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Abstract

This paper analyzes the impacts of logistics performance on environmental degradation for a panel of 20 Middle East and North Africa (MENA) economies over the period 2007-2018. In this context, logistics performance is measured by Logistics Performance Index (LPI) and its sub-indices developed by World Bank (2002), and environmental degradation is measured by CO_2 emissions and ecological footprint. Apart from LPI, variables such as income per capita, trade openness, industrialization and renewable energy consumption are also considered determinants of environmental degradation in the study. The empirical findings of this study suggest that the improvement in logistics performance contributes to environmental degradation rather than environmental sustainability for oil-rich MENA countries, while insignificant for non-oil-rich MENA countries. Moreover, our results show that having higher LPI and its sub-indices does not necessarily represent better green logistics, i.e. environmental-friendly logistics, performance in the MENA region. Therefore, considering the environmental effects of logistics performance, the necessity of logistics regulations such as encouraging the protection of natural resources, and implementation of green logistics practices is evident.

Keywords: Middle East and North Africa Economies, Logistics Performance, Environmental Degradation.

JEL Classifications: C13, C23, C33, F64, Q54, Q56.

ملخص

تحلل هذه الورقة آثار الأداء اللوجستي على التدهور البيئي لفريق من 20 اقتصادًا في منطقة الشرق الأوسط وشمال إفريقيا خلال الفترة 2007-2018. وفي هذا السياق، يقاس الأداء اللوجستي بمؤشر الأداء اللوجستي ومؤشراته الفرعية التي وضعها البنك الدولي (2002)، ويقاس التدهور البيئي بانبعاثات ثاني أكسيد الكربون والبصمة الإيكولوجية. بصرف النظر عن مؤشر أسعار المستهلكين، تعتبر المتغيرات مثل نصيب الفرد من الدخل والانفتاح التجاري والتصنيع واستهلاك الطاقة المتجددة من العوامل المحددة للتدهور البيئي في الدراسة. تشير النتائج التجريبية لهذه الدراسة إلى أن التحسن في الأداء اللوجستي يساهم في التدهور البيئي بدلاً من الاستدامة البيئية لبلدان الشرق الأوسط وشمال أفريقيا الغنية بالنفط، في حين أنه ضئيل بالنسبة للبلدان غير الغنية بالنفط في الشرق الأوسط وشمال أفريقيا. علاوة على ذلك، تظهر نتائجنا أن ارتفاع مؤشر أسعار المستهلكين ومؤشراته الفرعية لا يمثل بالضرورة لوجستيات خضراء أفضل، أي الخدمات اللوجستية الصديقة للبيئة، والأداء في منطقة الشرق الأوسط وشمال إفريقيا. ولذلك، وبالنظر إلى الآثار البيئية للأداء اللوجستي، فإن ضرورة وضع لوائح لوجستية مثل تشجيع حماية الموارد الطبيعية، وتنفيذ الممارسات اللوجستية الخضراء أمر واضح.

1. Introduction

A country's logistics performance is an important determinant of its economic performance since logistics infrastructure connects producers with supply networks, consumers with products, and people with communities throughout urban and rural environments. Effective and efficient logistics networks are the cornerstone of international trade and industry in the global economy. In this context, logistics refers to the set of integrated activities required to move products through the efficient supply chain process, which includes freight transportation, inventory storage and management, material handling, and information processing (Martel and Klibi, 2016). Poorly managed and inefficient logistics operations increase operational and capital costs due to under-utilization and waiting time (Windmark and Andersson, 2015). Therefore, improving logistics performance is becoming one of the main priorities of the countries to ensure economic growth, facilitate international trade, increase the export variety and increase competitiveness in global markets (Gani, 2017; Kim and Min, 2011; Töngür et al., 2020; D'Aleo and Sergi, 2017).

On the other hand, with the increasing concerns about environmental degradation in recent years, the effects of logistics activities on the environment have been questioned. According to the IEA (2019), along with electricity and heat generation, the transport sectors are responsible 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 considered negative environmental externalities for human health. Despite these negative impacts, Alam and Li (2021) claim that carbon emissions from logistics activities may increase by 60% by 2050 unless adequate measures are taken. Moreover, the International Transport Forum's Freight Model projects a factor of 3.9 increase in trade-related freight transport emissions by 2050 (Wild, 2021).

It is known that transportation is a significant contributor to greenhouse gas emissions, with road transportation being the most significant source (Larson, 2021). This is mainly due to the high dependence on fossil fuels for transportation, and the poor fuel efficiency of vehicles. Therefore, intensity of transportation and long delivery times increase carbon emissions by increasing fossil fuel consumption (Khan et al., 2019; Rashidi and Cullinane, 2019). Moreover, logistics is regarded as a high-energy-consuming sector. In response to increasing market demand, especially in developing countries, the transportation system is expanding rapidly. This increased demand may also result in higher energy demand, further degrading the environment. In addition to greenhouse gas emissions, logistics operations can also have significant impacts on local 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 lead to water pollution (Zaman and Shamsuddin, 2017).

Most developing countries face logistics-base inefficiencies in integrating with global production networks and delivering their products to world markets and also 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 growth is also quite high due to bad oil market conditions, rapid population growth, 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 factors to achieve sustainability goals may be a concern particularly for developing countries, including MENA region.

In fact, the dilemma is whether an improvement in logistics performance can eliminate the harmful effects of logistics activities on the environment. In the context of logistics performance and environmental impact, “Jevons' Paradox” which was first proposed by William Stanley Jevons (1906) in the 19th century 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. Also, 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. 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.

To mitigate the potential negative impacts of Jevons' Paradox in logistics, it is crucial to combine efficiency gains with sustainability measures throughout the supply chain. Around the discussions about logistics activities and the environment, the issue of green and sustainable logistics development comes to the fore. In this context, green logistics (GL) refers to the use of environmentally friendly and sustainable processes in logistics activities and thus aims to eliminate the environmental externalities of logistics operations and to provide a sustainable balance of economic and environmental goals (Liu et al., 2018). GL has also become a crucial component of green supply chain management (GSCM) (Carter and Liane Easton, 2011; Min and Kim, 2012). GSCM ensures 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. Thus, environmentally sustainable production strategies are formed by minimizing the energy and resource consumption required for the production of environmentally friendly goods and services (Yaprak and Doğan, 2019). They include promoting sustainable consumption patterns, encouraging modal shifts to greener transport modes, implementing renewable energy sources, optimizing routes to minimize empty mileage, and adopting ecofriendly packaging and waste reduction strategies. By integrating these 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 empirical literature, the relationship between logistics performance and environmental sustainability has been discussed recently (Khan and Qianli, 2017; Zaman and Shamsuddin, 2017; Khan et al., 2018; Khan et al., 2019; Liu et al., 2018; Li et al., 2021; Magazzino, 2021). Most of these studies employ the Logistics Performance Index (LPI) and its sub-indices developed by the World Bank (2007) as indicators of logistics performance while using CO_2 emissions as the main proxy for environmental degradation (Khan and Qianli, 2017; Zaman and Shamsuddin, 2017; Khan et al., 2018; Khan et al., 2019; Liu et al., 2018; Li et al., 2021; Magazzino, 2021). However, the findings show that the nature of the nexus between environmental degradation and logistics performance remains unclear and needs further investigation.

