

A Comparative Analysis of Green Supply Chains Among Countries in the Middle East, Latin America, and Europe

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Abstract—We used Data Envelopment Analysis (DEA) to compare the development of Sustainable (Green) Supply in three regions of the world, the countries of the Gulf Cooperation Council (GCC) in the Middle East, six countries in Europe, and six countries in Latin America, which were selected based on the rank of their Logistics Performance Index. The focal region were the six member countries of the GCC against which countries in the other two regions were compared over a 10-year period. We based our empirical analysis on UN SDGs concerned with affordable and clean energy (SDG 7), industry, innovation and infrastructure (SDG 9), sustainable cities and communities (SDG 11), and climate action (SDG 13). Using a modified model of RAM-DEA, Kuwait, Qatar, and Saudi Arabia in particular showed high levels of inefficiency, which were marked by high oil consumption, low investment in good inputs (e.g. R&D, academic basic and applied research), and low outputs, specifically in terms of clean (e.g. solar) energy. It could be said that countries in Western Europe still led in terms of inputs versus outputs. However, certain countries in other regions are also strong contenders in sustainable supply chains. These include the UAE, Oman, México, Panamá, and Ecuador.

Index Terms—DEA, GCC, Latin America, sustainable development goals, efficiency, supply chains, sustainability, renewable energy, corporate social responsibility, logistics performance index

I. INTRODUCTION

Global competitive pressures are forcing countries to strengthen their position in the world market through regional integration. With trade and customs agreements individual countries have been enabled to improve their competitive position within a single regional market towards other regions and countries globally. This was

also the incentive for the Gulf countries to establish a Cooperation Council for the Arab States of the Gulf in 1981, also known as Gulf Cooperation Council (GCC), comprising Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates. Gulf integration has enabled facilitation of the movement of production, removing trade barriers, and coordinating economic policies, extending the size of the market to 35.65 million people who live in this region [1], [2]. Moreover, it has created the preconditions for establishment of supply chains and sophisticated logistics networks with the aim of joint GCC exposure connecting the GCC as a region and globally. Internally, the GCC is an area of economic cooperation comprising the four freedoms akin to the EU. Externally the GCC has a growing network of free trade agreements with various parts of the world, most notably with EFTA countries, the US (Framework Agreement for Trade, Economic, Investment and Technical Cooperation), Singapore (GCC-Singapore FTA), and Australia, and bilateral cooperation agreements of individual countries such as UAE with Mexico. [3], [4]. According to the Statistical Centre for the Cooperation Council for the Arab Countries of the Gulf [5], total export of GCC countries was approximately USD 652 billion of USD in 2018 with an increasing trend. The export of oil, natural gas, and chemical products are the most important exports; however many other products form an important share of exports from GCC countries. For example, non-oil exports contribute 70% to the GDP of the UAE; however, these are mostly other commodities such as gold, jewellery, and electronics; a notable exception are the aerospace and defense sectors in which the UAE also excels and exports [7]. No other country in the GCC has reached the same level of economic diversification as the UAE. On average, the oil

and gas sector makes up 70% of exports from the GCC [7].

[1] found that supply chains in the GCC region confront three main challenges including “strategically selecting and integrating network resources”, ‘reliably contracting and delivering high-quality solutions’, and ‘cost effectively controlling and financing operational expansions’ [1].

One of the most rapid developing world regions by increasing worldwide circulation of commodities is the region of the Gulf Cooperation Council (GCC) countries which have become a central node in global trade [2]. The GCC region has a strategic geographic position between Asia and Europe and strong trade links with Africa. [1] estimated that this region accounts for around 30% of the globally known oil reserves. According to [2], authorities in this region have recognised the possibility of economic diversification by making significant investments into logistics infrastructure: maritime ports, roads, rail, airports and logistics cities [2], [3], [4], [5]. According to Fernandes and Rodrigues (2009), GCC countries are positioning themselves to be logistic hubs by strengthening transport, and connectivity, and this can lead to attracting foreign investments. [1] provided a useful insight into the existing literature of the supply chain management of the GCC region and found high levels of complexity and uncertainty within this regional business environment. One of the complexities found by these authors is related to strategically selecting and integrating network resources within the GCC region, focusing attention on the views of multinational companies towards regional supply chains. According to them, multinational companies located in the GCC region are very focused on regional supply chains. According to [6], oil-producing countries, with exception of the United Arab Emirates and Bahrain, perform below their potential and their logistics systems usually focus on their main export commodities rather than focusing on diversification on trade logistics. These authors pointed to an example of Dubai Ports World that has become one of the most important global port operators, operating 42 port terminals in 27 countries. In addition, the UAE has focused on its attention on cementing its maritime logistics efficiency by capitalising on its unique geographic advantage as the only country in the GCC with access to two bodies of water - the Persian Gulf and the Gulf of Oman (Indian Ocean) rendering the country independent of the conflict-prone Straits of Hormuz. As a result, a number of efficient ports exist on both coasts, all of which are connected through superb road infrastructure inside the country. [6] also pointed out that countries with better logistics capabilities can attract more foreign direct investments, decrease transaction costs, diversify export structure, and have higher growth. Accordingly, the UAE has posted the highest economic growth rates and has the highest LPI within the GCC and is in 11th place globally among its GCC peers [7]. In terms of supply chain competitiveness, the UAE is comparable to industrialised countries such as

