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# The relationship between logistics performance and carbon emissions: an empirical investigation on Balkan countries



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## Abstract

**Purpose** – The purpose of this paper is to analyze the impact of logistics performance on the carbon (CO2) emissions of Balkan countries.

**Design/methodology/approach** – Fixed-effects panel regression analysis is used to estimate the causal relationship between CO2 emissions and logistic performances of Balkan countries. Logistics performance is measured by logistics performance index (LPI) which was published by the World Bank in 2007, 2010, 2012, 2014 and 2016 and used for ranking countries by means of their logistics performance. LPI is based on six main indicators: customs procedures, logistics costs and the quality of the infrastructure for overland and maritime transport. As a measure of carbon emissions of sampled countries, the natural logarithm of carbon dioxide emission per capita is used in this study.

**Findings** – The results obtained reveal that there is a positive and significant relationship between logistics performance and CO2 performances of the sampled Balkan countries.

**Research limitations/implications** – This study is based on only 11 Balkan countries. In this sense, the data used in the analysis is limited.

**Originality/value** – Considering the important geostrategic position of the Balkan region, logistics sector has an important role for the development of the countries in that region. In this sense, the findings of this study may provide useful insights for policymakers to achieve sustainable economic development. Furthermore, as far as the authors know, this is the first study that focuses on the relationship between logistics performance and carbon emissions of Balkan countries.

**Keywords** Carbon emissions, Logistics performance index, Balkan countries

**Paper type** Research paper

## 1. Introduction

Logistics represent an important function for all organizations ranging from manufacturing to service, public to private. Before globalization, countries only competed with other

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countries in their regions, but with globalization the competition includes all of the countries around the world, and therefore logistics gained more importance in international trade and the development of countries in the past decade (Martí *et al.*, 2017; Rezaei *et al.*, 2018; Hofman, 2017). If the countries satisfy the needs of globalization, they can truly improve their logistics performance. Hence, there is a need for measuring and comparing the performance of logistics in different countries. To analyze the differences between countries in terms of logistics, the logistics performance index (LPI) was published by The World Bank in 2007 (Martí *et al.*, 2014; Martí *et al.*, 2017; Rezaei *et al.*, 2018). In 2010, 2012, 2014 and 2016, updated versions of LPI were published by The World Bank. LPI is used for benchmarking, as it allows a comparison across 160 countries included in most recent versions. This comparison allows countries identify challenges and opportunities and improve their performance. LPI includes six main pillars of logistics performance: customs, infrastructure, international shipments, logistics quality and competence, tracking and tracing and timeliness. To calculate the score of a country, experts are asked to rate these pillars with a scale ranging from 1 (worst) to 5 (best) (Arvis *et al.*, 2016).

First pillar of LPI, customs, is used for measuring the efficiency and effectiveness of custom procedures in terms of speed, simplicity and predictability. Infrastructure includes transportation and information technology infrastructure, and it measures the quality of these elements. International shipments measure how easy could the country arrange its international shipments at a reasonable price. Logistics quality and competence is a pillar used for measuring the quality and competence of local logistics activities. The measurement of tracking and tracing of international shipments is called as tracking and tracing (ITF, 2015). Finally, timeliness refers to be punctual to delivery times, and it is an important pillar of logistics because it affects competitiveness directly (Martí *et al.*, 2014; ITF, 2015).

The logistics industry plays an important role in the economic development of countries, and it also has a vital impact on the environmental and social issues. While consuming a huge amount of energy resources, the logistics industry generates a higher amount of carbon emissions (Rashidi and Cullinane, 2019). Therefore, an effective environmental management is needed for providing a healthy environment for efficient transportation and logistics. Growing globalization makes logistics global (Rodrigue *et al.*, 2001), and while facilitating trade, logistics activities cause an increase in carbon emissions. In this sense, logistics industry has been facing an increasing pressure to implement carbon management to improve the efficiency of logistics activities for economic development and to reduce the adverse effects of these activities on the environment (Herold and Lee, 2017). As a result, there is a need for developing economic aspect of a country in line with sustainability for logistics industry when compared to other sectors (Roth and Kåberger, 2002).