On this basis, this study aims to fill this gap for the MENA region and tries to make several contributions to the literature. The study analyzes the environmental impacts of improving logistics performance in 20 MENA economies for the period 2007-2018 based on the fixed effect panel estimation method. Considering the endogeneity, fixed effects instrumental variable regression (FE-IV), generalized methods of moments (GMM) estimators are also applied to check the robustness of the results. The findings of the study may also provide useful insights for policymakers to ensure sustainable economic development.

The rest of the paper is organized as follows. Section 2 presents the relevant literature review. Section 3 introduces the data and the descriptive statistics Section 4 presents the empirical methodology and the results. Section 5 concludes and provides some policy implications.

2. Literature Review

Most of the empirical 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 began to be examined only with the emergence of the green supply chain management literature (Liu, 2018).

Most of the studies examining this relationship employ LPI and its sub-indices as indicators of logistics performance. Some of these studies build green logistics performance indicators by integrating environmental indicators into the LPI. Khan et al. (2017), for example, combined the logistic performance and environmental indicators in order to analyze the relationship between environmental logistics performance and various economic growth factors for 15 selected countries. Mariano et al. (2017) constructed a composite low-carbon logistics performance index based on data from 104 countries. Kim and Min (2011) constructed a green logistics performance index (GLPI) for 146 countries by combining two of the six LPI indicators (infrastructure and timeliness) with Environmental Performance Index (EPI) indicators developed by the World Economic Forum that measure GHG and other emissions. Lu et al. (2019) developed an environmental logistics performance index (ELPI) for 112 countries to assess overall logistics performance in terms of green transportation and logistics practices.

There are few studies in the literature that examine the impact of logistics performance on environmental degradation at a macro level. The results of these studies are mixed. That is, there is no consensus that the improvement in logistics performance, measured by higher LPI, has an increasing, decreasing or insignificant effect on environmental degradation. Moreover, some of them point out that these effects differ according to LPI sub-indices and geographical regions.

Some of the recent studies finding that LPI contributes to environmental sustainability, that is, reduces CO_2 emissions, are mentioned below. For example, Liu et al. (2018) analyze the impact of logistics performance on the environmental degradation of 42 ASEAN countries between 2007 and 2016 based on the system-generalized method of moment (GMM) regression model. They represent logistic performance with sub-indicators of LPI and use them together in the same regression as explanatory variables. Liu et al. (2018) conclude that the impact of LPI on environmental degradation varies according to its sub-indicators. For example, while logistics 'timeliness' significantly increases CO_2 emissions, 'international shipment' significantly reduces them. Moreover, the impact of LPI's sub-indicators on the environment, for example 'tracking and tracing', 'services quality and competence', 'infrastructure quality, and 'customs efficiency' varies in different sub-regions of Asia such as East Asia, Central Asia, Middle East and South Asia. Zaman and Shamsuddin (2017) also discuss the same issue for 27 European countries over a period of 2007-2014 by employing GMM. Similar to Liu (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, improvement in 'transport-related infrastructure' decreases CO_2 emissions while improvement in 'competence and quality of logistics services' increases them. Comparing the results of Liu (2018) and Zaman and Shamsuddin (2017), it is seen that the impact of logistics performance on environmental degradation is quite different in European and Asian countries. Liu (2018) attributes this difference to the differences in environmental policies and GSCM practices in the two regions. Karaduman et al. (2020) investigated 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 less CO_2 emissions. In other words, they find a negative relationship between logistics performance and environmental degradation in the sampled Balkan countries. Suki et al. (2020) analyze the impact of overall LPI on CO_2 of top Asian countries such as China, Singapore, India, Japan and Turkey based on IPAT and STIRPAT models for the period 2010 and 2018. Similar to Karaduman et al. (2020), they find that LPI contributes significantly to pollution reduction.

On the other hand, there are also studies finding that CO_2 emissions increase as LPI increases. For example, Khan (2019) analyzes the relationship between environmental degradation and logistics performance for ASEAN countries from 2007 to 2017, based on GMM estimation. He uses two sub-indices (out of 6) of LPI, ‘quality of logistics services’ and ‘infrastructure’, as proxies of logistics performance and concludes that better logistics performance increases environmental degradation. Li et al. (2021) analyze the environmental impacts of LPI for One Belt and Road Initiative (OBRI) countries, Europe, MENA, East and South Asian regions based on two-stage least squares (2SLS) and generalized method of moments (GMM) methods over the period 2007-2019. They used the index used by Khan (2019) as a proxy for logistics performance and named it green logistics performance. They find that improvement in green logistics performance increases CO_2 emissions in OBRI, Central Asia and the MENA although decreases it in Europe, East and South Asia. The results of Larson (2021), who analyzes the relationship between LPI and environmental sustainability for 160 countries in 2016, indicate that logistics activities fail to reduce CO_2 emissions. Similarly, Magazzino (2021), in his study for 25 countries with the highest LPI between 2007 and 2018, uses Fully Modified Ordinary Least Squares (FMOLS), Generalized Method of Moments (GMM) and Quantile Regression (QR) models and concludes 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 levels.

In the literature, 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 been investigated. Income per capita is treated as a variable that increases environmental degradation (Apargis and Ozturk, 2015). The literature also points out that trade openness has 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 of the manufacturing, construction, electricity, water and gas sectors require intensive energy use (Hong et al., 2015, Sadorsky, 2013). On the other hand, the impact of FDI on environmental degradation is controversial. Some studies (e.g. Lee, 2009) confirm the ‘pollution haven’ hypothesis, which argues that FDI inflows increase pollution in the host countries, while others (e.g. Wang and Chen, 2014) confirm the ‘pollution halo’ hypothesis, which argues that FDI inflows reduce pollution in the host countries. Renewable energy consumption also considered as a determinant of environmental degradation (Adam and Acheampong, 2019).

