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Logistics Performance and Environmental Degradation: The Case of MENA Countries

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Abstract

This article analyzes the impact of logistics performance on environmental degradation for a panel of 20 economies in the Middle East and North Africa (MENA) from 2007 to 2018. Logistics performance is measured by the Logistics Performance Index (LPI) and its sub-indices as developed by the World Bank, while environmental degradation is measured by CO_2 emissions and ecological footprint. According to the empirical findings, improvements in logistics performance raise environmental degradation for oil-rich MENA countries, while the effect of that variable is statistically insignificant in the case of non-oil-rich MENA countries. Higher values for the LPI and its sub-indices are not necessarily associated with environment-friendly (green) practices. Considering the adverse environmental effects of logistics performance, such regulations as judicial and governmental protection of natural resources and well-designed practices for green logistics are needed. More accurate alternative indicators can also be developed and formulated to evaluate green logistics in the MENA region, as the LPI and its sub-indices do not tend to reflect environment-friendly practices.

Keywords: Middle East and North Africa Economies, logistics performance, environmental degradation, green practices

JEL Codes: C13, C23, C33, F64, Q56

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Lojistik Performans ve Çevresel Bozulma: MENA Ülkeleri Örneği

Öz

Bu makalede lojistik performansın çevresel bozulma üzerindeki etkisi, Orta Doğu ve Kuzey Afrika (MENA) bölgesindeki 20 ekonomiyi kapsayan bir panel veri kullanılarak 2007-2018 dönemi için analiz edilmektedir. Lojistik performans için Dünya Bankası tarafından geliştirilen Lojistik Performans Endeksi (LPI) ve alt endeksleri, çevresel bozulma için ise CO_2 emisyonları ve ekolojik ayak izi göstergeleri kullanılmaktadır. Ampirik bulgularda lojistik performansındaki iyileşmelerin petrol zengini MENA ülkeleri için çevresel bozulmayı artırmakta (dolayısıyla çevresel sürdürülebilirliği zayıflatmakta) olduğu, petrol zengini olmayan MENA ülkeleri için bu değişkenin etkisinin istatistiksel olarak anlamsız olduğu görülmektedir. LPI ve alt endekslerinin daha yüksek değerler alması ile çevre dostu (yeşil) uygulamalar arasında doğrudan bir ilişki olduğu söylenemez. Dolayısıyla lojistik performansın olumsuz çevresel etkileri göz önüne alındığında, doğal kaynakların hukuki ve resmi olarak korunması gibi düzenlemelere ve yeşil lojistik için iyi tasarlanmış uygulamalara ihtiyaç duyulmaktadır. LPI ve alt endeksleri çevre dostu uygulamaları yansıtma eğiliminde olmadığından, MENA bölgesindeki yeşil lojistiği değerlendirmek için daha uygun alternatif göstergeler geliştirilebilir ve formüle edilebilir.

Anahtar Kelimeler: Orta Doğu ve Kuzey Afrika Ekonomileri, lojistik performans, çevresel bozulma, yeşil uygulamalar

JEL Kodları: C13, C23, C33, F64, Q56

1. Introduction

At national level, a country's logistics performance is a major determinant of its economic capabilities because logistics infrastructure connects producers with supply chains, consumers with products and people with communities through urban and rural networks. At international level, effective and efficient logistics networks constitute the cornerstone of global production and trade. In this context, logistics refers to the group of connected activities necessary to transfer goods through effective supply-chains, which involve freight transportation, information processing, material handling, and the storage and management of inventory (Martel and Klibi, 2016). Ineffectively overseen and unproductive logistics procedures lead to heightened operational and capital expenditures due to such factors as under-utilization of existing resources and prolonged waiting time (Windmark and Andersson, 2015). Therefore, improvements in logistics performance are considered to be a major priority for sustaining economic growth, facilitating trade, increasing export variety and boosting competitiveness in global markets (Gani, 2017; Kim and Min, 2011; Töngür et al., 2020; D'Aleo and Sergi, 2017a).

However, potentially negative effects of logistics activities are also questioned along with the mounting concerns on environmental degradation. According to International Energy Agency (IEA)(2019), transport sectors, together with electricity and heat generation, are accountable for two-thirds of the total carbon emissions in 2017. Similarly, a United Nations (2014) report states that logistics transportation produces around 22% of global carbon dioxide (CO_2) and approximately 19% of black carbon emissions, which are technically negative environmental externalities detrimental to human health. In the face of such alarming estimations, Alam and Lee (2021) warn that, by 2050, carbon emissions from logistics activities may increase by 60%, unless adequate measures are taken. The International Transport Forum's "Freight Model" forecasts approximately a fourfold increase in increased emissions from trade-related freight transportation also by 2050 (Wild, 2021).

Transportation is an obvious cause of greenhouse gas (GHG) emissions, with road transportation being the most significant source (Larson, 2021). This causation runs mainly through the high dependence on fossil fuels for transportation and the fuel inefficiency of vehicles. Intensity of transportation and long delivery times increase carbon emissions by raising fossil fuel consumption (Khan et al., 2019; Rashidi and Cullinane, 2019). Moreover, logistics is a consumptive segment of the economy in terms of its propensity for energy depletion. Immoderate levels of energy usage tend to become all the more problematic especially in emerging and developing economies where transportation systems expand rapidly in response to soaring market demand, degrading the environment further through the augmented need for energy. Last but not least, logistics operations can also have adverse impacts on air and water quality. The use of heavy-duty trucks and other transportation equipment can lead to air pollution, while the disposal of hazardous materials such as oil and chemicals can result in water pollution (Zaman and Shamsuddin, 2017).

On the other hand, environmentally-conscious improvements in logistics performance can help reduce carbon emissions and enhance environmental quality and sustainability. For example, raising the efficiency of transportation systems can economize fuel consumption and reduce emissions by optimizing transportation routes and vehicle utilization (Barth and Boriboonsomsin, 2009). Effective and prudent investments in logistics can promote modal shifts in transportation, favoring, for instance, substitutable and more sustainable modes like railways or waterways that reduce carbon emissions as well as trucking congestions (Larina et al., 2021). Environment-friendly infrastructure development projects can also be associated with energy-efficient technologies and sustainable construction practices. Such technologies and practices encompassing the entire supply chain, such as waste-reduction acts and eco-friendly procurements, can remarkably improve environmental performance.

On the contrary, increased transport activity resulting from improved logistics can lead to higher carbon emissions and air pollution if it relies on environmentally impactful modes of transport. Infrastructural enlargements to support logistics improvements can effectuate habitat destruction and loss of biodiversity if not properly planned. Unregulated expansion of logistics activities may cause transport congestions, leading to delays, inefficiencies, increased fuel consumption, rising emissions and heavier air pollution. Greater priority put on transportation speed and commercial efficiency in the context of logistics operations can generate environmentally undesirable outcomes, such as resource overutilization and packaging waste. While well-designed logistics improvements have the potential to enhance transportation efficiency and environmental sustainability at the same time, uncontrolled hikes in overall energy consumption can bring about environmental degradation especially if cleaner energy alternatives are not adopted.

This dilemma can be addressed within the context of Jevons' paradox. This paradox was first proposed by William Stanley Jevons in the 19th century in relation to coal consumption in the UK. Jevons (1906) observed that the higher efficiency in coal utilization resulted in an increase in its consumption rather than a decrease, due to the lower cost and increased resource availability. Therefore, it pertains to the occurrence in which enhancements in the efficiency and productivity of resource utilization might result in a rise in the total consumption of the resource, rather than a reduction. Jevons' paradox is relevant to resource efficiency and sustainability discussions in various ways. For example, in the case of irrigation technology, Sears et al. (2018) suggest that embracing advanced irrigation technology for enhanced efficiency may not necessarily lead to a decrease in water consumption, as farmers may choose to irrigate more land or crops due to the lower cost and increased availability of water. Similarly, in the case of agricultural productivity, Ceddia (2019) suggests that increased productivity may lead to agricultural expansion, rather than land-sparing, due to the increased value of cleared land. Jevons' Paradox is also associated with discussions of energy efficiency, climate change and environmental degradation. Trincado et al. (2021) suggest that energy efficiency measures may lead to higher levels of energy consumption, due to the lower cost and increased availability of energy, which could increase the risk of climate change and environmental degradation.

In our study, Jevons' paradox is discussed in the context of logistics performance and environmental degradation. In this context, Jevons' paradox suggests that even if improvements in logistics efficiency and sustainability practices result in lower energy consumption or emissions per unit of transported goods, the overall environmental benefits may be offset or even eliminated by an increase in the total volume of goods being transported. For example, if logistics improvements allow for faster and cheaper delivery of goods, it can stimulate an increase in consumer demand and global trade. This increase in demand can lead to a higher volume of goods being transported, resulting in more energy consumption, emissions, and environmental impacts. This paradoxical outcome is known as the "rebound effect" or "backfire effect". Therefore, as the "Jevons' Paradox" emphasizes, it is critical to consider the unintended implications of logistics improvements and to take a holistic approach to sustainability that considers the complex interactions between economic, social and environmental factors.

