | resilience      | SC risk management culture & ability to cope with unexpected disturbance (Kumar & Anbanandam, 2020). |
|             | green           | Environmental criteria for risk sharing & Internal environment management system (Sarkheil et al., 2020). |
|             | sustainability  | Stable; Have internal sustainable management system & sustainable measuring criteria (Seuring & Müller, 2008; Schaltegger & Burritt, 2014). |
| Strategic Approach | lean            | Collaboration with upstream & downstream actors (Lazarevicab et al., 2011). |
|             | agility         | Develop new competences & open up new products lines to cope with volatile demand (Shiri et al., 2015). |
|             | resilience      | Develop new capabilities through flexibility & redundancy or keeping strategic surplus capacity & inventory (Meyer, 2020). |
|             | green           | Focus should be on development & deployment on the internal SC resources (Bowen et al., 2001). |
|             | sustainability  | Cooperation among the various entities in SC (Seuring & Müller, 2008) Maximise performance & minimise cost (Vonderembse et al., 2006; Dües et al., 2013). |
| Product design Strategy | lean            | Product designing based on the customers' requirements (Vonderembse et al., 2006) Integration of material life cycle & eco-design & postponement strategy or delayed differentiation (Dües et al., 2013). |
|             | agility         | Postponement strategy or delayed differentiation (Meyer, 2020). |
|             | resilience      | Integration of material life cycle & eco-design & postponement strategy or delayed differentiation (Dües et al., 2013). |
|             | green           | Based on the TBL² philosophy & postponement strategy or delayed differentiation (Sridhar & Jones, 2013). |
| Product variety | lean            | Low (Carvalho & Cruz-Machado, 2011; Raut et al., 2021). |
|             | agility         | High (Carvalho & Cruz-Machado, 2011; Raut et al., 2021). |
|             | resilience      | High (Carvalho & Cruz-Machado, 2011; Raut et al., 2021). |
|             | green           | High (Carvalho & Cruz-Machado, 2011; Raut et al., 2021). |
|             | sustainability  | High (Raut et al., 2021). |
| SC Features | LARGS Paradigms | LARGS Criterions based on SC Features |
| Practices/ tools/ Principles | lean            | Value stream mapping, JIT, Kanban, respect for employees, automated mistake proofing, SS SMED & cellular manufacturing (Dües et al., 2013). |
|             | agility         | Collaborative relationships, process & information integration, customer/market sensitivity analysis & wait; approach to customer (Lin et al., 2006; Grunfleh & Tarafdar, 2013). |
|             | resilience      | Supply chain engineering & reengineering, collaboration, agility & risk management culture (Christopher & Peck, 2004). |
|             | green           | Sustainable value stream mapping & life cycle assessment tools (Dües et al., 2013). |
|             | sustainability  | Dedicated to concepts of triple bottom line, partner selection & development, long-term relationships, enhanced communication, logistics & technological integration, development operation st&ardisation & selective monitoring, stakeholder management & lifecycle assessment (Schaltegger & Burritt, 2014). |
| Production planning & control | lean            | Confined orders with reliable demand forecasts (Vonderembse et al., 2006) Based on mass customisation to quickly respond to varying customers' demand (Vonderembse et al., 2006). |
|             | agility         | Based on mass customisation to quickly respond to varying customers' demand & disruptive event (Meyer, 2020). |
|             | resilience      | High capability with respect to customer's needs (Chen & Liu, 2020). |
|             | green           | High sustainable practices based on TBL² practices (Raﬁ-Ul-Shan et al., 2018). |
|             | sustainability  | (Continued) |
Table 1. (Continued).