The studies in the literature do not have a consensus on the environmental effect of LPI. It varies according to the sub-indexes of LPI, geographical regions, differences in countries’ environmental policies and GSCM practices and the estimation methods. This study tries to make several contributions to the literature. First, to the best of our knowledge, this is the first attempt to clarify whether the improvement in logistics performance contributes to environmental degradation by focusing only on MENA countries. In addition, besides CO_2 emissions, the ecological footprint (EF), which includes the ecological assets that a population must produce, the natural resources it consumes, and the absorption of its waste (Balogh, 2019) is used as a proxy of environmental degradation. The study also provides policy recommendations specific to the MENA region to ensure sustainable economic development.

3. Data and Some Descriptive Statistics

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

The definition and data sources for all variables are given in Table 1. We use CO_2 emissions and ecological footprint as proxies of environmental degradation. CO_2 emissions have traditionally been the most frequently used proxy variable of environmental degradation. The data for CO_2 emissions are presented in terms of metric per capita and taken from WDI (2022). However, since CO_2 emissions account for only a portion of environmental degradation, we also employ ecological footprint as a broader and more reliable indicator of environmental degradation. The ecological footprint is measured by Global Footprint Network (GFN) and it shows how much biologically productive land and water is required to meet all the competing demands of humans 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 ecological footprint data are obtained from GFN (2022).

Table 1. Variable Definitions and Data Sources

Variable	Definition	Data Source
$CO2$	Carbon dioxide emission per capita	World Bank's World Development Indicators (WDI)
EF	Ecological footprint per capita (in global hectares)	Global Footprint Network (GFN)
LPI	Overall logistics performance index	World Bank's LPI database
$LPIC$	Logistics performance index measuring the efficiency of the customs clearance process. This sub-index assesses the effectiveness and efficiency of customs procedures in terms of speed, simplicity, and predictability	World Bank's LPI database

Table 1. Variable Definitions and Data Sources (contd.)

$LPIIN$	Logistics performance index measuring the quality of trade and transport-related infrastructure. This sub-index measures the quality of transportation infrastructure.	World Bank's LPI database
$LPIIS$	Logistics performance index measuring the ease of arranging competitively priced shipments. 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 competence and quality 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 trace and trace consignments. This sub-index measures the tracking and tracing of international shipments.	World Bank's LPI database
$LPIT$	Logistics performance index measuring the frequency with which shipments reach consignee within scheduled or expected time. This sub-index assesses deliveries to be on time	World Bank's LPI database
GDP_{pc}	Gross domestic product per capita at constant prices	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. The LPI score measures the logistics performance of a country and is constructed from six core indicators using 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 has been aggregated as a weighted average of these six core indicators. The value of an LPI score ranges from 1 to 5, with a score of 5 representing the best logistics performance (Arvis et al., 2014).

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

Trends of CO_2 emissions, ecological footprint 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. Table 2 shows the descriptive statistics.

Table 2. Descriptive Statistics

	All sample			Oil-rich			Non-oil-rich		
Variables	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 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 from the table that CO_2 emissions are much higher and more volatile in oil-rich MENA countries compared to non-oil-rich MENA countries. The same pattern applies, less noticeably, 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 slightly higher in oil-rich MENA countries compared to non-oil-rich ones. Considering LPI sub-indices, the highest mean value among all sub-indices belongs to LPIT (the frequency with which shipments reach the consignee within scheduled or expected time) (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 most significant difference between oil-rich and non-oil-rich countries is in 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. Also, the trade openness of oil-rich countries (94.33 percent) is 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:

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

where the subscripts i and t refer country and years, respectively. ED refers the environmental degradation which is proxied by CO_2 emissions (*CO2*) and ecological footprint (*EF*), alternatively. The key variable is logistics performance (*LPIX*). First of all, we use overall logistics performance index (*LPI*) for this measure. We also extend the regression by employing sub-indices of *LPI* (*LPIC, LPIIN, LPIIS, LPIQC, LPITT, LPIT*) to analyze the effects of the different types of measures of logistics performance on environmental degradation. We used each sub-index in a separate regression in order to avoid multicollinearity. The variables η_i and φ_t denote time-invariant country-specific effects and time-specific effects, respectively. The last term u_{it} is idiosyncratic error component.

Equation (1) is estimated by using fixed effects (FE) model. We adopt Hoechle (2007) approach that produces Driscoll-Kraay standard errors for panel models since those are robust to serial correlation, heteroskedasticity, and cross-sectional dependence. Moreover, Driscoll and Kraay standard errors have significantly better small sample properties than commonly applied alternative techniques for estimating standard errors when cross-sectional dependence is present as in our case[3].

[3] We rejected the null hypothesis of cross-sectional independence for all models by using Pesaran test. Test results are available upon request.

Table 3 presents the results of the fixed effects panel regression analysis for Equation (1). Alternative dependent variables are CO_2 emissions and ecological footprint, and the main independent variable is the overall LPI. In addition, the results are presented separately for the whole sample, oil-rich MENA countries and non-oil-rich countries.

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 and year dummies but not reported to save space.
Driscoll-Kraay standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. p-values in brackets for test statistics.

In Table 3, the first point to note is that there is a positive relationship between overall LPI and environmental degradation for the whole sample and oil-rich countries, while this relationship is insignificant for non-oil-rich countries. In other words, improvement in LPI contributes to environmental degradation both in the whole sample and oil-rich countries. More specifically, the table shows that a one percent improvement in the overall LPI resulted 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 are consistent with Wan et al. (2022), Magazzino (2021) and Kim and Min (2011).

Considering the ecological footprint as another indicator of environmental degradation, Table 3 shows a one percent increase in overall LPI increases the ecological footprint 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 ecological footprint, similar to CO_2 emissions. One notable point in Table 3 is that the impact of overall LPI on ecological footprint 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 ecological footprint 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. The ecological footprint measures the amount of biologically productive land and water required to sustainably support the consumption and waste assimilation of a population. If the efficiency gains achieved through the LPI lead to increased trade volumes and global supply chain activities, it can potentially contribute to a higher overall ecological footprint due to increased resource consumption, emissions, and environmental impacts on a global scale.

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 higher ecological footprint in the MENA region, especially in oil-rich ones. 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 environment for MENA. This shows us that Jevons' Paradox applies 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 ecological footprint, due to the use of resources to build and maintain that infrastructure. Also, improved logistics performance can lead to increased trade volumes (Çelebi, 2019) and shipping activity. In the MENA region, the majority of this increased activity is based on road transport, which is the largest contributor to carbon emissions, so it can result in higher fossil fuel consumption and therefore higher carbon emissions and air pollution (Liu et al., 2018).