Switzerland, United States, United Kingdom, and Finland which are countries within two ranks (above and below) the UAE. As a result of the logistical strength of the UAE, the GCC therefore has a high overall mean LPI. The UAE is followed by Qatar, Oman, and Saudi Arabia in logistical strength at ranks, 30, 43, and 55, respectively, placing them into similar categories as industrialised emerging economies such as Poland and Slovenia in Europe, and Mexico, Chile, and Panama in Latin America [7].

II. THEORETICAL BACKGROUND

Efficient supply chains have become a source of competitive advantage for companies globally [8], [9], [10], [11], [12]. Effective management of Supply Chains can lead a competitive advantage by supporting market strategy [13]. Since 2005, the company Procter & Gamble (P&G) considers three moments of truth as a part of its market strategy. The first moment of truth is when the consumer finds the right product on the shelf. P&G describes this as the “moment a consumer chooses a product over the other competitors’ offerings” [14]. The second one is when the consumer uses the product to capture the perceived value [14]. The third is when a customer shares feedback with the company as well as other prospective consumers [14]. Moreover, in 2011, Google introduced the concept of *Zero Moment of Truth* (ZMOT). It happens when a customer searches websites and reviews about a product before purchasing it. In 2014, Eventricity Ltd. proposed the *Less Than Zero Moment of Truth* (<ZMOT), which is when a factor triggers a consumer to start looking for or searching a product. E-commerce provided a push factor towards optimisation of supply chains since profiting from all these moments of truth requires a fast, responsive, reliable, and resilient supply chains that is always ready to support any intended disruptive business model. Many other studies have been conducted on the management of logistics operations that support the aforementioned examples. One of these issues, as stated by [15] is related to managing goods flows between facilities in a chain of operations, thus putting focus on the importance of coordinated planning approaches that can reduce costs. Several scholars have warned of the need to have an appropriate coordination in decision making on the design of international facility networks [16], [17]. [18] argued that with establishment of the global commodity chain approach, the importance of regions in economic activities arises. [19] argued that the location of the logistics centres is a key element of the transport system and location decisions should be done strategically. Due to advantages for the economy, regional authorities want their region to be considered for logistical centres and this could lead to rising logistics costs, increasing travel distances by trucks, and lacking multi-modal transportation possibilities. This is particularly an issue for countries that follow a federal system of government (e.g. the UAE), where competing interests among

regional rulers can lead to duplication of infrastructure and therefore non-optimisation of costs in the long term. However, negative effects are often cushioned when oil prices rise and are therefore not always given the sense of urgency it deserves. On the other hand, redundancies in infrastructure can also have positive effects, for example when back-up options are needed when a critical road undergoes maintenance. In some GCC countries, notably the UAE, examples of duplicate infrastructure can include too many roads connecting the same city pairs as well as transport hubs and companies in close proximity (e.g. Dubai and Abu Dhabi airports, Emirates and Etihad as global airlines) which are assets of their respective emirates (states) and their ruling families rather than federal assets and therefore often lack a coordinated approach, which could affect efficiency [21]. In his study of the GCC, [21] also finds support for the argument of a large degree of duplication in port infrastructure in the region. Therefore, an analysis of GCC countries and their comparison to emerging and industrialising countries in Latin America for perspective is fully justified and is the focus of this study.

The chosen pair of regions (6 countries of GCC and 6 countries with high LPIs in Latin America) is relevant because of the necessity to build long-term relationships and trade links between regions, which, according to [21], are critical factors to establish successful logistics systems. Trade volume between the two regions has been rising as a result of multilateral trade and economic partnership agreements among countries in the two regions [21].