| SC Features | LARGS Paradigms | LARGS Criterions based on SC Features |
|-------------|-----------------|---------------------------------------|
| Planning level | lean | Strategic & operational (Anvari et al., 2014a). |
|               | agility | Strategic & operational (Shiri et al., 2015). |
|               | resilience | Strategic, tactical, operational (Christopher & Peck, 2004). |
|               | green | Strategic & operational (Seuring & Müller, 2008; Sayyadi Tooranloo et al., 2018). |
|               | sustainability | Strategic & operational (Seuring & Müller, 2008; Sayyadi Tooranloo et al., 2018). |
| Market | lean | Current market segment with predictable (Mason-Jones et al., 2000). |
|           | agility | Highly unpredictable, volatile & fragmented market (Vonderembse et al., 2006). |
|           | resilience | Turbulent & uncertain market (Christopher & Peck, 2004). |
|           | green | Current as well as highly unpredictable & volatile market (Ejaz, 2021). |
| Market/order Qualifier | lean | Quality, lead time & service level (Mason-Jones et al., 2000; Agarwal et al., 2006). |
|                  | agility | Cost, quality & lead time (Mason-Jones et al., 2000; Agarwal et al., 2006). |
|                  | resilience | Quality, delivery & service level (Mathews & Lakshmi, 2019). |
|                  | green | Cost, quality, lead time & delivery (Kainuma & Tawara, 2006). |
|                  | sustainability | Cost, quality, lead time, delivery & service level (Bortolini et al., 2016). |
| Market/order Winning | lean | Cost & service level (Agarwal et al., 2006; Dues et al., 2013). |
|               | agility | Flexibility & service level (Mason-Jones et al., 2000; Agarwal et al., 2006). |
|               | resilience | Cost, time, flexibility & innovativeness (Kumar & Anbanandam, 2020). |
|               | green | CO2 & service level; green innovation (Dues et al., 2013; Lin & Tseng, 2016). |
|               | sustainability | Innovation (Lin & Tseng, 2016). |
| Limitations | lean | Lack of external responsiveness to customers’ demands (Vonderembse et al., 2006). |
|               | agility | May not be cost-effective or lowest cost supply chain (Shiri et al., 2015). |
|               | resilience | Have to keep strategic capacity & inventory buffer that is responsible for extra (Raut et al., 2021). |
|               | green | Expensive practices & product cost (Çankaya & Sezen, 2019). |
|               | sustainability | Expensive practices & product cost (Çankaya & Sezen, 2019). |

*Triple bottom line*

Given research literature, the study variables include operational performance, economic performance, and environmental performance (Alam et al., 2014; Azevedo et al., 2011; Mariano & La Rovere, 2002); comparative advantage (Cabral et al., 2012); timely production and distribution, suppliers’ communication, reduced cycle time, quick customer response, flexibility in the production and distribution of different values, ability to change the time, the flexibility in production and distribution according to inventory and supply conditions, reduced waiting time, production and distribution in terms of demand, reduced material diversification, suppliers’ collaboration (Cabral et al., 2012; Azevedo et al., 2011); and economic factors, environmental factors, and social factors (Büyüköztürk & Berkol, 2011). Indicators of the questionnaires are shown in Tables 2 and 3.

Based on the conceptual model, the relationship between supply chain dimensions and the organization’s functional variables is investigated using partial least squares (PLS). AHP technique is used to determine weights to prioritize the determinant factors to achieve a comparative advantage through SCM, and VIKOR technique is used to determine the degree of importance (Anvari et al., 2014a).

### 3.1. Measurement of latent variables—external model

To evaluate the model, first, the external model is used to assess the relationships between latent variables and their measurement items. The external model examines the relationship between questions and constructs. In fact, if the questions do not measure the latent
Table 2. Criteria and sub-criteria for measuring performance.

| Criteria             | Sub – Criteria          |
|----------------------|-------------------------|
| P1                   | Operational performance |
|                      | P11 Reduce time         |
|                      | P12 Customer satisfaction|
|                      | P13 Quality             |
|                      | P14 Inventory level      |
| P2                   | Economic performance    |
|                      | P21 Liquidity cycle      |
|                      | P22 Environmental costs  |
|                      | P23 General expenses     |
| P3                   | Environmental performance|
|                      | S31 Business waste       |
| P4                   | Competitive advantages   |
|                      | P41 Increase the quality level|
|                      | P42 Increase the level    |
|                      | P43 Reduce time          |
|                      | P44 Reduce costs         |
variables properly, the relationships cannot be tested. The external model is used to demonstrate the proper measurement of latent variables. The measurement model is presented in appendix 1.