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-oil-rich countries. This finding indicates that an increase in per capita income increases both CO_2 emissions and ecological footprint, and thus means that increased economic activity degrades the environment. This is consistent with the existing literature (Grossman and Krueger, 1995). Table 3 also indicates that the rate of industrialization has a negative impact on environmental degradation for the whole sample and the oil-rich countries. In other words, an increase in industrial activity reduces CO_2 emissions and ecological footprint in the whole sample, CO_2 emissions only in oil-rich countries. While our result is consistent with Liu et al. (2018)'s finding for East Asia and the Middle East, it contradicts the expected result that industrial activity increases carbon emissions. Trade openness increases CO_2 emissions and reduces the ecological footprint in the whole sample. Zaman and Shamsuddin (2017) also find a positive relationship between trade openness and CO_2 emissions for European countries. Liu et al. (2018) find this effect insignificant for Middle Eastern countries, but their results for Asia and East Asia are similar to our results. In the oil-rich countries, trade openness reduces both CO_2 emissions and ecological footprint, indicating that trade liberalization policies of oil-rich MENA countries are designed to reduce environmental degradation. Table 3 also shows that FDI inflows have a significant impact only on CO_2 emissions. Moreover, this impact is positive for oil-rich countries while negative for non-oil-rich countries and the whole sample. The results suggest that pollution haven hypothesis is valid in oil-rich countries while pollution halo hypothesis is valid for non-oil rich MENA countries. The results of Zaman and Shamsuddin (2017) for European countries are consistent with what we found for non-oil-rich countries. However, Taşdemir and Ekmen-Özçelik (2022) suggest a non-linear relationship between FDI inflows and environmental degradation for 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 ecological footprint 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. Estimation results are summarized in the table. The full results are presented in the Appendix Table A1-A3.

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)
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)
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)
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)
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)
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)

Note: Driscoll-Kraay standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.
See appendix for full estimation results by sub-indices.

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 (2018) found for South Asia, but he found this effect insignificant for the rest of Asia, including the Middle East. On the other hand, the table shows that 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 the environmental degradation both in the whole sample and oil-rich countries. The results show that better quality logistics infrastructure leads to environmental degradation, especially in oil-rich countries. This finding may indicate that environmental standards are neglected while improving logistics infrastructure in MENA countries.

LPIIS has positive impact on both CO_2 emissions and ecological footprint. In other words, as the ease of arranging competitively priced shipments increases, both CO_2 emissions and ecological footprint increase. This result contradicts the result of Liu et. al. (2018) for Asia, Middle East and East Asia countries but is consistent with the result of Zaman and Shamsuddin (2017).

LPIQC also positively related to environmental degradation in oil-rich countries. That's, competence and quality of logistics services increase environmental degradation in terms of both CO_2 emissions and ecological footprint in oil-rich countries. Zaman and Shamsuddin (2017) also find a positive relationship between LPIQC and CO_2 emissions in European countries.

Similarly, we find a positive impact of LPIIT on both CO_2 emissions and environmental degradation for the whole sample and oil-rich countries. This result suggests that an increase in the ability to trace and trace consignments may lead to environmental degradation in MENA. The result is consistent with what Liu et al. (2018) found for East Asia, but contradicts what they found for the Middle East.

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 ecological footprint of the entire sample. This is consistent with Liu et al. (2018) for Asia and East Asia countries. Our result indicates that as the timeliness of freight transport improves, the ecological footprint also increases. On the other hand, the timeliness of freight transportation demonstrates the reliability and predictability of the supply chain and is critical for companies in the global value chain (Arvis et al., 2016). Therefore, policymakers should consider this paradox between the timing of freight transport and emissions and develop methods to resolve this paradox.

All in all, the results in Table-4 show that the improvement in all sub-indices shows environmental degradation generating performance in MENA, except for the reducing effect of LPIC on CO_2 emissions of non-oil-rich countries. It is a fact that the improvement in LPI and its sub-indices points to a more efficient logistics system. However, the findings of our study indicate that an efficient logistics system also contributes to environmental degradation for MENA. Countries with an efficient logistics structure and therefore low logistics costs also have a competitive advantage in the international market (Aigigner, 1998). More efficient logistics systems facilitate international trade, ensure product safety and product mobility, and increase delivery time and speed (La and Song, 2019). These improvements can contribute to environmental degradation by leading to a shift to longer supply chains and higher emission modes of transport. Therefore, it is necessary to develop the necessary policies to solve this paradox.

As well as robustness checks with respect to sub-samples and alternative measures of both environmental degradation and logistics performance that we discussed above, we also check whether our regressions suffer from problems of multicollinearity and endogeneity. First of all, potential multicollinearity is detected with 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 low VIF values indicate there is no empirical evidence of severe multicollinearity for any set of estimations in the study. On the other hand, 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 quite similar to the main findings in our study (see Table A4 in appendix).

5. Conclusion and Policy Implications

This study aims to analyze the impact of logistics performance on environmental degradation in MENA countries. Our sample comprises an unbalanced panel of 20 MENA countries for the period 2007-2018. Also, due to heterogeneity in their natural resource endowments and economic performance, we also divide countries into two groups, oil-rich countries and non-oil-rich countries. We use CO_2 emissions and ecological footprint as indicators of environmental degradation, and overall LPI and its sub-indices as indicators of logistics performance.

Our results show that an improvement in LPI contributes to environmental degradation in the whole sample and in oil-rich MENA countries. Considering the LPI sub-indices, an increase in all sub-indices except tracking and tracing leads to environmental degradation in oil-rich MENA countries. In other words, increase in the efficiency of logistics infrastructure, custom procedure, international shipments, tracking and tracing, timeliness and quality of logistics services are not useful in mitigating the CO_2 emissions and ecological footprint.

Therefore, we can suggest that logistics performance in the MENA region does not progress in an environmentally friendly manner and environmental concerns are largely ignored in the supply chain process. This result points to the urgent need to implement policies to support green logistics, especially in oil-rich countries. These practices are especially essential for oil-rich countries, because environmental degradation poses a greater threat in oil-rich countries due to less stringent environmental laws and concerns for economic growth (Ike et al., 2020). Moreover, most of the increase in world electricity production, which contributes significantly to environmental degradation, comes from oil-producing countries where energy sources are predominantly fossil fuels (Enerdata, 2019). Thus, improvements in logistics performance should be reconsidered to reduce environmental issues and incorporate the green supply chain process. Green supply chain networks that encompass green and energy-efficient practices need to be designed.