In the empirical literature, the link between logistics performance and environmental sustainability has recently been a topic of discussion (Li et al., 2021; Magazzino et al., 2022). However, the findings show that the nature of the nexus between environmental degradation and logistics performance remains unclear and needs further investigation.

Most developing nations experience logistics-base inefficiencies when it comes to connecting to global manufacturing networks and distributing their products to global markets as well as environmental degradation alongside their economic growth targets (Hausman et al., 2013; Martí et al., 2014; Yadav, 2014; Saslavsky and Shepherd, 2014). This dilemma is particularly critical for the Middle East and North Africa (MENA) region. While environmental degradation is a serious concern for the MENA economies due to the abundant use of fossil fuels and non-renewable energy sources, the need for more sustained growth is also quite high due to occasionally unfavorable conditions in the oil market, rapid population growth, structural unemployment and other socio-economic problems. MENA countries also suffer from logistics inefficiencies such as customs procedures, customs clearance and bureaucratic control in transit. Therefore, balancing economic and environmental aspirations so as to achieve sustainability goals is all the more momentous in the MENA region. Indeed, the gist of the story for MENA is attached to the question as to whether improvements in logistics performance can also serve to eliminate or mitigate the harmful effects of logistics activities on the environment. And if the answer is negative, countries in the region should look for ways to accomplish this task.

In light of this introductory background, this study aims to fill several gaps in the literature by focusing on the MENA region. Environmental effects of logistics performance are examined in detail through descriptive and econometric analyses for 20 economies in the MENA region, using annual data spanning from 2007 to 2018. Our benchmark regression analysis employs fixed-effects panel data estimation. Considering the potential problem of endogeneity, fixed-effects instrumental variable (FE-IV) regression and generalized methods of moments (GMM) estimation are also implemented, which provide us with robustness checks for the results of the benchmark regression.

The rest of the paper is organized as follows. Section 2 presents the literature review. Section 3 introduces the data and the descriptive statistics. Section 4 presents the econometric methodologies and the regression results. Section 5 concludes with some useful policy implications that can serve as data-based insights for policymakers to pave the way for constructing a sustainable development agenda in the MENA region.

2. Literature Review

Most of the studies in the literature examine the relationship between logistics performance and various economic variables such as trade volumes (Çelebi, 2019; Marti et al., 2014), world economic growth (Coto-Millan et al., 2013) and export variety (Töngür et al., 2020). On the other hand, the relationship between logistics performance and environmental sustainability has begun to be examined systematically quite recently alongside the green supply chain management (GSCM) and green logistics (GL) literatures (Liu et al., 2018). The GSCM aims to ensure environmental protection and increasing environmental quality in all processes of the supply chain, from the procurement of raw materials to their final use by consumers. The GL, which can also be understood as a crucial component of GSCM, refers to the use of environmentally friendly and sustainable processes in logistics activities, and thus intends to reduce the negative environmental effects of logistics operations and provide a long-term balancing of environmental and economic objectives (Carter and Liane Easton, 2011; Min and Kim, 2012, Liu et al., 2018).

In general, the empirical studies examining the relationship between logistics activities and the environment employ the Logistics Performance Index (LPI) and its sub-indices developed by the World Bank (2022a) as indicators of logistics performance, while CO_2 emissions are the primary indicator of environmental degradation (Zaman and Shamsuddin, 2017; Khan et al., 2019; Liu et al., 2018; Li et al., 2021; Magazzino et al., 2021). Some of these studies build green logistics performance indices by integrating collateral environmental indicators into the LPI. Khan et al. (2017), for example, brought together the logistic performance and environmental indicators to analyze the connection between environmental logistics performance and various economic growth factors in 15 selected countries. In a study covering 104 countries, Mariano et al. (2017) constructed a “composite low-carbon logistics performance index”. Kim and Min (2011) expounded a “green logistics performance index (GLPI)”, applied to 146 nations, merging two out of the six LPI indicators (specifically “infrastructure and timeliness”) with indicators in the “Environmental Performance Index (EPI)” developed by the World Economic Forum, which measure GHG and other emissions. Lu et al. (2019) developed an “environmental logistics performance index (ELPI)” to assess overall logistics performance in terms of environmentally-friendly transportation and logistics applications in 112 countries.

There are few studies that examine specifically the effect of logistics activities on environmental degradation at a macro level, and the results of these studies are mixed. That is to say, there is no consensus as to whether improvements in logistics performance, measured by higher LPI, have significant or positive effects on environmental degradation. Moreover, some of the studies point out that these effects vary considerably according to LPI sub-indices and geographical regions.

Some recent studies find that increases in LPI contribute to environmental sustainability by reducing CO2 emissions. For instance, Liu et al. (2018) analyze the impact of logistics performance on environmental degradation in 42 ASEAN countries between 2007 and 2016, based on a system-generalized method of moments (GMM) regression model. They conclude that the impact of LPI on environmental degradation varies according to its sub-indicators (e.g., logistics ‘timeliness’ significantly increases CO_2 emissions, whereas ‘international shipment’ significantly reduces them). They also emphasize that the effects of LPI vary in the sub-regions of Asia, such as East Asia, Central Asia, Middle East and South Asia. Zaman and Shamsuddin (2017) analyze the same relationship for 27 European countries from 2007 to 2014 by GMM regressions. Similar to Liu et al. (2018), they use sub-indices of LPI as proxies for logistics performance and conclude that the sub-indices are significantly related to environmental degradation. For example, improvements in ‘transport-related infrastructure’ decrease CO_2 emissions, while higher ‘competence and quality of logistics services’ increase them. Comparing the results of Liu et al. (2018) and Zaman and Shamsuddin (2017), it can be deduced that the impact of logistics performance on environmental degradation is quite different in Asian and European countries. Liu et al. (2018) attribute this variation to the differences in environmental policies and GSCM practices in the two regions. Karaduman et al. (2020) analyzed the effects of logistics performance on environmental degradation for 11 Balkan countries for the period 2010-2016, using the fixed-effects panel data model. Similar to Liu et al. (2018) and Zaman and Shamsuddin (2017), they measure logistics performance by LPI, but unlike them, they use overall LPI instead of its sub-indexes in their models. Their analysis shows that higher LPI scores lead to lower CO_2 emissions. Suki et al. (2021) analyze the impact of overall LPI on CO_2 emissions in such Asian countries as China, Singapore, India, Japan and Turkey, based on "IPAT (Impacts, Population, Affluence, and Technology)" and "STIRPAT (Stochastic Impacts by Regression on Population, Affluence, and Technology)" models for the period 2010-2018. Similar to Karaduman et al. (2020), they find that LPI contributes significantly to pollution reduction

There are also studies finding that CO_2 emissions increase as LPI increases. For example, Khan (2019) uses two sub-indices of LPI, 'quality of logistics services' and 'infrastructure', as proxies of logistics performance and concludes that better logistics performance increases environmental degradation for ASEAN countries, based on an GMM estimation from 2007 to 2017. Li et al. (2021) use the same sub-indices. In their study, based on two-stage least squares (2SLS) and GMM models over the period 2007-2019, they find that enhancements in logistics efficiency increase CO_2 emissions in One Belt and Road Initiative (OBRI) countries, Central Asia and MENA, but decreases them in Europe, East and South Asia. The results of Larson (2021) also indicate that logistics activities fail to reduce CO2 emissions for 160 countries in 2016. Similarly, Magazzino et al. (2021), in his study for 25 countries with the highest LPI between 2007 and 2018, uses Fully Modified Ordinary Least Squares (FMOLS), GMM and Quantile Regression (QR) models to conclude that LPI increases CO_2 emissions. Wan et al. (2022) also investigate the impact of logistics performance on the environmental quality in 22 emerging countries for the period between 2007 and 2018, based on the Method of Moments Quantile Regression (MMQR). Their results show that improving logistics performance reduces environmental quality by raising CO_2 emissions.

Besides logistics performance, the effects of various factors such as per capita income, openness to trade, industrialization, foreign direct investment (FDI) and renewable energy consumption on environmental degradation have also been examined in the literature. For example, income per capita is found to increase environmental degradation (Apergis and Ozturk, 2015). Trade openness has also a significant impact on CO_2 emissions (Dogan and Turkekul, 2016; Ozturk and Acaravci 2016). The findings generally suggest that trade openness increases environmental pollution, as it stimulates growth and therefore energy consumption. The industrialization rate is also generally considered to increase CO_2 emissions since the production processes in the manufacturing, construction, electricity, water and gas sectors require intensive energy use (Hong et al., 2015; Sadorsky, 2013). The impact of FDI on environmental degradation is ambiguous, though. Some studies (e.g. Lee, 2009) confirm the validity of 'pollution haven' hypothesis, which states that FDI inflows increase pollution in the host countries, while others (e.g. Wang and Chen, 2014) affirm the 'pollution halo' hypothesis, which asserts that FDI inflows reduce pollution. Last but not least, renewable energy consumption is also observed to be one of the determinants of environmental degradation (Adams and Acheampong, 2019).