In this sense, besides measuring the logistics performance of countries, LPI broadens the focus on environmental sustainability (Arvis *et al.*, 2018). Thus, LPI can be used as a green logistics performance indicator by integrating with environmental indicators (Liu *et al.*, 2018). Starting from this point of view, this study mainly aims to analyze the relationship between logistics performance and CO2 emissions in Balkan countries. Analyzing the relationship between logistics and carbon performance of Balkan region represents an interesting research field for two reasons. First, as a result of deep economic and social crises, most Balkan countries (especially Western Balkan countries) have experienced political change in 1990s. Since then, most of these countries have demonstrated high economic growth rates, with the exception of 2008 global financial crisis, and now they are in the process of joining the European Union (EU) (Pere, 2015; Georgopoulou *et al.*, 2015). As we know, during and after the EU integration process, countries have to comply with the legislations of the EU. In this framework, the Balkan countries which are already the members or in the process of becoming a member of the EU have to adopt carbon reduction targets and implement mitigation policies and measures that are in line with the EU legislations (Georgopoulou *et al.*, 2015; Golušin *et al.*, 2013). Second, as the Balkan region has an important geostrategic position for the transport thank links between Europe and Asia, logistics sector plays a critical role for the development of the countries in this region (Skayannis and Skyrgiannis, 2002; Stoilova, 2019). For the purpose of this study, 11 Balkan countries are included in the analysis which are Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Greece, Montenegro, North Macedonia, Romania, Serbia, Slovenia and Turkey. The results of the panel data analysis show that the higher LPI scores lead to less carbon emissions. In other words, there is a positive relationship between logistics performance and carbon performance of sampled Balkan countries.

The rest of the paper is structured as follows. Section 2 presents the background of the study and reviews the relevant literature. Section 3 describes the methodology, and Section 4 provides the results and discussion. Finally, Section 5 concludes the study.

## 2. Background and literature review

As stated by Hofman (2017), logistics represent one of the key sectors for economic development, as logistic performance directly affects the growth and development. In this sense, there are several studies in the literature emphasizing this direct relationship between logistics performance and the economic development of countries (Martí *et al.*, 2017; Rezaei *et al.*, 2018; Liu *et al.*, 2018). However, development would not be appreciated in a pure economic sense, but instead it covers all the aspects of sustainability: economic, environmental and social development. Environmental and social aspects of sustainability have been increasingly on public agenda (Seuring and Müller, 2008). Responsible and sustainable management of the supply chain is one of the issues addressed in this respect (The World Bank, 2010, 2018; United Nations, 2010; OECD, 2011; World Economic Forum, 2015). The World Bank (2018) defines sustainable supply chain as "the management of environmental, social and economic impacts, and the encouragement of good governance practices, throughout the lifecycles of goods and services," and they address the goal of sustainable supply chain management as creating, protecting and growing long-term environmental, social and economic value for all stakeholders involved in bringing products and services to market.

Being a very huge market, the environmental effects of logistic sector have been receiving an increasing attention. It can be said that environmental aspect of sustainability is mainly related to climate change, or in other words, global warming. Global warming is an average increase in temperature owing to greenhouse gas (GHG) emissions such as carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O). As carbon dioxide (CO2) represents the most common GHG in terms of the quantity released and the total impact on global warming, these GHGs are often measured as carbon dioxide equivalents (CO2-e), and as in this study, the terms "carbon" and "carbon dioxide (CO2)" are used interchangeably with "GHG" (Simnett *et al.*, 2009; Brander and Davis, 2012; Hossain *et al.*, 2017). Figure 1 shows the CO2 emissions by sector between the years of 1990 and 2017, all over the world. It is clear that CO2 emissions caused by electricity and heat, transport and industry sectors have been increasing since 1990. Furthermore, according to the Figure 2, compared to 1990, in 2017, the carbon emissions of the electricity and heat generation, transport, other energy industries and manufacturing industries and construction sectors increased by 78.4%, 75%, 62% and 57.3%, respectively (IEA, 2019).

Finally, Figure 3 presents the $CO_2$ emissions by sector in the year of 2017. According to the Figure 3, electricity and heat generation and transport sectors were responsible for two-thirds of total $CO_2$ emissions in 2017 (IEA, 2019).