Improving the logistics performance can bring many economic benefits, including economic growth, export diversification and trade facilitation. However, sustainable economic development includes not only economic but also social and environmental factors. Higher LPI and its sub-indices represent the efficient logistics activities in border management, higher quality of logistics services and easier tracing and tracking, but may not represent better performance in green logistics. Our results suggest that the environmental impact of higher logistics performance, measured by LPI, is deteriorating for MENA countries, particularly for oil-rich countries. This finding can be based on the fact that the improvement in logistics performance increases transportation activities, which in turn increases fossil fuel consumption and leads to an increase in CO_2 emissions (Wan et al., 2022). Also, the improvement in logistics performance may decrease environmental performance most likely through increased economic activities, and thereby energy use and fossil fuel use. For example, Magazzino et al. (2021) argue that improving the quality of logistics can lead to the development of Information and Communication Technology (ICT), which is heavily dependent on energy, and also trigger energy use by increasing vehicle density.

In order for the improvement in logistics performance to have positive effects on the environment and ecosystem, it should be supported by green practices. Therefore, introducing green logistics and green supply chain management practices is essential for the MENA region to reduce the environmental externalities of logistics operations and to achieve sustainable development goals. For *example*, environmentally friendly methods can be used in the processes of handling materials, processing information and storing the inventory (Li et al., 2018). Also, 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). Magazzino et al. (2021) suggest improving the operational use of energy by international transport and enhancing its efficiency through modal split, reducing the carbon content of power sources to suppliers and ensuring more efficient energy during the logistics process. In addition, Rodt et al., (2010) suggest encouraging environmentally friendly modes of transportation and implementing policies to increase vehicle efficiency. By considering green logistics practices, it will be possible to improve both environmental quality and logistics performance simultaneously. It should also be noted that maintaining environmentally friendly logistics management through these practices requires strong policy support.

Finally, our results point out that the LPI and its sub-indices are not much useful for measuring MENA's green logistics performance. Therefore, a more accurate measure is needed to evaluate MENA's green logistics performance. Future work may be to examine the logistics performance of MENA by considering environmental factors. A new MENA-specific performance metric could be developed that simultaneously considers both sustainability and logistics efficiency.

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Appendix

Figure A1. CO_2 emissions (Oil-rich countries)

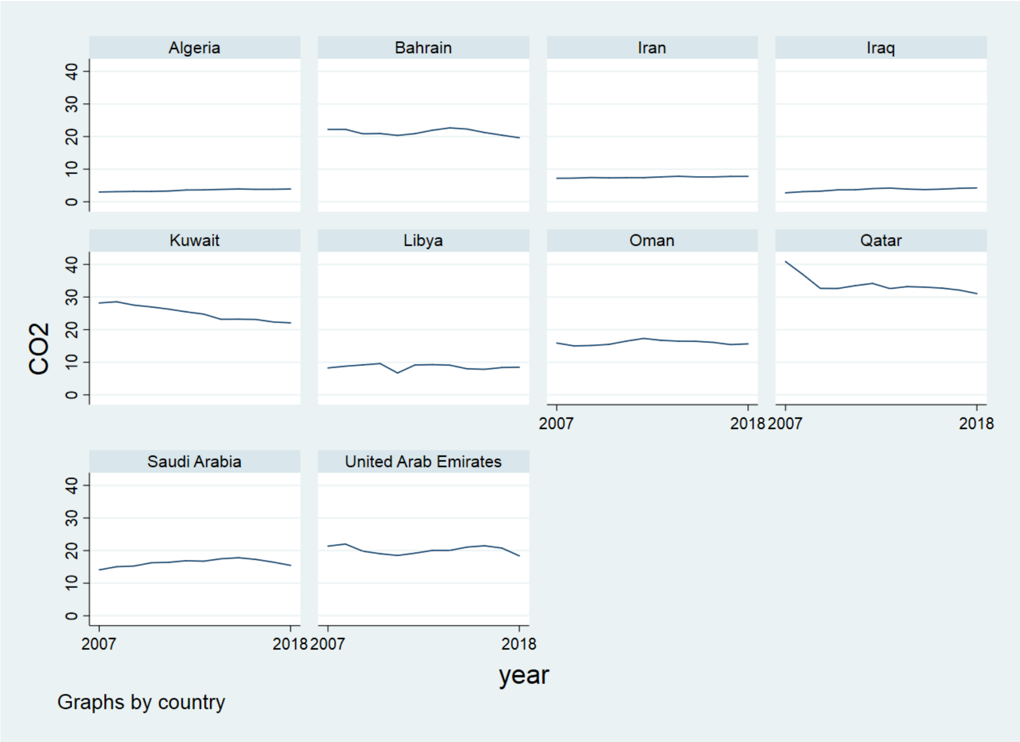

Figure A2. CO2 emissions (Non-oil-rich countries)

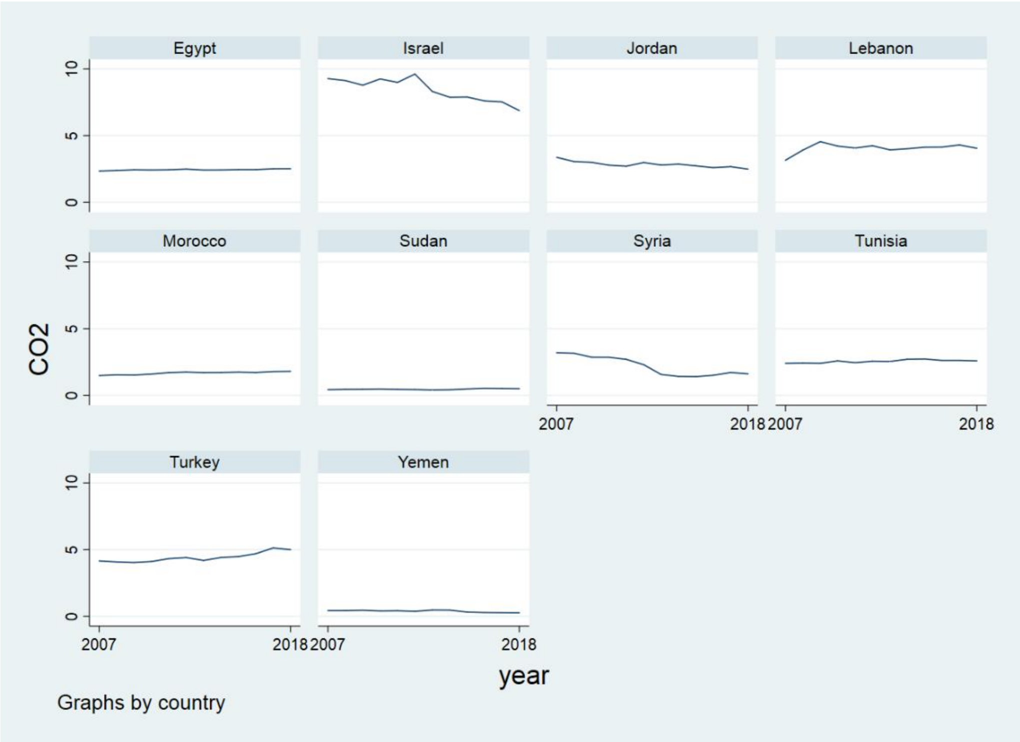

Figure A3. Ecological Footprint (Oil-rich countries)