III. GREEN SUPPLY CHAINS

Supply chain management is an area of increasing strategic importance due to global competition, outsourcing of noncore activities to developing countries, short product life cycles, and shortened lead times in all aspects of the supply chain [22]. Management attention has moved from competition between firms to competition between supply chains and value chains [23], [24], [25]. The capability to establish close and long-term relationships with suppliers and other strategic partners has become a crucial factor in creating competitive advantage. At the same time, various stakeholders, including consumers, shareholders, non-governmental organisations (NGOs), public authorities, trade unions, and international organisations, are showing an increasing interest in environmental and social issues related to international business. Concepts such as supply chain sustainability [26], [27], [28], environmental management [29], corporate greening [30], green supply [31], [32], [33] and corporate social responsibility (CSR) in supply chains [34], [35] have increasingly been studied and resulted in new findings by [36], [37], [38], and [39] across various industries, company types (MNCs and SMEs), and countries. An increasing number of companies, especially large multinational corporations, have implemented environmental annual reports,

sustainability strategies, and voluntary codes of conduct [40], [41]. The promotion of ecological aspects in many parts of consumer life and the continuous improvement of consumers' environmental awareness, not only are green products becoming favoured by the market but also sustainable supply chains [42].

According to [43], "effective logistics and supply chain management can provide a major source of competitive advantage". Having in mind the necessity of GCC countries to be included effectively into global supply chains while conforming to sustainability mandates set by the UN through its SDGs (Sustainable Development Goals), we analysed logistical and green supply chain performance of GCC countries and a similar number of the most developed countries in Latin America. The main research questions are:

How sustainable are Logistics Networks in both regions in terms of not only their LPI but also their contribution towards green supply chains, mainly represented by SDGs 7, 9, 11, and 13?

Which of these regions is likely to have an edge in terms of both Logistics Performance and Green Supply Chains combined in future?

What will be the implications of the findings for policy makers and businesses in both regions?

In line with the six member countries of the GCC, which represent the highest economically developed countries in the MENA region, we selected six similarly developed countries in Latin America based mainly on the rank of their LPI, which is also correlated to their level of economic development, to have a comparable base to the GCC. The six countries we chose in Latin America include Mexico, Brazil, Argentina, Chile, Ecuador, and Panama. For the third region of comparison, we selected six countries in Europe by highest Logistics Performance Index.

IV. LOGISTICS PERFORMANCE INDEX (LPI)

The Logistics Performance Index is a tool developed by the World Bank to identify the strengths and opportunities the countries have in their performance on trade logistics and what can be done to improve their performance. Logistics Performance Index attempts to provide a standardised method to compare supply chain efficiency among countries [42].

V. RESEARCH DESIGN

[43] highlighted that international trade has been affected by increased competitiveness of lagged regions that in the past did not play such an important role in the world. Thus, they believe that only those countries prepared to implement the advances that commercial globalisation requires can benefit from improved logistics performance. According to [43], measurement of performance must recognise the role of an organisation in a supply chain. [44] pointed out that logistics performance is an accelerator of the competitiveness of a

country and thus, they need to evaluate their position using various indicators including logistics performance index (LPI). [44] also indicated the usefulness of LPI as a composite index which shows that building the logistics capacity to connect firms, suppliers and consumers is even more important today than costs. Thus, within logistics performance analysis for GCC countries we will use LPI data. [45] performed a comparative analysis of the G7 and BRICS countries on the basis of logistical competitiveness, and they expanded the criteria by using the adoption of information and communication technologies and CO₂ intensity in addition to the LPI criteria.

Significant studies can be found in the literature that deal with the problem of selection of logistics centres using multi-criteria decision analysis, such as studies by [46], and [47]. They analysed among 15 regional logistics centre cities and thirteen criteria to identify logistics centre location and captured the vagueness associated with subjective perception of decision makers using fuzzy logic, while [47] used a DEA approach to identify effective and sustainable logistics locations.

[48] developed a benchmarking framework for selection of logistics centres and found that freight demand, closeness to market, production area, customers, and transportation costs are most important factors for selection and applied Proximity Indexed Values to perform a comparative analysis of the G7 and BRICS countries, while [49] put their focus in selection of locations that maximise profits and minimise costs. Focusing on several criteria, such as proximities to highway, railway, airports, and seaports; volume of international trade; total population; and handling capabilities of the ports, [49] also combined spatial statistics and analysis approaches to evaluate suitable levels of performance for logistics centres. [50] searched for the best location of logistics centres used an AHP method of multi-criteria analysis.