These figures clearly demonstrate the importance of the logistics industry to achieve sustainable development. In this sense, it would not be wrong to say that the performance of logistics industry in terms of sustainability which covers economic, environmental and social development has become a popular research theme in the literature. Especially, in recent years, environmental and social aspects of sustainability have been taking place on public agenda (Seuring and Müller, 2008). Herold and Lee (2017) investigated the carbon management practices in the logistics and transportation sector. The paper is based on a literature review of studies published between the years 2000 and 2015. They found that carbon management practices in logistics and transportation have been increasing, but only carbon reduction initiatives have been discussed at length in the literature. The results of the study show that carbon performance and carbon reporting are still under-researched fields in carbon management literature. Based upon these findings, the study proposed future research directions for the logistics and transportation sector. Lee and Herold (2015) conducted three case studies with three important players of the global logistics industry

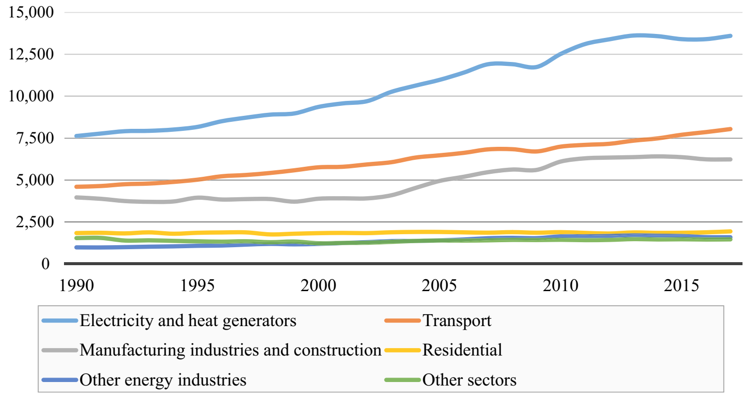


**Figure 1.**
$CO_2$ emissions (Million Tonnes) by sector, World 1990–2017

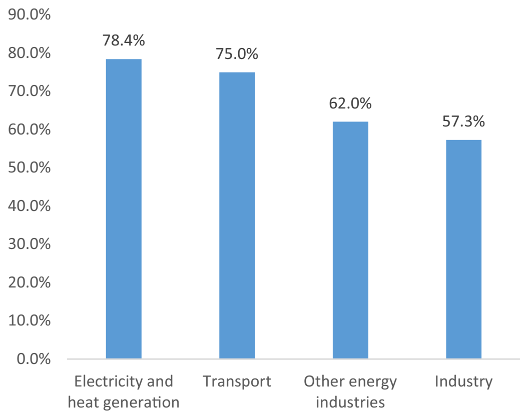


**Figure 2.**
$CO_2$ emissions % change by sector, 1990–2017

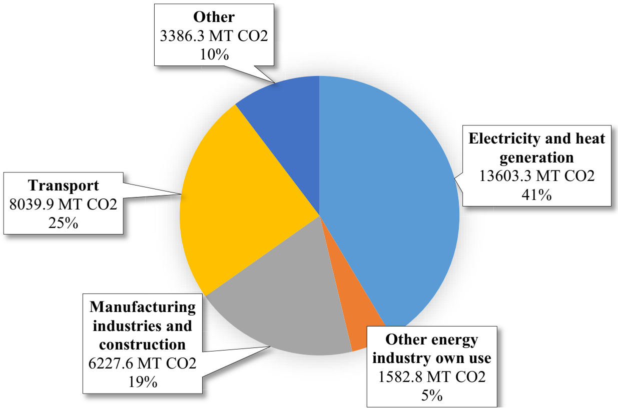


**Figure 3.** CO2 emissions by sector in 2017

(FedEx, UPS and DHL) to investigate the similarities and differences of carbon performance measurement and reporting in this sector. The results of the study show that FedEx and DHL prefer to use financial control approach, while UPS prefers to use an operational approach for carbon emission reporting.

Zaman and Shamsuddin (2017) investigated the interrelationships among logistics performance indicators, energy demand, environmental factors and economic health, using a panel data set of 27 European countries, for a period of 2007–2014. Their results indicate that improving the quality of travel and transport infrastructure reduces the carbon emissions, while improving the quality of logistics services has a negative impact on the carbon performance (Zaman and Shamsuddin, 2017).