To examine the significance of the correlation between observable variables and relevant latent variables, bootstrapping value (t-statistic) is measured based on the measurement model results (appendix no 2).

Based on the measurement model results, the factor loading in all cases is higher than 0.2, indicating an appropriate correlation between observable variables (questions) and their relevant latent variables (techniques and performance).

According to the measurement model results, the bootstrapping value (t-statistic) is higher than the critical value of 1.96 in all cases indicating that the correlation between observable variables and their relevant latent variables is significant. Therefore, it can be concluded that each main variable is properly assessed, and concerning the results of this scale, the research hypotheses can be tested.

### 3.2. Hypothesis testing

Three observable variables, i.e. successful (operational, economic, and social) performance, are used to assess lean, agile, resilience, green, and sustainable constructs in the supply chain. The results are shown in terms of five hypotheses (Table 4).

As Table 4 shows, the power of the relationship between variables in the supply chain and successful performance is more than 0.20, which is an acceptable value. The test statistic of obtained hypotheses is higher than the critical value (t-value) at an error level of 5%, i.e. 1.96, indicating that the correlation is significant. Therefore, lean, agile,

| NO | Hypothesis                                                                 | Factor loading | T-value statistics |
|----|---------------------------------------------------------------------------|----------------|-------------------|
| 1  | Leaness in the supply chain is essential for successful performance.       | 0.230          | 3.266             |
| 2  | Agility in the supply chain is essential for successful performance.      | 0.369          | 2.326             |
| 3  | Resilience in the supply chain is essential for successful performance.  | 0.383          | 3.870             |
| 4  | Greenness in the supply chain is essential for successful performance.   | 0.259          | 2.582             |
| 5  | Sustainability in the supply chain is essential for successful performance. | 0.308 | 2.518              |
resilience, green, and sustainable supply chain has a direct positive effect on the successful performance. In this study, the effect of lean, agile, resilience, green, and sustainable supply chain on successful performance has been studied. In other words, using PLS technique, the effect of each variable related to these constructs is examined separately by considering the simultaneous effects of variables. The structural model of Smart PLS software output is displayed in Figure 2. In Figure 3, t-statistic is shown for assessing the significance of relationships.

Figures 2 and 3 show the structural output model of Smart PLS software. In these figures, the effect of five variables of leanness in the supply chain, agility in the supply chain, flexibility in the supply chain, greenness, and sustainability in the supply chain’s performance success variable was examined. Figure 2 shows the strength of the relationship between the factor (hidden variable) and the observable variable by the factor loading. The factor loading is a value between zero and one. If the factor loading is less than 0.3, a weak relationship is considered and ignored. The factor loading between 0.3 and 0.6 is acceptable, and if it is greater than 0.6, it is very desirable. Therefore, according to the factor loading coefficients in Figure 2, all coefficients are in the defined range.

The calculation of t-statistic to measure the significance of the relationships between the variables is shown in Figure 3. The value of t-statistic among all variables is greater than 1.96. Therefore, based on the results of the general model, it can be concluded that the studied techniques play a decisive role in performance success.
3.3. **Final research model**

Finally, in this section, using PLS technique, the overall effect of different techniques on the performance is investigated in terms of a general model. The final structural model is shown in Figure 4, and t-statistic for assessing the significance of the relationships is shown in Figure 5.

The power of relationship (standardized factor loadings) between LARG and sustainable supply chain techniques and performance is obtained 0.715 (Figure 4), which shows a high correlation. In addition, t-value is calculated 16.440 (Figure 5), which is higher than 1.96. Therefore, based on the results of the general model, it can be concluded that
LARG and sustainable supply chain techniques have a crucial role in successful performance.