As the above review shows, the literature does not allow for a consensus on the environmental effects of LPI. Such effects vary according to the sub-indexes of LPI, geographical regions, differences in countries' environmental policies and GSCM practices, as well as estimation methods. In this regard, this article attempts to make several contributions to the literature. First, to the best of our knowledge, this is the first study to focus on the MENA region in the context of the nexus between logistics performance and environmental degradation. Moreover, as a proxy for environmental degradation, we use not only CO2 emissions, but also "ecological footprint" (EF), which involves the ecological assets to be generated, the natural resources to be utilized and the wastes to be absorbed (Balogh, 2019). Our study also provides region-specific policy recommendations to pave the way for sustainable economic development in the MENA countries.

3. Data and Descriptive Statistics

Our sample comprises an unbalanced panel of 20 MENA countries (Algeria, Bahrain, Egypt, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Qatar, Saudi Arabia, Sudan, Syria, Tunisia, Turkey, United Arab Emirates and Yemen) for the period 2007-2018. Due to heterogeneity in their natural resource endowments, we divide countries into two groups, oil-rich countries (Algeria, Bahrain, Iran, Iraq, Kuwait, Libya, Oman, Qatar, Saudi Arabia and United Arab Emirates) and non-oil-rich countries (Egypt, Israel, Jordan, Lebanon, Morocco, Sudan, Syria, Tunisia, Turkey, Yemen).

Definitions and data sources for all variables are given in Table 1. CO_2 emissions and EF are used as proxies for environmental degradation. CO_2 emissions have traditionally been used as the most common proxy variable to reflect environmental degradation. The data for CO_2 emissions are presented in terms of metric per capita and taken from the WDI by World Bank (2022b). However, since CO_2 emissions account for only a certain portion of environmental degradation, we also employ EF as a broader and more reliable indicator of environmental degradation. The EF is measured by "Global Footprint Network (GFN)", and it indicates the "extent of biologically productive land and water required to meet all the competing demands and to absorb the waste it generates". These land and water areas are defined by GFN as follows: cropland, grazing land, forest land showing forest products and CO_2 sequestration, fishing ground and built-up land. The EF data are obtained from GFN (2022).

Table 1. Variable Definitions and Data Sources

Variable	Definition	Data Source
$CO2$	Carbon dioxide emission per capita (metric tons per capita)	World Bank's World Development Indicators (WDI)
EF	Ecological footprint per capita (in global hectares, gha)	Global Footprint Network (GFN)
LPI	Overall logistics performance index	World Bank's LPI database
$LPIC$	Logistics performance index measuring the effectiveness of the customs clearance process. This sub-index evaluates the efficiency and effectiveness of customs procedures regarding their rapidity, ease, and predictability.	World Bank's LPI database
$LPIIN$	Logistics performance index measuring the quality of infrastructure associated with trade and transportation. This sub-index measures the quality of transportation infrastructure.	World Bank's LPI database
$LPIIS$	Logistics performance index measuring the simplicity of organizing cost-effective shipping. This sub-index assesses how simple it is for the country to organize its international shipping at a reasonable cost	World Bank's LPI database
$LPIQC$	Logistics performance index measuring the quality and competence of logistics services. This sub-index assesses the quality and competence of local logistics activities.	World Bank's LPI database
$LPITT$	Logistics performance index measuring the ability to track and trace shipments. This sub-index measures the tracking and tracing of international shipments.	World Bank's LPI database
$LPIT$	Logistics performance index measuring how often deliveries arrive at their destination in a timely manner. This sub-index assesses deliveries to be on time	World Bank's LPI database
GDP_{pc}	Gross domestic product per capita at constant prices (constant 2015 US$)	World Bank's World Development Indicators (WDI)
$livas$	Industrialization: Industry value added as a share of GDP	World Bank's World Development Indicators (WDI)
$tros$	Trade openness: Sum of exports and imports as a share of GDP	World Bank's World Development Indicators (WDI)
$fdis$	Foreign direct investment (FDI): FDI inflows as a share of GDP	World Bank's World Development Indicators (WDI)
$recs$	Renewable energy: Renewable energy consumption as a share of total final energy consumption	World Bank's World Development Indicators (WDI)

We employ overall LPI and its sub-indices as indicators of logistics performance. LPI database was developed by The World Bank and contains information on more than 170 countries for the period 2007-2018 (World Bank, 2022a; Arvis et al., 2016). The LPI score measures a country's logistics performance and is created by analyzing six fundamental indicators through the use of principal component analysis. (1) "the efficiency of customs and border management clearance" ("Customs"); (2) "the quality of trade and transport infrastructure" ("Infrastructure"); (3) "the ease of arranging competitively priced shipments" ("International shipments"); (4) "the competence and quality of logistics services" ("Services quality and competence"); (5) "the ability to track and trace consignments" ("Tracking and tracing"); and (6) "the frequency with which shipments reach consignees within scheduled or expected delivery times" ("Timeliness"). These indicators were developed through empirical research and extensive consultations with international freight transport experts. The overall LPI is aggregated as a weighted average of these six core indicators. The LPI scores range from 1 to 5, a score of 5 representing the best logistics performance (World Bank, 2022a; Arvis et al., 2016).

In addition to LPI, the variables that may affect environmental degradation are income (measured by GDP per capita), trade openness (measured by trade as percentage of GDP), the industrialization rate (measured by industry value added as percentage of GDP), FDI (measured by FDI inflows as percentage of GDP), renewable energy (measured by renewable energy consumption as percentage of total energy consumption). Data for all these variables are gathered from the World Development Indicators (WDI) database published by the World Bank (World Bank, 2022b).

Trends of CO_2 emissions, EF and LPI values over the 2007-2018 period are presented in Figure A1-A6 in appendix for each oil-rich and non-oil-rich country in the MENA region. Table 2 shows descriptive statistics for the variables in Table 1.

Table 2. Descriptive Statistics

	All sample			**Oil-rich**			**Non-oil-rich**		
	Mean	**Median**	**Std. Dev.**	**Mean**	**Median**	**Std. Dev.**	**Mean**	**Median**	**Std. Dev.**
CO_2	9.273	4.203	9.361	15.602	16.338	9.495	2.945	2.531	2.251
EF	4.363	3.154	3.499	6.385	5.787	3.839	2.340	1.933	1.264
LPI	2.836	2.839	0.454	2.923	2.985	0.481	2.754	2.727	0.412
LPIC	2.580	2.544	0.490	2.687	2.710	0.527	2.478	2.406	0.431
LPIIN	2.732	2.714	0.554	2.863	2.968	0.590	2.608	2.589	0.488
LPIIS	2.813	2.827	0.428	2.880	2.859	0.451	2.748	2.816	0.396
LPIQC	2.769	2.736	0.486	2.841	2.849	0.489	2.700	2.589	0.475
LPITT	2.821	2.806	0.511	2.898	3.016	0.563	2.747	2.675	0.446
LPIT	3.296	3.280	0.465	3.365	3.398	0.487	3.230	3.218	0.435
GDPpc	14509.4	6164.2	15835.6	21761.2	19907.5	17524.7	7257.6	3759.5	9511.1
livas	39.262	36.367	16.828	52.469	52.135	12.936	26.826	26.121	8.544
tros	80.797	77.372	35.957	94.338	90.521	37.174	66.909	64.386	28.784
fdis	2.521	1.929	2.976	1.700	1.107	2.537	3.393	2.783	3.164
recs	6.471	1.405	13.734	0.522	0.090	0.847	12.420	5.800	17.514
Obs.	240			120			120		
Countries	20			10			10		

According to Table 2, the mean of CO_2 emissions, in terms of metric tons per capita, is 9.27 for the whole sample, 15.60 for the oil-rich countries and 2.94 for the non-oil-rich countries. It is obvious that CO_2 emissions are significantly greater and subject to more pronounced fluctuations in oil-rich MENA countries as compared to non-oil-rich ones. The same pattern applies, though less prominently, to the ecological footprint (EF). On the other hand, the mean of LPI is 2.83 for the whole sample, 2.92 for oil-rich countries and 2.75 for non-oil-rich countries. The volatility of LPI is only slightly higher in oil-rich MENA countries as compared to non-oil-rich ones. Considering LPI sub-indices, the highest mean value among all sub-indices belongs to LPIT (how often deliveries arrive at their destination in a timely manner) (3.29) while the lowest mean value belongs to LPIC (the efficiency of the customs clearance process) (2.580). Also, the mean values of the LPI sub-indices are slightly higher and slightly more volatile in oil-rich countries than in non-oil-rich countries. The mean value of GDP per capita (GDPpc) for the whole sample is $14509.4. The difference between oil-rich and non-oil-rich countries is all the more pronounced in terms of this variable. That is, the mean and volatility of GDP per capita for oil-rich MENA countries are much higher than for non-oil-rich countries. The mean value of the industrialization ratio (livas) is 39.26 percent for the whole sample, 52.46 percent for oil-rich countries and 26.82 percent for non-oil-rich countries. The mean value of trade openness (tros) for the whole sample is 80.79 percent. The trade openness of oil-rich countries (94.33 percent) is also considerably higher than non-oil-rich countries (66.90 percent). The mean value of FDI inflows is 2.52 for the whole sample. Moreover, non-oil-rich countries have a higher average FDI and greater volatility than oil-rich countries. Similarly, the average renewable energy consumption (recs) and its volatility are substantially much higher in non-oil-rich MENA countries.