We followed the previous methods used and used improved composite indices to compare the impact of green logistics on international trade in developed and developing countries using Data Envelopment Analysis.

DEA is a data-driven and nonparametric mathematical programming approach, we obtained results for 18 countries in three regions using 6 parameters, divided into three parameters of slack inputs and 3 parameters of slack outputs. According to [50], the countries to be compared need to be three times the sum of of slack inputs and outputs (18 countries) in order for the model to function. The slack inputs consist of three variables under SDGs 7 and 9, namely Clean Fuel (SDG 7), Articles (SDG 9), and Research and Development Expenditure (SDG 9). The slack outputs consist of three variables under SDGs 7, 9, and 13. These are Logistics Performance Index (LPI – SDG 9), CO₂ emissions from fuel combustion/electricity output (CO₂TWH – SDG 7), and energy-related CO₂ emissions per capita (CO₂PC – SDG 13), respectively.

TABLE I. DATA ENVELOPMENT ANALYSIS OF COUNTRIES IN LATIN AMERICA, EUROPE, AND GCC

	Efficiencies	slack input			slack output		
		7_cleanfuel	9_articles	9_rdex	9_lpi	7_co2twh	13_co2pc
Chile	0.97111	0	12.25	0.00	0.00	2.70	8.38
Panama	1	0	0.00	0.00	0.00	0.00	0.00
Brazil	0.89985	0	0.95	15.04	0.00	12.01	9.02
Mexico	1	0	0.00	0.00	0.00	0.00	0.00
Argentina	0.86972	0	1.95	1.25	3.88	1.67	0.00
Ecuador	1	0	0.00	0.00	0.00	0.00	0.00
Germany	1	0	0.00	0.00	0.00	0.00	0.00
Netherlands	1	0	0.00	0.00	0.00	0.00	0.00
Sweden	1	0	11.98	33.04	0.00	21.39	25.22
Austria	0.99797	0	0.00	13.14	0.00	3.56	10.48
UK	0.98251	0	8.20	0.00	0.00	4.61	29.22
Switzerland	0.98032	0	27.76	39.92	0.00	15.48	24.01
Emirates	1	0	0.00	0.00	0.00	0.00	0.00
Bahrain	1	0	0.00	0.00	0.00	0.00	0.00
Kuwait	1	0	0.00	0.00	0.00	0.00	0.00
Oman	1	0	0.00	0.00	0.00	0.00	0.00
Qatar	1	0	0.00	0.00	0.00	0.00	0.00
Arabia	1	0	0.00	0.00	0.00	0.00	0.00

According to Table I, the results show that those countries showing 0 in the tables run at optimal efficiency in terms of inputs versus output ratios. However, it should be noted that all results are relative, both across countries, and across inputs versus outputs, which does not automatically mean that “efficient” is “good”. Efficiency can also be a result of low inputs and low outputs, which is not necessarily good. The interpretation for efficient countries simply means that their outputs are efficient relative to inputs if the result shows 0. What we can see from the results is that the countries of the Middle East, in general, are very similar. Their efficiencies are adequate for the inputs and outputs they have. However, the results do not indicate absolute values of inputs and outputs.

For European countries, the results are more mixed. Some inefficiencies can be seen for Switzerland, the United Kingdom, and Austria. However, these countries overinvest in Rdex (SDG 9) in the case of Austria, and in Articles (SDG 9) for the case of the UK and Switzerland. Despite having efficiencies of 1, the case of Switzerland is special, since it has excesses in publications and R&D investments, being able to further reduce its CO₂ emissions. Hence, for the amount of investment, the outputs are not yet satisfactory. Output inefficiencies can be seen in CO₂TWH (CO₂ Emissions from fuel combustion - SDG 7) and CO₂PC (Energy-related CO₂ emissions per capita - SDG 13). This is not necessarily a negative aspect, it simply means that the mentioned countries invest a great deal, but have not yet obtained matching returns on their investment.

In the case of countries in the Middle East, they may not be investing enough relative to their GDPs and the outputs are correspondingly matching the inputs, still showing up as efficient. In reality, several large projects aimed at building renewable energy capacities and sustainable cities in the Middle East have failed or been abandoned since inception. A prominent example is Masdar City near Abu Dhabi, which was meant to be a large-scale green city powered by solar electricity with one of largest fields of solar panels in the Middle East, but it has been abandoned since 2015. However, the UAE has plans to increase investment in sustainable energy production by 500% in the coming decade (2020-2030) (Reuters, 2020), but the outcome is yet to be seen.