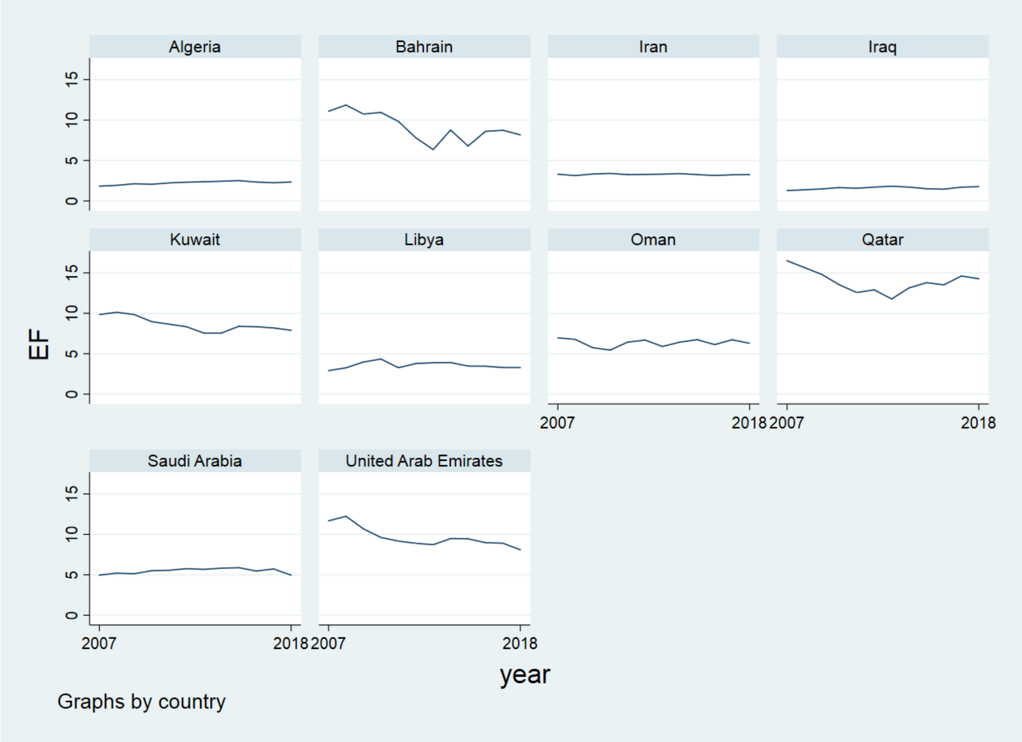

Figure A4. Ecological Footprint (Non-oil-rich countries)

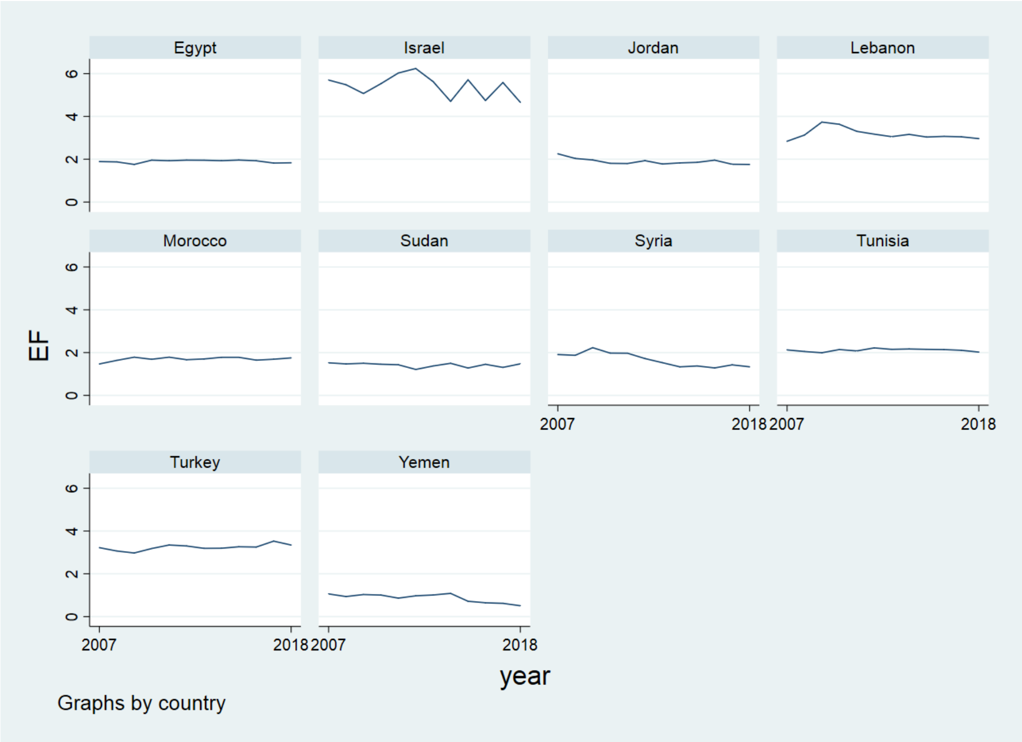

Figure A5. Overall LPI (Oil-rich countries)