4. Empirical Methodology and Estimation Results

In order to analyze the impacts of logistics performance on environmental degradation, we consider the following benchmark equation:

$$\ln(ED)_{it} = \alpha_0 + \alpha_1 \ln(LPIX)_{it} + \alpha_2 \ln(GDPpc)_{it} + \alpha_3 (livas)_{it} + \alpha_4 (tros)_{it} + \alpha_5 (fdis)_{it} + \alpha_6 (recs)_{it} + \eta_i + \varphi_t + u_{it} \tag{1}$$

where the subscripts i and t denote countries and years, respectively. ED refers to environmental degradation which is proxied by CO_2 emissions (*CO2*) and ecological footprint (*EF*), alternatively. The key explanatory variable is logistics performance (*LPIX*). First, we use the overall logistics performance index (*LPI*) for this variable. We also extend the regression by employing the sub-indices of *LPI* (*LPIC, LPIIN, LPIIS, LPIQC, LPITT, LPIT*) to analyze the effects of different dimensions of logistics performance. We use each sub-index in a separate regression in order to avoid multicollinearity. We add GDP per capita (*GDPpc*), industrialization (*livas*), trade openness (*tros*), foreign direct investment (*fdis*), and renewable energy (*recs*) into the estimation equation as control variables. The variables η_i and φ_t denote time-invariant country-specific effects and time-specific effects, respectively. The last term u_{it} is an idiosyncratic error term.

Equation (1) is estimated by using the fixed effects (FE) model. We adopt Hoechle (2007) approach that produces Driscoll-Kraay standard errors for panel models as those are robust to serial correlation, heteroskedasticity and cross-sectional dependence. Moreover, Driscoll-Kraay standard errors exhibit notably superior characteristics in small samples when compared to commonly used alternative methods for estimating standard errors, particularly in the presence of cross-sectional dependence, as in our case[1].

Additionally, we examine the multicollinearity and endogeneity problems of our regressions, as well as robustness checks with respect to sub-samples and alternative measures of both environmental degradation and logistics performance that we discussed above. First of all, we identify the potential presence of multicollinearity by calculating the variance inflation factor (VIF) for each set of estimations in this work. As a rule of thumb, a VIF larger than ten may be indicative of serious multicollinearity. The computed mean VIF values of the models vary from 1.87 to 2.16 for the whole sample, 2.73 to 3.95 for oil-rich sample, and 2.24 to 2.75 for non-oil-rich sample. These relatively lower VIF values suggest that there is no substantial empirical indication of significant multicollinearity within any set of estimations in the study. In contrast, we acknowledge that logistics performance might be endogenous. To address potential endogeneity issues, we use two alternative estimators. First, we apply FE-IV using lagged values of LPI as its instruments. Second, we conduct a dynamic panel data estimation using GMM specification where one-year lagged dependent variable and LPI are endogenous. The results of alternative estimations are closely similar to the primary findings in our study (see Table A1 in appendix). On the other hand, as another robustness check, after converting the data to 2-year periods by taking a two-year average for each variable, we conduct all FE estimates with these 2-year average data. Our results are very similar to our main results. (see Table A2 in the appendix for overall LPI and Table A3 for LPI-sub-indices)

Table 3 presents the results for the FE panel regressions for Equation (1). Alternative dependent variables are CO_2 emissions and EF, and the main independent variable is the overall LPI. The results are presented separately for the whole sample, oil-rich MENA countries and non-oil-rich ones.

[1] We rejected the null hypothesis of cross-sectional independence for all models by using the Pesaran test. Note that the p-values of Pesaran's cross sectional independence test statistics for our main models are 0.069 (0.078) in whole sample, 0.026 (0.036) in oil-rich sample, and 0.037 (0.027) in non-oil-rich sample for CO2 (EF) models.

Table 3. Fixed Effect Estimation Results, overall LPI

	All sample		Oil-rich		Non-oil-rich	
	ln (*CO2*)	**ln (*EF*)**	**ln (*CO2*)**	**ln (*EF*)**	**ln (*CO2*)**	**ln (*EF*)**
ln (*LPI*)	0.124**	0.437***	0.405***	1.119***	-0.013	0.089
	(0.054)	(0.056)	(0.065)	(0.159)	(0.071)	(0.139)
ln (*GDPpc*)	0.464***	0.503***	0.506***	0.331*	0.518***	0.631***
	(0.027)	(0.067)	(0.051)	(0.165)	(0.129)	(0.134)
livas	-0.309**	-0.346**	-0.293***	-0.229	-0.146	0.286
	(0.104)	(0.128)	(0.071)	(0.242)	(0.300)	(0.413)
tros	0.061**	-0.229***	-0.056*	-0.275***	0.087	-0.194
	(0.020)	(0.042)	(0.029)	(0.081)	(0.122)	(0.161)
fdis	-0.367***	-0.080	0.290**	-0.422	-1.225**	0.152
	(0.115)	(0.403)	(0.124)	(0.595)	(0.487)	(0.251)
recs	-1.401**	-1.097***	-6.241	-4.697	-1.820*	-0.705
	(0.631)	(0.347)	(3.877)	(7.489)	(0.831)	(0.458)
Observations	217	217	107	107	110	110
Countries	20	20	10	10	10	10
R-squared	0.468	0.468	0.686	0.520	0.492	0.619
F-stat. (Overall)	9.32	9.30	10.27	5.10	4.73	7.94
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
F-stat. (Country FE)	478.64	78.64	229.78	32.21	262.22	52.95
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]

Note: All models include a constant, country fixed effects and year dummies. Driscoll-Kraay standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. p-values for the F-statistics are in brackets.

The first point to note in Table 3 is that there is a significantly positive effect of overall LPI on environmental degradation for the whole sample and oil-rich countries, while this relationship is statistically insignificant for non-oil-rich countries. In other words, improvements in LPI raise environmental degradation in the whole sample and oil-rich countries, but they neither increase nor decrease environmental degradation in the non-oil-rich ones. A one-percent increase in the overall LPI results in a 0.12-percent increase in CO_2 emissions in the whole sample and a 0.40-percent increase in oil-rich countries. Our results, in this regard, are consistent with the findings of Wan et al. (2022), Magazzino et al. (2021) and Kim and Min (2011).

Considering the ecological footprint (EF), Table 3 shows that a one-percent increase in overall LPI increases the EF for the whole sample and oil-rich countries by 0.43 percent and 1.11 percent, respectively. For non-oil-rich countries, the LPI has no significant impact on the EF, similar to CO_2 emissions. One notable point in Table 3 is that the impact of overall LPI on EF is remarkably stronger than CO_2 emissions. When evaluating the impact of the LPI on CO2 emissions at a local level, the focus is primarily on the direct emissions associated with transportation activities within a specific region or country. The EF provides a broader perspective by considering the overall environmental impact of various human activities, including logistics, on a global scale. It takes into account not only CO_2 emissions but also other factors such as land use, water consumption, resource depletion and waste generation. Indeed, the EF measures "the amount of biologically productive land and water" required to sustainably support the consumption and waste absorption of a population.

All in all, our results in Table-3 show that an increase in LPI leads to environmental degradation in the form of more CO_2 emissions and a higher EF in the MENA region, especially in oil-rich countries. A higher LPI score indicates a more efficient logistics system. However, the results show that a more efficient logistics system does not maintain a better environmental quality for MENA. This shows us that a kind of Jevons Paradox tends to apply to MENA. Oil-producing MENA countries, for example, may have more efficient customs clearance procedures, but they may also have a high volume of freight traffic, which might result in increased CO_2 emissions. Similarly, they may have a better quality of infrastructure, but it may also have a large EF due to the intense use of resources to build and maintain that infrastructure.

In oil-rich MENA countries, where CO_2 emissions are closely linked to oil-based industries such as oil extraction, refining, transportation and exports, improved logistics performance can lead to increased trade volumes (Çelebi, 2019) and transportation activities. The majority of this increased activity is based on road transport, which is the largest contributor to carbon emissions, thus may lead to higher fossil fuel consumption and therefore higher carbon emissions and air pollution (Liu et al., 2018). Moreover, if efficiency gains achieved through the LPI lead to increased trade volumes and global supply chain activities, they could potentially contribute to a higher overall ecological footprint compared to CO_2 emissions due to increased resource consumption, emissions, and environmental impacts on a global scale.