The power of relationship (standardized factor loadings) between LARG and sustainable supply chain techniques and competitive advantage is 0.243 (Figure 4), which shows an average correlation. Furthermore, t-value is 2.232 (Figure 5), which is higher than 1.96. Therefore, according to the results of the general model, it can be concluded that LARG and sustainable supply chain techniques have a determinant role in achieving competitive advantage.

The power of the relationship (standardized factor loadings) between performance dimensions and competitive advantage is 0.976 (Figure 4), which shows a high correlation. Furthermore, t-value is calculated 13.063 (Figure 5), which is higher than 1.96. Therefore, based on the results of the general model, it can be concluded that performance dimensions have a critical role in achieving competitive advantage.

### 3.4. Prioritization using fuzzy MCDM

In the previous stage, the relation and influence of LARG and sustainable model’s factors on the performance criteria and competitive advantage were examined, and it was revealed that sustainability was at third priority. Then it could be a factor affecting the development of LARG model into LARGS model. In this stage, examining LARG and sustainable factors using fuzzy MCDM techniques, with a paired comparison of performance criteria and competitive advantage through fuzzy AHP (Anvari et al., 2014b); LARG and sustainable model’s factors are prioritized using VIKOR technique to determine which of these factors is effective while the sustainability is also determined at this stage.

#### 3.4.1. Prioritization of criteria (performance, economic, and environmental criteria) through FAHP technique

In this study, first, the relationships between variables are examined. After determining causal relations pattern, performance criteria and sub-criteria are determined. For this purpose, a questionnaire based on paired comparison and Saaty’s nine-point
scale is used. The questionnaires are distributed among experts. At this stage, seven experts’ views are utilized. The study’s main performance criteria include operational performance, economic performance, and environmental performance. For each of these criteria, several sub-criteria are considered, and ten sub-criteria are selected.

Using Super-Decision software, the final weight and priority of criteria (operational performance, economic performance, and environmental performance) and 10 sub-criteria are calculated. The results of calculations and relevant weights are presented in Table 5.

3.4.2. Prioritizing the comparative advantage criteria of Petrochemical Industries’ supply chain

At the first step, performance criteria and sub-criteria are prioritized. The study comparative advantage criteria include enhanced quality, increased service level, reduced time, and decreased distribution cost. The comparative advantage sub-criteria of the supply chain are presented in Table 6.

Therefore, given the calculations, the final weights of the model’s criteria are determined through FAHP technique (Table 5). The final weight will be used for the prioritization of techniques using VIKOR method (Table 6).

3.5. Ranking of supply chain dimensions using VIKOR technique

In this study, the first main performance criteria and sub-criteria were ranked using fuzzy AHP. In this step, based on the weight of identified criteria, the existing techniques were prioritized using VIKOR technique. The ranking of LARG and sustainable supply chain techniques was carried out based on performance and competitive advantage indicators (Table 7).

A comparison of the results of both PLS (Table 5) and VIKOR method (Table 7) is presented in Table 8.

| Table 5. Determining the final priority of criteria using FAHP technique. |
|-----------------------------|----------------|-------------------|-----------------|-----------------|----------------|
| criteria                   | Weight | Sub-criteria | Symbol | Primary weight | Final weight | ranked |
| Operational performance    | 0.302  | ● Reduce time | P11    | 0.439          | 0.136         | 3      |
|                            |        | ● Customer reduce | P12  | 0.310          | 0.087         | 6      |
|                            |        | ● Quality      | P13    | 0.157          | 0.049         | 8      |
|                            |        | ● Inventory level | P14  | 0.095          | 0.030         | 10     |
| Economic performance       | 0.345  | ● Liquidity Cycle | P21  | 0.487          | 0.175         | 2      |
|                            |        | ● Environmental costs | P22  | 0.346          | 0.126         | 4      |
|                            |        | ● Public costs  | P23    | 0.167          | 0.044         | 9      |
| Environmental operation    | 0.353  | ● Waste of business | P31  | 0.495          | 0.181         | 1      |
|                            |        | ● Particulate emissions | P32  | 0.236          | 0.068         | 7      |
|                            |        | ● Thermal discharge | P33  | 0.269          | 0.105         | 5      |