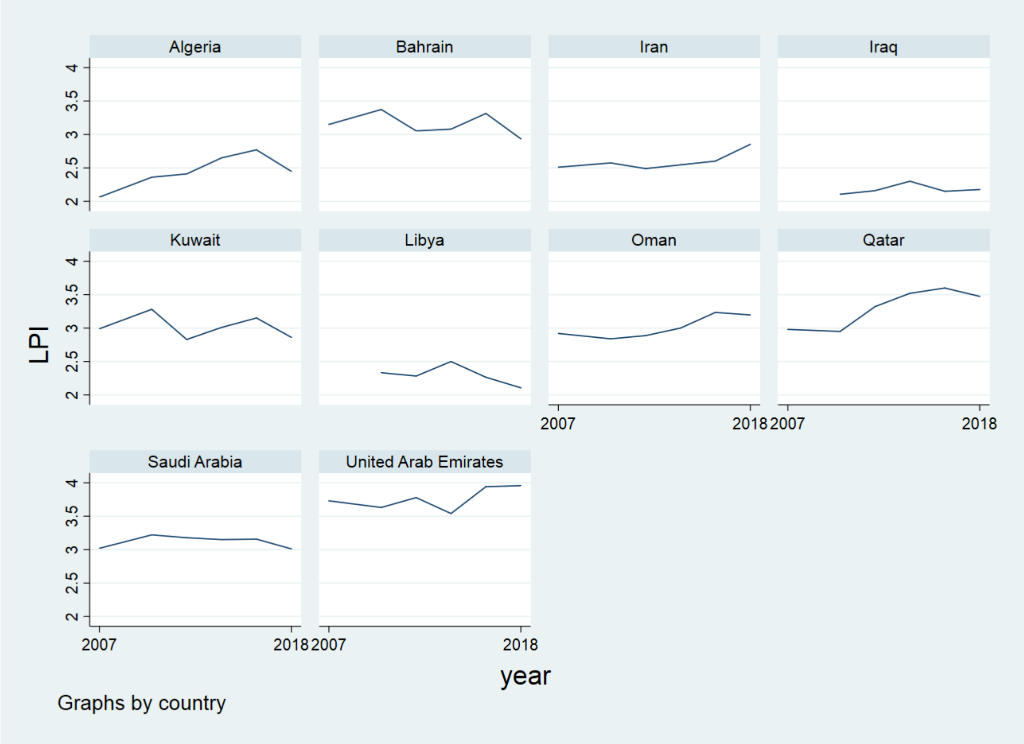

Figure A6. Overall LPI (Non-oil-rich countries)

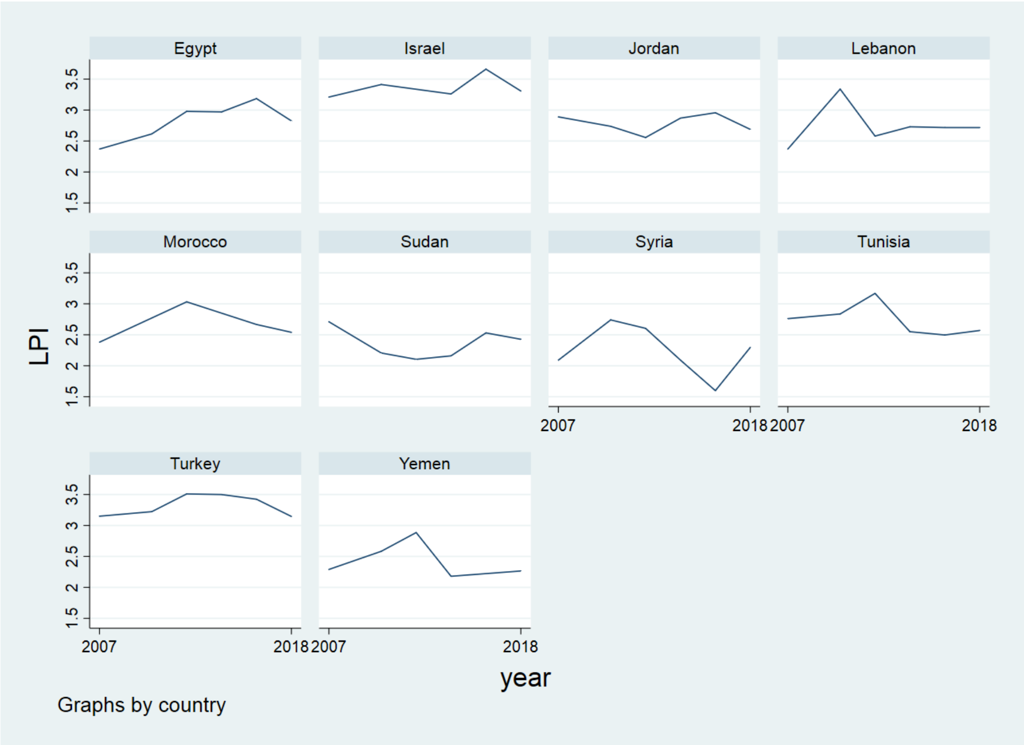

Table A1. FE results by sub-indices: All sample

	ln (*CO2*)						ln (*EF*)					
ln (*GDPpc*)	0.487***	0.450***	0.465***	0.477***	0.470***	0.501***	0.569***	0.512***	0.535***	0.536***	0.536***	0.546***
	(0.021)	(0.034)	(0.018)	(0.024)	(0.026)	(0.030)	(0.062)	(0.073)	(0.046)	(0.065)	(0.069)	(0.075)
livas	-0.335***	-0.295**	-0.304***	-0.315**	-0.331***	-0.352**	-0.427***	-0.361**	-0.370**	-0.341**	-0.426***	-0.399**
	(0.100)	(0.114)	(0.093)	(0.105)	(0.099)	(0.114)	(0.113)	(0.124)	(0.126)	(0.146)	(0.125)	(0.144)
tros	0.054*	0.077***	0.063**	0.059**	0.052**	0.053**	-0.250***	-0.210***	-0.235***	-0.230***	-0.259***	-0.251***
	(0.025)	(0.017)	(0.024)	(0.020)	(0.018)	(0.024)	(0.042)	(0.043)	(0.040)	(0.049)	(0.050)	(0.048)
fdis	-0.324**	-0.373**	-0.353***	-0.402***	-0.345**	-0.343***	0.008	-0.028	0.003	-0.299	0.009	0.095
	(0.107)	(0.134)	(0.110)	(0.097)	(0.119)	(0.108)	(0.424)	(0.404)	(0.385)	(0.459)	(0.384)	(0.434)
recs	-1.419*	-1.529**	-1.465**	-1.432**	-1.399**	-1.526**	-1.176***	-1.373***	-1.265**	-1.225***	-1.107***	-0.922**
	(0.651)	(0.620)	(0.598)	(0.635)	(0.627)	(0.639)	(0.318)	(0.345)	(0.414)	(0.287)	(0.299)	(0.408)
ln (*LPIC*)	-0.005						0.094					
	(0.034)						(0.063)					
ln (*LPIIN*)		0.129**						0.247***				
		(0.055)						(0.044)				
ln (*LPIIS*)			0.152**						0.336***			
			(0.055)						(0.040)			
ln (*LPIQC*)				0.066						0.318***		
				(0.046)						(0.058)		
ln (*LPITT*)					0.123**						0.347***	
					(0.040)						(0.051)	
ln (*LPIT*)						-0.063						0.144**
						(0.074)						(0.062)
Observations	217	217	217	217	217	217	217	217	217	217	217	217
Countries	20	20	20	20	20	20	20	20	20	20	20	20
R-squared	0.461	0.474	0.483	0.464	0.477	0.463	0.411	0.438	0.478	0.457	0.493	0.412
F-stat.	9.05	9.55	9.88	9.17	9.66	9.13	7.39	8.25	9.70	8.92	10.30	7.43
(Overall)	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
F-stat.	476.95	491.47	498.59	476.98	480.42	460.80	69.77	72.96	80.11	76.52	83.53	71.07
(Country FE)	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]

Note: All models include a constant and year dummies but not reported to save space.
Driscoll-Kraay standard errors in parentheses *** $p<0.01$, ** $p<0.05$, * $p<0.1$. p-values in brackets for test statistics.