On the other hand, efforts to increase the efficiency of logistics operations in non-oil-rich MENA countries, that is, do not have significant oil reserves, do not lead to a decrease in CO_2 emissions. In many non-oil-rich MENA countries, the energy sector may not be heavily dependent on fossil fuels such as oil for power generation or transportation. Instead, they might use alternative energy sources such as natural gas and renewables.[2] In such cases, improving logistics efficiency, which primarily affects the movement of goods and services, may not directly impact the energy mix or carbon emissions. Therefore, improvements in logistics efficiency may not have a direct impact on the energy sector, which contributes significantly to CO2 emissions in oil-rich countries. This situation can be considered as an advantage of non-oil-rich MENA countries in terms of sustainable development opportunities.

In the case of other explanatory variables, Table 3 shows that per-capita GDP is positively related to environmental degradation for the whole sample, oil-rich and non-

[2] For example, according to the report by Australian Climate Counsil Report (2022), Morocco has utilized its abundant solar resources to become a world leader in solar energy.

oil-rich countries. This finding indicates that an increase in per-capita income increases both CO_2 emissions and EF, and thus increased economic activity degrades the environment. This is consistent with the existing literature (e.g., Grossman and Krueger, 1995). Table 3 also shows that the rate of industrialization has a mitigating effect on environmental degradation for the whole sample and the oil-rich countries. An increase in industrial activity reduces CO_2 emissions and EF in the whole sample and reduces CO2 emissions in oil-rich countries. While our result is consistent with the findings for East Asia and Middle East by Liu et al. (2018), it contradicts the expected result that industrial activity increases carbon emissions. However, this result can be explained by the relatively lower degree of industrialization in MENA region

Trade openness increases CO_2 emissions and reduces the EF in the whole sample. Zaman and Shamsuddin (2017) find a positive relationship between trade openness and CO_2 emissions in European countries. Liu et al. (2018) find this effect to be insignificant for Middle Eastern countries, but their results for Asia and East Asia are similar to our results. In oil-rich countries, trade openness reduces both CO_2 emissions and EF, indicating that trade liberalization policies of oil-rich MENA countries might have been designed to control environmental degradation.

FDI inflows have a significant impact only on CO_2 emissions. Moreover, this impact is positive for oil-rich countries and negative for non-oil-rich countries and the whole sample. These results suggest that the "pollution haven hypothesis" is valid in oil-rich MENA countries, while the "pollution halo hypothesis" applies to non-oil-rich ones. The results of Zaman and Shamsuddin (2017) for European countries are consistent with what we find for non-oil-rich countries. However, Taşdemir and Ekmen-Özçelik (2023) suggest a non-linear relationship between FDI inflows and environmental degradation for the MENA region. They conclude that this relationship is not invariant to country characteristics such as institutional quality and human capital level.

Finally, according to our results, an increase in renewable energy consumption reduces CO_2 emissions and EF in the whole sample, while reducing only CO_2 emissions in non-oil-rich countries, and its impact is insignificant for oil-rich MENA countries.

Next, we analyze the impact of sub-LPI indices on environmental degradation. Table 4 below presents the estimations results of Equation (1) for each sub-LPI index.

Table 4. Fixed Effect Estimation Results: Coefficient estimates of sub-indices

	All sample		Oil-rich		Non-oil-rich	
	ln (*CO2*)	**ln (*EF*)**	**ln (*CO2*)**	**ln (*EF*)**	**ln (*CO2*)**	**ln (*EF*)**
ln (*LPIC*)	-0.005	0.094	0.174***	0.313**	-0.159**	-0.084
	(0.034)	(0.063)	(0.026)	(0.107)	(0.059)	(0.099)
R-squared	0.461	0.411	0.660	0.370	0.514	0.622
ln (*LPIIN*)	0.129**	0.247***	0.346***	0.635***	0.025	0.008
	(0.055)	(0.044)	(0.058)	(0.114)	(0.068)	(0.110)
R-squared	0.474	0.438	0.698	0.428	0.493	0.616
ln (*LPIIS*)	0.152**	0.336***	0.135*	0.614***	0.174***	0.087
	(0.055)	(0.040)	(0.070)	(0.070)	(0.055)	(0.069)
R-squared	0.483	0.478	0.646	0.506	0.510	0.621
ln (*LPIQC*)	0.066	0.318***	0.244***	0.566***	-0.007	0.131
	(0.046)	(0.058)	(0.045)	(0.143)	(0.058)	(0.082)
R-squared	0.464	0.457	0.669	0.424	0.492	0.627
ln (*LPITT*)	0.123**	0.347***	0.196***	0.502***	0.016	0.163
	(0.040)	(0.051)	(0.040)	(0.069)	(0.077)	(0.106)
R-squared	0.477	0.493	0.678	0.472	0.492	0.634
ln (*LPIT*)	-0.063	0.144**	-0.083	0.062	-0.048	0.086
	(0.074)	(0.062)	(0.084)	(0.123)	(0.070)	(0.124)
R-squared	0.463	0.412	0.630	0.323	0.493	0.619
Control variables	YES	YES	YES	YES	YES	YES
Country FE	YES	YES	YES	YES	YES	YES
Year dummies	YES	YES	YES	YES	YES	YES

Note: All models include a constant, country fixed effects, year dummies, and control variables (*GDPpc*, *livas*, *tros*, *fdis*, *recs*) but the results are not reported to save space. Driscoll-Kraay standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

According to Table 4, LPIC has a significantly positive impact on CO_2 emissions in oil-rich countries. More specifically, a 1-percent improvement in the efficiency of the customs clearance process leads to 0.17-percent increase in CO_2 emissions in oil-rich MENA countries. This result is consistent with what Liu et al. (2018) found for South Asia, but he found this effect insignificant for the rest of Asia, including the Middle East. When customs clearance is more efficient, goods and products can cross borders and ports more easily and faster. Easier and faster customs clearance can increase trade volumes by reducing business delays and transaction costs. This can result in an upsurge in oil exports of oil-rich MENA countries. However, since oil is predominantly transported by fossil-fuel-powered modes of transportation such as ships, trucks and planes, increased trade may result in higher CO2 emissions. Efficient customs processes could also motivate oil companies to boost their oil production and exports more frequently. However, this could lead to a rise in the use of fossil fuels, which release CO2 when burned for energy. On the other hand, as the table shows, an increase in LPIC decreases CO_2 emissions in non-oil countries. Moreover, LPIC is the only LPI sub-index that has a reducing effect on CO_2 emissions.

LPIIN increases environmental degradation both in the whole sample and oil-rich countries. That is, better quality of logistics infrastructure leads to environmental degradation, especially in oil-rich countries. A higher quality logistics infrastructure implies that the oil-rich MENA countries have the capacity to handle more efficient, reliable and larger volumes of goods, including oil and its derivatives, with less delays and interruptions. Thus, shipping of petroleum products will likely contribute to higher CO2 emissions. This finding may also indicate that environmental standards are neglected while improving logistics infrastructure in oil-rich countries.

LPIIS has a positive impact on both CO_2 emissions and EF. In other words, as the ease of arranging competitively priced shipments increases, both CO_2 emissions and EF increase. This result contradicts the result of Liu et. al. (2018) for Asian, Middle Eastern and East Asian countries, but it is consistent with the findings of Zaman and Shamsuddin (2017). For the MENA region, making shipments more accessible and cost-effective can lead to greater trading volumes, as with other sub-indices of LPI. This, in turn, will contribute to higher transport activities that will lead to higher CO2 emissions from fossil fuel-powered vehicles.

LPIQC is also positively related to environmental degradation in oil-rich countries. That is, competence and quality of logistics services increase environmental degradation in terms of both CO_2 emissions and EF in oil-rich countries. Zaman and Shamsuddin (2017) also find a positive relationship between LPIQC and CO_2 emissions in European countries. When the efficiency and effectiveness of transportation, storage and distribution of goods within the country's borders are enhanced, domestic trade and transportation of goods may improve as well. Increasing transportation activities is likely to result in more extensive use of fossil fuel-powered cars in oil-rich MENA countries, raising CO2 emissions.

Similarly, we find a positive effect of LPIIT on environmental degradation for the whole sample and oil-rich countries. This result suggests that an increase in the ability to track and trace consignments can lead to environmental degradation. The result is consistent with what Liu et al. (2018) found for East Asia but contradicts what they found for the Middle East. Logistic activities can be more efficient when shipments are more traceable and visible. This enables firms to detect possible supply chain delays or disturbances and take regularity measures. These actions can lead to faster transport and delivery of goods, resulting in increased fuel consumption and higher CO2 emissions in the transportation process.

Finally, Table 4 shows that LPIT, which measures the frequency with which shipments reach the recipient within the planned or expected time, is insignificant for oil-rich and non-oil-rich countries, while positively related to the EF of the entire sample. This is consistent with Liu et al. (2018) for Asian and East Asian countries. As the timeliness of freight transport improves, the EF in MENA also increases, as it affects various environmental aspects beyond carbon emissions. On the other hand, the timeliness of freight transportation reflects the reliability and predictability of the supply chain and is critical for companies in the global value chains (Arvis et al., 2016). Therefore, policymakers should consider this trade-off between the timeliness of freight transport and emissions so as to develop methods to resolve it.