According to [50], GCC countries intend to reach 72 GW of renewable energy capacity by 2030 through solar power. However, the current output across the GCC in solar energy is only about 800MW led by the UAE and Oman. As the largest economy, the share of Saudi Arabia's output in renewable energy was a mere 5MW in 2018 indicating that there is still a long way to go in investment in green energy as inputs versus corresponding outputs [51].

TABLE II. RAM-DEA ANALYSIS OF COUNTRIES IN LATIN AMERICA, EUROPE, AND GCC

Country	Efficiencies	stacks input oil consumption / pop	stacks good output sdg11_gm	stacks bad output sd7_co2wh	stacks bad output sdg11_gm25	stacks bad output sdg11_co2pc
Chile	0.9182	0	0.01374499	0.4172016	10.437927	1.685191
Panama	1.0000	0	0	0	0	0
Brazil	1.0000	0	0	0	0	0
Mexico	0.8893	0	0.00383475	0.7491509	9.789111	1.147607
Argentina	0.8818	0	0.24880736	0.7504053	1.396596	1.955532
Ecuador	0.9476	0.974586	0.53490246	0.8357081	2.750121	0
Germany	1.0000	0	0	0	0	0
Netherlands	0.8545	28.436985	0	0.6905334	2.444003	2.93779
Sweden	1.0000	0	0	0	0	0
Austria	0.9457	0	0.40368432	0.7976046	6.094739	2.205929
United Arab Emirates	0.5558	47.705637	0.388807	1.3621163	31.004	17.910526
Belgium	0.5274	10.844932	1.05395	0.9105496	55.8	18.428576
Kuwait	0.3026	90.989133	0.934662	1.0848241	48.665	18.37526
Oman	0.5188	7.581091	1.209135	1.9300883	30.752	10.350959
Qatar	0.2129	72.034962	0.854639	1.8570852	71.874	39.752532
Saudi Arabia	0.3265	70.537223	0.75157	1.4805146	48.649	14.134663

According to the model results in Table II, there are four countries which could be considered efficient: Panama and Brazil in Latin America, and Germany and Sweden in Europe.

GCC countries obtained an inefficient index compared to countries in Europe and Latin America. The most inefficient components for these countries are the oil consumption and the annual mean concentration of particulate matter of less than 2.5 microns of diameter. The most inefficient countries were Kuwait, Qatar, and Saudi Arabia.

VI. CONCLUSION

While results are promising, it can be seen that countries are generally moving in the direction of sustainable logistics. The data for European countries shows that significant investments (inputs) are being made while results relative to the investments are not yet always obtained. However, countries such as the United Kingdom, Switzerland, and Austria have other constraints of not being fully integrated with the EU, either as a result of being non-EU members (Switzerland and UK), being landlocked (Switzerland and Austria), or being insular in addition to outside the EU (the UK). Therefore, inefficiencies in the LPI could have shown up as a result of these. However, we did not specifically measure for these constraints. The other results are as expected, in that countries such as Germany, the Netherlands, and Sweden, are fully efficient in terms of green LPI.

The scenario was more mixed for countries in the Middle East. The initial model listed all as being efficient; however, the inputs have not been consistently high or of significant duration, such as the green project of Masdar City in Abu Dhabi, the very low share of solar energy generation in the largest GCC economy Saudi Arabia, and generally low inputs from countries such as Kuwait and Qatar. By this account, it can still be seen that the

UAE and Oman are ahead of the remaining four economies of the GCC in terms of sustainable logistics.

For countries in Latin America, the results were more mixed, especially in the second model. A common problem are CO₂ emissions, especially those experienced by the larger economies of Brazil, Chile, and Argentina. Although the model shows that investments in research and development are being made (Rdex – SDG 9), especially in Brazil, the effects of these investments have not yet materialised in the case of Brazil. We can also see that Chile is making headways in academic research of sustainability as evidenced by SDG 9 – Articles in Table 1, but, similarly, the effects are not yet matched by outputs. A similar scenario of academic research applies to Argentina, albeit on a smaller scale, where inputs are not matched by outputs.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

All authors conducted research and analysis of data for their respective countries and contributed by writing parts of the article. José Guadalupe and Luis Fernando contributed the mathematical analysis. All authors had approved the final version.

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