Table A2. FE results by sub-indices: Oil-rich MENA countries

	ln (*CO2*)						ln (*EF*)					
ln (*GDPpc*)	0.478***	0.456***	0.545***	0.537***	0.563***	0.541***	0.303	0.260	0.470***	0.412**	0.482**	0.386
	(0.068)	(0.069)	(0.040)	(0.046)	(0.035)	(0.051)	(0.218)	(0.231)	(0.147)	(0.184)	(0.188)	(0.222)
livas	-0.269**	-0.196**	-0.429***	-0.378***	-0.411***	-0.430***	-0.278	-0.140	-0.677**	-0.468	-0.550*	-0.463
	(0.087)	(0.064)	(0.069)	(0.070)	(0.039)	(0.091)	(0.290)	(0.313)	(0.253)	(0.296)	(0.301)	(0.373)
tros	-0.072*	-0.028	-0.049*	-0.039	-0.073**	-0.058	-0.313**	-0.233**	-0.227***	-0.241*	-0.320***	-0.306**
	(0.038)	(0.028)	(0.027)	(0.041)	(0.027)	(0.033)	(0.114)	(0.084)	(0.073)	(0.115)	(0.088)	(0.110)
fdis	0.391*	0.236	0.375	0.235	0.338**	0.420	-0.089	-0.376	-0.318	-0.481	-0.269	0.033
	(0.195)	(0.142)	(0.216)	(0.150)	(0.149)	(0.276)	(0.801)	(0.624)	(0.721)	(0.852)	(0.609)	(0.856)
recs	-7.205*	-5.618	-8.001**	-8.536**	-5.494	-8.551**	-8.290	-5.343	-9.254*	-10.876	-3.162	-9.741
	(3.530)	(4.056)	(3.293)	(3.810)	(3.225)	(3.100)	(6.581)	(7.423)	(5.094)	(6.558)	(6.333)	(5.736)
ln (*LPIC*)	0.174***						0.313**					
	(0.026)						(0.107)					
ln (*LPIIN*)		0.346***						0.635***				
		(0.058)						(0.114)				
ln (*LPIIS*)			0.135*						0.614***			
			(0.070)						(0.070)			
ln (*LPIQC*)				0.244***						0.566***		
				(0.045)						(0.143)		
ln (*LPITT*)					0.196***						0.502***	
					(0.040)						(0.069)	
ln (*LPIT*)						-0.083						0.062
						(0.084)						(0.123)
Observations	107	107	107	107	107	107	107	107	107	107	107	107
Countries	10	10	10	10	10	10	10	10	10	10	10	10
R-squared	0.660	0.698	0.646	0.669	0.678	0.630	0.370	0.428	0.506	0.424	0.472	0.323
F-stat. (Overall)	9.14	10.89	8.58	9.53	9.92	8.00	2.77	3.52	4.82	3.47	4.20	2.25
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
F-stat. (Country FE)	207.74	230.38	202.23	215.39	224.26	176.21	21.81	25.45	30.17	25.17	28.47	18.27
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]

Note: All models include a constant and year dummies but not reported to save space.
Driscoll-Kraay standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. p-values in brackets for test statistics.

Table A3. FE results by sub-indices: Non-oil-rich MENA countries

	ln (*CO2*)						ln (*EF*)					
ln (*GDPpc*)	0.515***	0.508***	0.479***	0.516***	0.510***	0.529***	0.650***	0.648***	0.633***	0.633***	0.595***	0.626***
	(0.096)	(0.133)	(0.105)	(0.123)	(0.141)	(0.120)	(0.086)	(0.131)	(0.105)	(0.120)	(0.138)	(0.135)
livas	0.080	-0.199	-0.408	-0.154	-0.179	-0.137	0.515	0.375	0.265	0.257	0.201	0.345
	(0.276)	(0.320)	(0.305)	(0.305)	(0.318)	(0.322)	(0.400)	(0.415)	(0.340)	(0.357)	(0.388)	(0.322)
tros	0.055	0.102	0.160	0.089	0.096	0.084	-0.238	-0.215	-0.185	-0.190	-0.168	-0.207
	(0.106)	(0.128)	(0.107)	(0.117)	(0.129)	(0.109)	(0.132)	(0.170)	(0.138)	(0.143)	(0.142)	(0.131)
fdis	-0.998*	-1.260**	-1.365**	-1.222**	-1.239**	-1.239**	0.352	0.219	0.163	-0.052	0.199	0.231
	(0.504)	(0.492)	(0.487)	(0.431)	(0.491)	(0.509)	(0.298)	(0.273)	(0.243)	(0.293)	(0.249)	(0.267)
recs	-1.811*	-1.838**	-1.778**	-1.815**	-1.814**	-1.888**	-0.722	-0.732	-0.705	-0.756	-0.692	-0.597
	(0.870)	(0.796)	(0.751)	(0.814)	(0.821)	(0.818)	(0.504)	(0.505)	(0.475)	(0.437)	(0.399)	(0.533)
ln (*LPIC*)	-0.159**						-0.084					
	(0.059)						(0.099)					
ln (*LPIIN*)		0.025						0.008				
		(0.068)						(0.110)				
ln (*LPIIS*)			0.174***						0.087			
			(0.055)						(0.069)			
ln (*LPIQC*)				-0.007						0.131		
				(0.058)						(0.082)		
ln (*LPITT*)					0.016						0.163	
					(0.077)						(0.106)	
ln (*LPIT*)						-0.048						0.086
						(0.070)						(0.124)
Observations	110	110	110	110	110	110	110	110	110	110	110	110
Countries	10	10	10	10	10	10	10	10	10	10	10	10
R-squared	0.514	0.493	0.510	0.492	0.492	0.493	0.622	0.616	0.621	0.627	0.634	0.619
F-stat. (Overall)	5.16	4.74	5.09	4.73	4.74	4.75	8.04	7.84	7.99	8.20	8.46	7.95
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
F-stat. (Country	302.29	266.09	288.45	284.86	282.91	278.64	59.90	55.67	58.23	58.89	55.59	53.15
FE)	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]

Note: All models include a constant and year dummies but not reported to save space.
Driscoll-Kraay standard errors in parentheses *** $p<0.01$, ** $p<0.05$, * $p<0.1$. p-values in brackets for test statistics.

Table A4. 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