The improvements in LPI and its sub-indices point to a more efficient logistics system. However, the findings in Table-4 indicate generally that an efficient logistics system also generates environmental degradation for MENA. Countries with an efficient logistics structure and hence low logistics costs also have a competitive advantage in the international markets (Aigigner, 1998). More efficient logistics systems facilitate international trade, ensure product safety and product mobility, and reduce delivery time and increase delivery speed (La and Song, 2019). Such improvements can augment environmental degradation by increasing transportation activities, which can cause higher energy consumption and carbon emissions, as well as longer supply chains and shifts to higher emission modes of transport. Therefore, it is necessary to deploy preventive policies to eliminate or mitigate such side-effects.

5. Conclusion and Policy Implications

Our results suggest that improvements in logistics performance heighten environmental degradation rather than contribute to environmental sustainability, particularly in oil-rich MENA countries. In other words, a more efficient logistics system does not provide better environmental quality. Indeed, better logistics tends to generate environmentally worse outcomes. This general finding hints at the validity of Jevons Paradox in the case of oil-rich countries of MENA, while others tend to escape this paradox through what may be called the advantage of being a non-oil-rich country in terms of sustainable economic development.

Some reasonable explanations for this result are due. Improvements in logistics performance can increase transportation activities, which, in turn, raise fossil fuel consumption and lead to higher CO2 emissions. For example, oil-producing MENA countries tend to have more efficient customs clearance procedures, but at the same time they have higher volumes of freight traffic, which can also result in increased CO2 emissions. Similarly, they may have a higher quality infrastructure but also a larger EF due to the more intensive use of resources to build up and maintain that infrastructure. In addition, improved logistics performance can lead to increased trade volumes and shipping activities, resulting in higher fossil-fuel consumption and hence higher carbon emissions and air pollution, especially in oil-rich MENA countries. Moreover, if the efficiency gains achieved through the LPI lead to increased trade volumes and global supply chain activities, they can potentially generate a higher overall EF, as compared to CO_2 emissions, due to increased resource consumption, larger emissions and more detrimental environmental impacts on a global scale.

On the other hand, in non-oil-rich MENA countries, endeavors aimed at improving the efficiency of logistics operations do not result in a reduction in CO_2 emissions. In those countries, enhancing the efficiency of logistics, which primarily influences the transportation of goods and services, may not directly influence the energy sources used or carbon emissions. This situation can be viewed as a benefit for MENA nations without significant oil reserves when it comes to opportunities for sustainable development.

All in all, it can be argued that logistics performance in the MENA region, and especially in oil-rich countries, has not progressed through an environmentally friendly path. This undesirable outcome seems to point out the neglect of environmental concerns along the supply chain process. To mitigate the negative impacts associated with the logistics-version of the Jevons Paradox, it is crucial to reconcile efficiency gains with sustainability measures throughout the supply chains. Around the discussions about logistics activities and the environment, the issue of green and sustainable logistics development has recently come to the fore. In this regard, environmentally friendly methods can be used in the processes of handling materials, processing information, storing the inventory and also implementing waste management (Li et al., 2021). Incentive-oriented policies such as subsidies and tax reductions can be applied to companies that use biofuels and renewable energy sources in their logistics processes (Li, 2014). Environmentally friendly modes of transportation can also be encouraged and policies to increase vehicle efficiency can be implemented (Abbasi and Nilsson,2016; Rodt et al., 2010). The importance of technological developments to achieve environmental sustainability goals is particularly emphasized (Winkler and Mocanu, 2020). Environmentally sustainable production strategies can be developed by taking measures for optimizing the consumption of energy and resources required for the production of environmentally friendly goods and services (Yaprak and Doğan, 2019). By integrating such green practices, it is possible to reduce both the environmental impact per unit of transported goods and the overall volume of environmental resources being consumed.

In the face of environmental challenges, some MENA countries are already making efforts to improve the sustainability of their logistics operations (e.g. Dubai Green Mobility Initiative-2030, investments in sustainable transportation systems in Qatar, promotion of renewable energy sources by Saudi Arabia, Egypt's development of logistics infrastructure on important shipping routes such as the Suez Canal in line with green sustainability, adoption of more efficient and sustainable practices by Tunisia). Indeed, there are many opportunities to improve the environmental sustainability of logistics operations through green practices, such as adoption of new technologies, better planning and coordination, the use of alternative fuels, etc. By addressing these challenges and opportunities, MENA countries can promote economic growth and development while protecting the environment effectively for future generations.

Finally, our results also suggest that more accurate alternative measures are needed to evaluate MENA's green logistics performance, as higher LPI does not reflect better green logistics performance for MENA countries. Future research can aim to develop a new and MENA-specific performance metric that simultaneously considers environmental sustainability and logistics efficiency.

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Appendix

Figure A1. CO_2 emissions, metric tons per capita (Oil-rich countries)

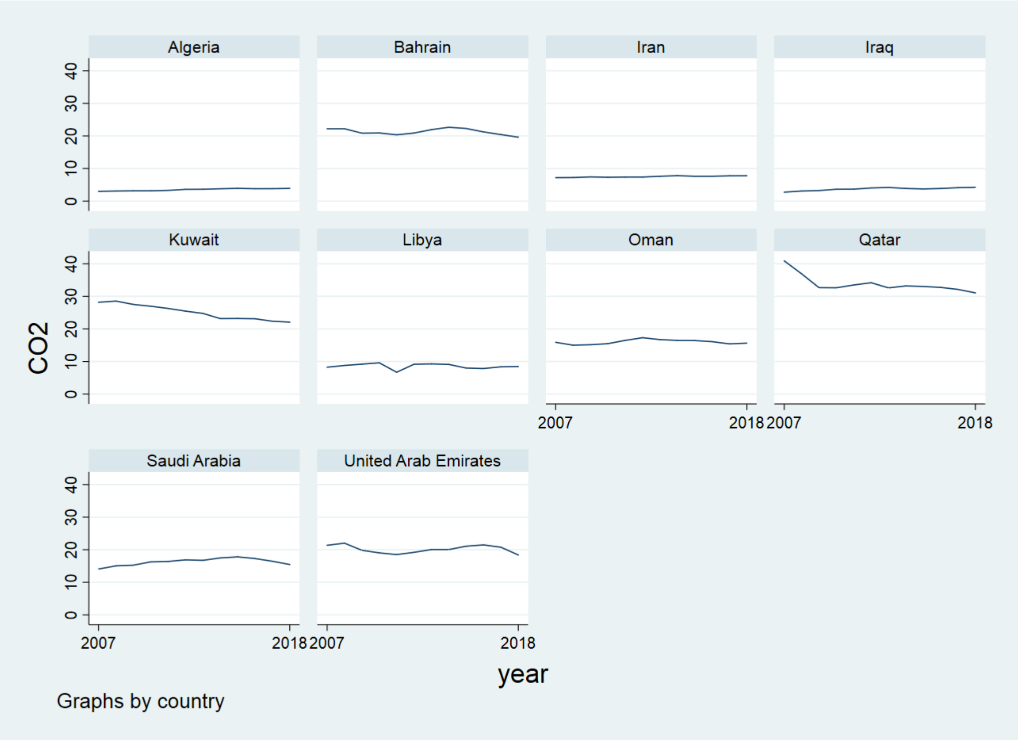

Figure A2. CO2 emissions, metric tons per capita (Non-oil-rich countries)

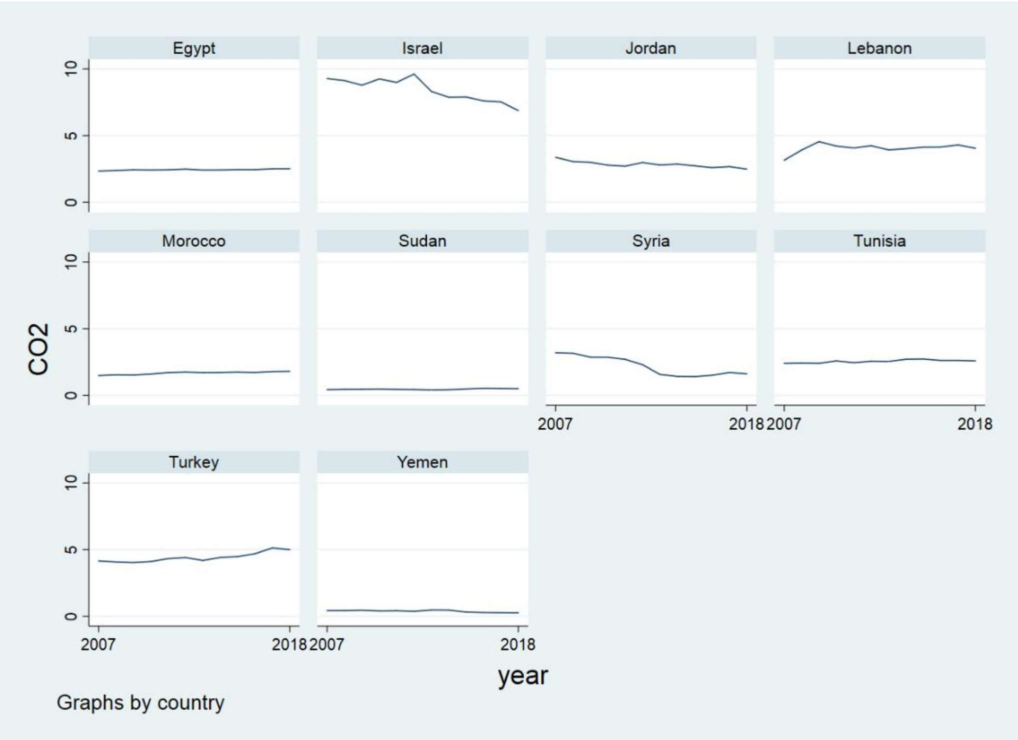

Figure A3. Ecological Footprint per capita, in global hectares (gha) (Oil-rich countries)