| Table 6. Final prioritization of comparative advantage sub-criteria of Petrochemical Industries’ supply chain. |
|-----------------------------|----------------|-------------------|-----------------|-----------------|----------------|
| Criteria                   | weight | Sub-criteria      | Final weight | Ranked |
| Advantage factors of supply chain | 0.092  | Increasing quality level | 0.416          | 1      |
|                            |        | Increasing service level | 0.261          | 2      |
|                            |        | Decreasing time     | 0.226          | 3      |
|                            |        | Decreasing cost     | 0.097          | 4      |
Table 7. Ranking of LARG and sustainable supply chain criteria based on performance indicators.

| LARGS Factors | LARGS SCM Indicators based on performance criterions | LARGS SCM Indicators based on competitive advantage criterions |
|---------------|----------------------------------------------------|---------------------------------------------------------------|
|               | S quant  R quant  Q quant  S quant  R quant  Q quant  | S quant  R quant  Q quant  S quant  R quant  Q quant |
|               | rank     rank     rank     rank     rank     rank     | rank     rank     rank     rank     rank     rank |
| leanness      | 0.509  4  0.202  5  0.953  5  | 0.042  4  0.038  5  0.850  5  |
| agility       | 0.335  2  0.135  3  0.253  2  | 0.041  3  0.021  3  0.544  3  |
| resilience    | 0.285  1  0.108  1  0.000  1  | 0.015  2  0.008  1  0.000  1  |
| greenness     | 0.333  5  0.171  4  0.834  4  | 0.054  5  0.024  4  0.762  4  |
| sustainability| 0.460  3  0.110  2  0.366  3  | 0.012  1  0.012  2  0.039  2  |

Table 8. Summarized results of PLS and VIKOR techniques.

| Dimensions affecting the performance | Ranking by PLS | Ranking by Vikor |
|--------------------------------------|----------------|-----------------|
| Leanness                             | 5              | 5               |
| Agility                              | 2              | 2               |
| Resilience                           | 3              | 1               |
| Greenness                            | 1              | 4               |
| Sustainability                       | 4              | 3               |

As it can be observed in Table 8, determining the importance degree and ranking of LARGS factors through PLS technique is supported by VIKOR technique. These results indicate that the development of LARGS model is highly reliable. Therefore, in this study, LARG model extends into LARGS model.

The Goodness of Fit is used to examine the verification and model fitting solution that controls both the measurement and structural model. Therefore, achieving a value of 0.435 for GOF indicates a suitable model of Goodness of Fit.

4. Discussion and Conclusion

Since SCM plays an essential role in any enterprise project, the selection and evaluation of SCM are key decisions for managers and decision-makers. Therefore, the identification and evaluation of a series of selection criteria of SCM will remove inefficient SCM from the organizational process. Thus, after data processing and analysis, the research questions are answered as follows:

**Question 1:** What are the basic requirements, effective factors and performance indicators to achieve a competitive supply chain? In other words, to achieve a competitive advantage in the supply chain; What is the role of the LARGS paradigms in meeting the basic requirements as effective factors in performance outcomes?

In this study, based on literature review; for developing LARGS supply chain model (lean, agile, resilience, green, and sustainable), competitive advantage factors (Cabral et al., 2012), including cost, quality, time, and service level, are determined and examined. Given the results, increased quality, increased production and distribution level, reduced production and distribution time, and cost reduction have the most importance to the least importance, respectively.
Also, based on others’ studies (Büyüközkan & Berkol, 2011; Cabral et al., 2012; S. G. Azevedo et al., 2011), it is demonstrated that lean, agility, resilience, green and sustainability in the supply chain have a critical role in successful performance.