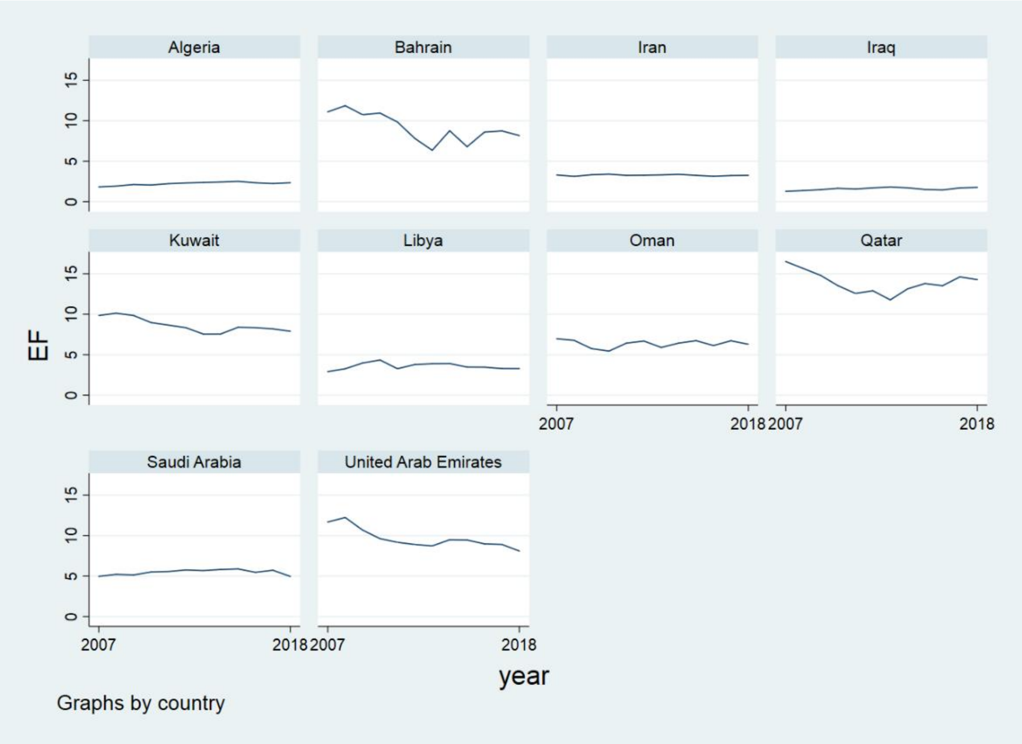

Figure A4. Ecological Footprint per capita, in global hectares (gha) (Non-oil-rich countries)

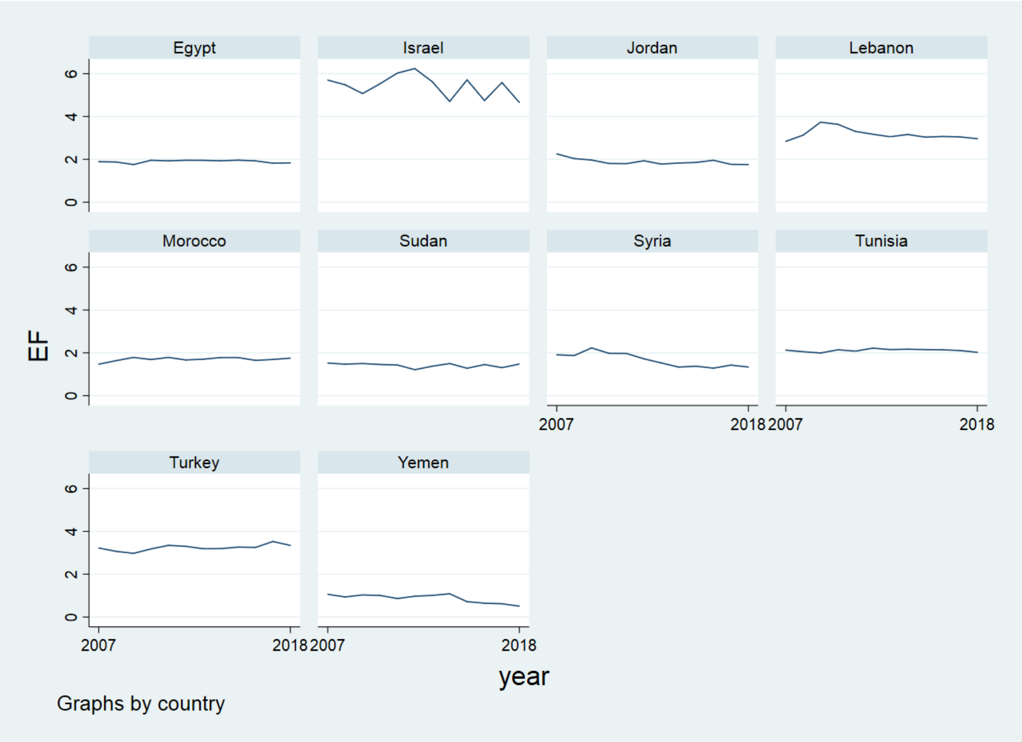

Figure A5. Overall logistics performance index (LPI) (Oil-rich countries)

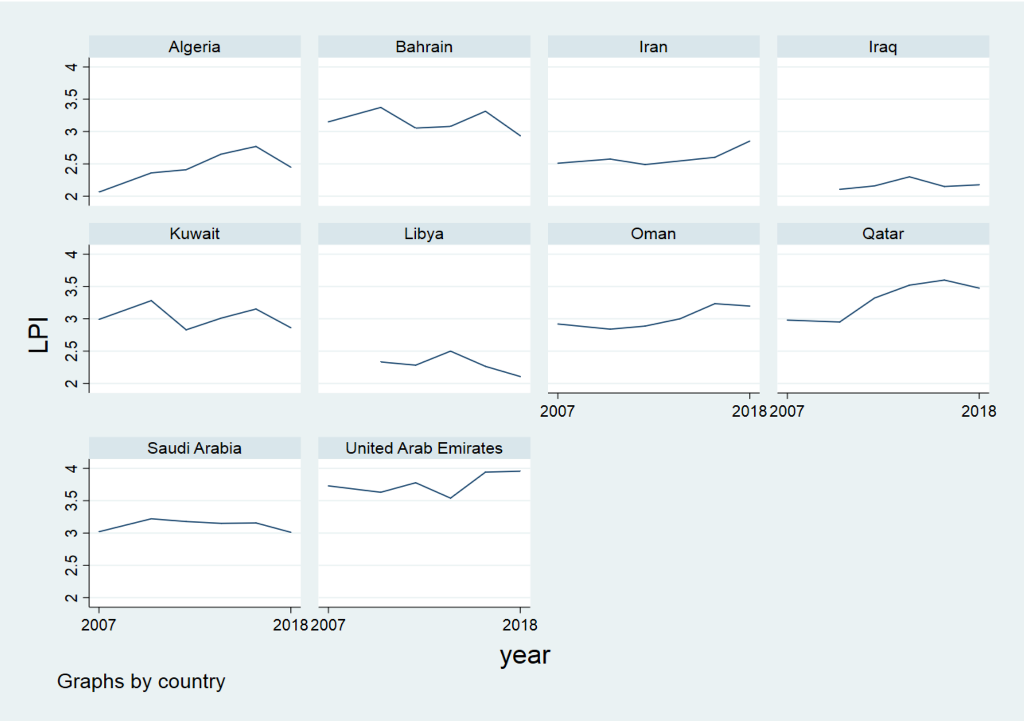

Figure A6. Overall logistics performance index (LPI) (Non-oil-rich countries)