In addition, the primary results (Büyüközkan & Berkol, 2011) indicate that key indicators for achieving a supply chain with competitive advantage characteristics are determined based on the following three main factors and ten sub-factors. While the main competitive advantage factors affecting LARG - SCM have been identified (Table 5).

- Operational performance (reduced time, satisfaction, customer, and quality of inventory level)
- Economic performance (general costs, environmental costs, and liquidity cycle)
- Environmental performance (Waste of business, Particulate emissions, Thermal discharge)

**Question 2**: Which sustainable LARG supply chain parameters are of greater importance for achieving a supply chain with competitive advantage? What are the current trends in the relationships of LARGS paradigms, among themselves, to achieving supply chain with competitive advantage?

The results of PLS and VIKOR techniques indicated that resilience, agility, and sustainability were on the first to third priorities (Table 8). However, in creating competitive advantage (VIKOR method), sustainability was at the fourth-ranking. The results of this study are consistent with Buenkozkan and Berkol (2011), S. G. Azevedo et al. (2011); Alam et al. (2014), and Cabral et al. (2012) studies.

**Question 3**: What SCM model is more effective in achieving the competitive advantage of the company’s supply chain? For this, it is important to study which types of LARGS techniques have been targeted in the literature? In addition, In addition, which paradigm was more important?

Generally, to answer this question, it could be said that first, by reviewing the literature and doing specialized interviews, main competitive advantage factors (cost, quality, time, and service); LARG, and sustainable supply chain indicators (lean, agility, resilience, green, and sustainability), as well as three criteria (operational, economic, and environmental) were identified as performance criteria affecting the SCM. Then, by examining each of them, an extended presumed model was presented. In this model, using PLS, FAHP, and VIKOR techniques, the cause and effect relation pattern among variables was evaluated and ranked. The results of the general model indicated that LARGS techniques with development and improvement approach of performance indicators had a crucial role in gaining competitive advantage.

In conclusion;

- In this study, for developing LARGS supply chain model, competitive advantage factors including cost, quality, time, and service level are determined and examined.
- It is demonstrated that the effective factors of LARGS indexes in the supply chain have a critical role in successful performance.
• The main competitive advantage factors are determined based on three listed factors and ten sub-factors, and the main factors are shown in Table 4.
• The results indicated that sustainability was on the third priority, and in creating competitive advantage, sustainability was at the fourth-ranking.
• Key factors of competitive advantages, LARG-SCM indexes, and three criteria were identified as performance criteria affecting the SCM. The cause and effect relation pattern among variables was evaluated and ranked. The results indicate that LARGS techniques had an essential role in achieving competitive advantage.

Therefore, the proposed model could be an effective and efficient SCM model to achieve competitive advantage in Petrochemical Industries’ supply chain. The results indicated that the development of LARG model to LARGS model was highly reliable. Also, the proposed model contributes to a deeper understanding of lean, agile, resilient, green, and sustainable paradigms in SCM. From the managerial point of view, managers can use this model as a checklist to identify possible practices to achieve their strategic goals. Also, it offers an integrated model giving managers insights on how to make SC’s leaner, agiler, more resilient, and greener to achieve the organization’s operational, economic, and environmental performance objectives.

Despite the important contribution of this paper, limitations of the study should be noted. The conceptual model was developed using anecdotal and empirical evidence presented in the literature, and no validation where performed. It is necessary to conduct further research concerning the influence of LARGS practices on manufacturing supply chain performance, both in terms of testing the proposed model and the greater understanding of this discipline.

Future work will be necessary to expand validations and to include more than three practices. Also, it is important to evaluate perceptions from various entities within the supply chain and compare the results.

The present study is qualitative research and has proposed a LARGS-quality hybrid theory. Whereas the purpose of grounded theorizing is to produce theory; Therefore, in order for the data analysis to become a theory qualitatively, for the correctness of LARGS integrated model, it is suggested that future researchers conduct this research using the grounded theory method.

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