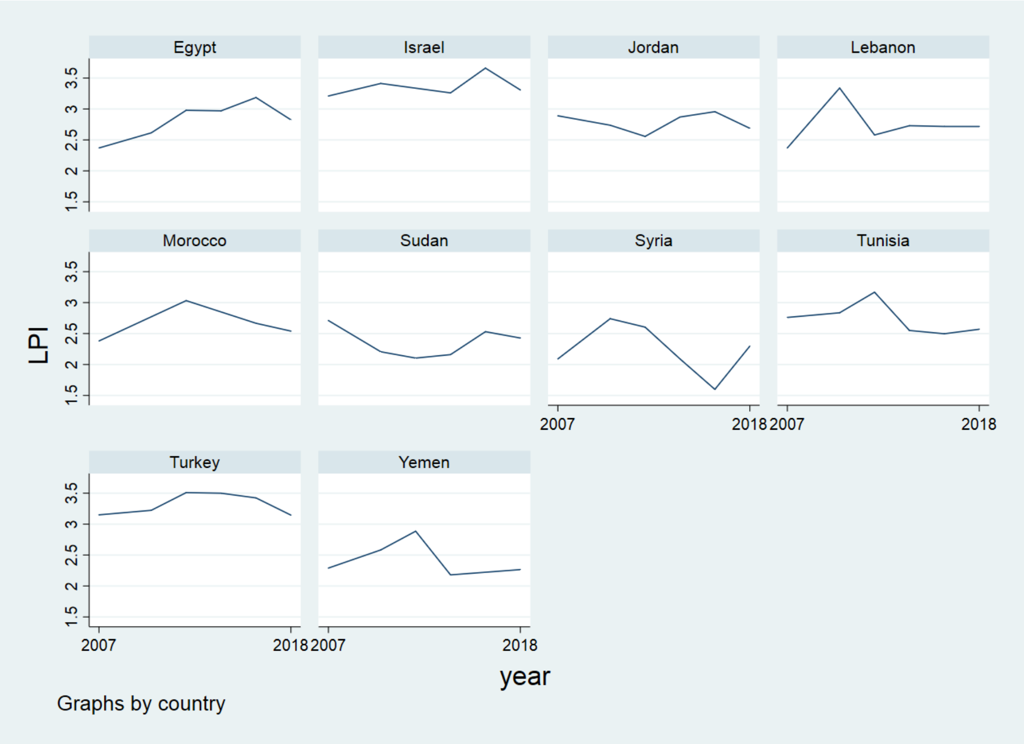

Table A1. FE-IV (2SLS) and GMM Results

	All sample				Oil-rich		Non-oil-rich	
	IV ln (*CO2*)	**IV ln (*EF*)**	**GMM ln (*CO2*)**	**GMM ln (*EF*)**	**IV ln (*CO2*)**	**IV ln (*EF*)**	**IV ln (*CO2*)**	**IV ln (*EF*)**
ln (*LPI*)	0.167	0.599***	0.157	0.668*	0.348***	1.179***	0.091	0.129
	(0.105)	(0.124)	(0.374)	(0.391)	(0.125)	(0.221)	(0.153)	(0.120)
ln (*GDPpc*)	0.471***	0.478***	0.341**	0.227	0.526***	0.235*	0.556***	0.663***
	(0.063)	(0.089)	(0.162)	(0.160)	(0.076)	(0.120)	(0.099)	(0.097)
livas	- 0.236***	-0.285**	-0.032	-0.016	-0.295**	-0.238	-0.232	0.193
	(0.091)	(0.114)	(0.213)	(0.376)	(0.149)	(0.265)	(0.333)	(0.329)
tros	0.044	-0.233***	-0.075	0.084	-0.070*	-0.259***	0.023	-0.236*
	(0.046)	(0.079)	(0.115)	(0.187)	(0.038)	(0.088)	(0.119)	(0.124)
fdis	-0.411	-0.460	1.850	1.020	0.389*	-0.824	-1.435**	-0.076
	(0.301)	(0.484)	(1.550)	(1.540)	(0.219)	(0.602)	(0.656)	(0.528)
recs	-1.012	-0.849	-1.212	-0.575	-10.878***	-5.856	-1.318*	-0.305
	(0.732)	(0.659)	(1.564)	(1.392)	(4.058)	(6.916)	(0.755)	(0.660)
Lag.ln (*CO2*)			0.450*					
			(0.247)					
Lag.ln (*EF*)				0.461**				
				(0.185)				
Observations	200	200	202	202	99	99	101	101
Countries	20	20	20	20	10	10	10	10
R-squared	0.464	0.428			0.655	0.475	0.507	0.622
F-stat	8.88***	7.84***	526.75***	68.84***	8.20***	3.63***	4.87***	7.85***
Hansen (p-val)	0.491	0.182	0.999	0.857	0.081	0.724	0.795	0.135
AR (1) (p-val)			0.072	0.028				
AR (2) (p-val)			0.723	0.353				

Note: All models include a constant and year dummies but not reported to save space.
Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table A2. Environmental Degradation and Overall LPI, FE Estimations with 2-year averages

	All sample		Oil-rich		Non-oil-rich	
	ln (*CO2*)	**ln (*EF*)**	**ln (*CO2*)**	**ln (*EF*)**	**ln (*CO2*)**	**ln (*EF*)**
ln (*LPI*)	0.100	0.317***	0.353***	0.896***	0.011	0.159
	(0.053)	(0.059)	(0.036)	(0.067)	(0.094)	(0.173)
ln (*GDPpc*)	0.504***	0.571***	0.503***	0.255	0.590***	0.703***
	(0.026)	(0.042)	(0.022)	(0.166)	(0.120)	(0.136)
livas	-0.345*	-0.433***	-0.300**	-0.325	-0.661**	-0.482
	(0.142)	(0.094)	(0.088)	(0.300)	(0.239)	(0.569)
tros	0.073*	-0.230***	-0.092	-0.296*	0.138	-0.058
	(0.033)	(0.034)	(0.053)	(0.126)	(0.258)	(0.276)
fdis	-0.657***	0.125	0.486**	0.240	-2.062***	-0.659
	(0.156)	(0.358)	(0.155)	(0.777)	(0.426)	(0.366)
recs	-1.329	-1.071***	-11.079***	-15.502***	-1.842	-0.478
	(0.806)	(0.214)	(2.331)	(3.772)	(1.075)	(0.336)
Observations	106	106	54	54	52	52
Countries	20	20	10	10	10	10
R-squared	0.473	0.550	0.744	0.620	0.549	0.778
F-stat. (Overall)	6.12	8.33	8.71	4.90	3.44	9.85
	[0.000]	[0.000]	[0.000]	[0.000]	[0.003]	[0.000]
F-stat. (Country FE)	217.20	49.30	125.85	19.97	118.05	39.17
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]

Note: All models include a constant, country fixed effects and year dummies. Driscoll-Kraay standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. p-values for the F-statistics are in brackets.

Table A3. Environmental Degradation and Sub-indices of LPI, FE Estimations with 2-year averages

	All sample		**Oil-rich**		**Non-oil-rich**	
	ln (*CO2*)	**ln (*EF*)**	**ln (*CO2*)**	**ln (*EF*)**	**ln (*CO2*)**	**ln (*EF*)**
ln (*LPIC*)	-0.008	0.039	0.111***	0.196*	-0.127	-0.032
	(0.040)	(0.060)	(0.028)	(0.096)	(0.103)	(0.123)
R-squared	0.466	0.497	0.696	0.453	0.566	0.764
ln (*LPIIN*)	0.102*	0.167***	0.324***	0.533***	0.036	0.056
	(0.046)	(0.032)	(0.035)	(0.061)	(0.081)	(0.157)
R-squared	0.478	0.521	0.767	0.539	0.550	0.765
ln (*LPIIS*)	0.106*	0.241***	0.100*	0.447***	0.128	0.117
	(0.051)	(0.038)	(0.044)	(0.046)	(0.069)	(0.060)
R-squared	0.482	0.557	0.697	0.587	0.564	0.777
ln (*LPIQC*)	0.056	0.202**	0.240***	0.453***	0.028	0.144
	(0.032)	(0.051)	(0.032)	(0.112)	(0.064)	(0.087)
R-squared	0.469	0.532	0.739	0.527	0.550	0.786
ln (*LPITT*)	0.098*	0.287***	0.166**	0.415***	0.001	0.164
	(0.042)	(0.046)	(0.046)	(0.047)	(0.093)	(0.104)
R-squared	0.482	0.600	0.739	0.601	0.549	0.796
ln (*LPIT*)	-0.017	0.115**	-0.015	0.088	-0.000	0.112
	(0.067)	(0.035)	(0.088)	(0.150)	(0.038)	(0.144)
R-squared	0.466	0.504	0.680	0.433	0.549	0.772
Control variables	YES	YES	YES	YES	YES	YES
Country FE	YES	YES	YES	YES	YES	YES
Year dummies	YES	YES	YES	YES	YES	YES

Note: All models include a constant, country fixed effects, year dummies, and control variables (*GDPpc*, *livas*, *tros*, *fdis*, *recs*) but the results are not reported to save space. Driscoll-Kraay standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.