As a useful tool to assess the performance of logistics industry from the perspective of sustainability, the combination of LPI and environmental factors has been used by several researchers (Liu *et al.*, 2018; Lu *et al.*, 2019). In this framework, Kim and Min (2011) constructed the green logistics performance index (GLPI) by combining the LPI and environmental performance index (EPI) which was developed by the collaboration of World Economic Forum and the academia. Based on their results, the authors suggest that the GLPI can be used as an appropriate indicator of a country's green logistics efficiency (Kim and Min, 2011). Similarly, Mariano *et al.* (2017) developed a composite index, low-carbon logistics performance index to measure the logistics performance and carbon emissions level in the transport sector of countries in an integrated way. They assert that such indices are helpful in developing a global index which can be used for measuring the success of countries in translating their logistics and economic performances to CO2 emission reductions (Mariano *et al.*, 2017).

In line with the studies mentioned previously, for the purpose of investigating the long-run and causal relationship between environmental logistics performance indicators and macro-economic factors, Khan *et al.* (2017) developed an interactive environmental model by using a number of LPI components with mediation of environmental factors such as energy consumptions, fossil fuel energy consumptions and carbon emissions. The researchers state that their environmental logistics performance model provides a better understanding of green supply chain management which is essential for achieving sustainable development goals of countries (Khan *et al.*, 2017).

Liu *et al.* (2018) analyzed the impact of logistics performance on environmental degradation using LPI data obtained from 42 Asian countries between 2007 and 2016. Their results indicate that there is a significant relationship between logistics performance and environmental degradation. In particular, one of the pillars of LPI, international shipment significantly decreases CO2 emissions, while the pillar timeliness of logistics leads to an increase in the CO2 emissions in Asian countries. Based upon the results, other pillars of LPI such as tracking and tracing, services quality and competence, infrastructure quality and efficiency of customs are also significantly related to the environment in different sub-regions of Asia. Other variables which have a significant influence on CO2 emissions are also investigated. The results indicate that industrialization and urbanization both increase CO2 emissions in Asian countries, while trade openness decreases CO2 emissions.

In another study, by combining LPI, CO2 emissions and oil consumption of the transport sector, Lu *et al.* (2019) constructed an environmental logistics performance index (ELPI) to evaluate the overall performance in green transportation and logistics practices of 112 countries. Their findings show that there is a strong correlation between ELPI and LPI, and the income and region are also closely related to ELPI scores of the countries. The authors conclude that countries with high LPI scores generally have better performance in terms of green transportation, and in this sense, it is possible to enhance both the logistics performance and green transportation by effective environmental regulations and encouraging clean energy use (Lu *et al.*, 2019).

More recently, Khan *et al.* (2020) investigated the relationships among green logistics operations, economic and environmental indicators in 42 selected countries over the period from 2007 to 2018. The results show that foreign direct investment inflows, renewable energy consumption and energy demand have positive impacts on the green logistics performance for the sampled countries. On the other hand, they found that there is a significant negative correlation between CO2 emissions and green logistics.

## 3. Methodology

### *3.1 Sample and data*

The purpose of this research is to analyze the relationship between logistic performance and carbon dioxide emissions in Balkan Countries. Our initial sample consists of 12 countries lying in the Balkan region: Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Greece, Montenegro, North Macedonia, Romania, Serbia, Kosovo, Slovenia and Turkey. On the other hand, we excluded Kosovo from the sample, as this country has not relevant data for the analyzed period.

The data for 11 remaining countries belong to the years 2010, 2012, 2014 and 2016. Therefore, our final sample comprises of 44 country-year observations. The required data was gathered from The World Bank Database (2020) from the years 2010 to 2016 for the sampled 11 countries.

### *3.2 Empirical model and the variables*

To examine the relationship between logistics performance and CO2 emission, we use fixed-effects panel data model to discard possible source of endogeneity by controlling for unobservable factors that do not change over time (Wooldridge, 2010; Baltagi, 2008). The following model is constructed:

$$lnCO2_{it} = constant + \alpha LPI_{it} + \beta lnGDP_{it} + \gamma URBANPOP_{it} + \delta INTTRADE_{it} + \theta INDVA_{it} + \eta_i + year\ \ dummies + u_{it}$$

where $\eta_i$ is the country-specific fixed-effects (time-invariant unobserved heterogeneity), and year dummies represent time-fixed effects. Here, $i$ is the number of cross sectional units: the countries in the sample ($i$ = 1, 2, 3, . . ., 12), and $t$ is the time span ($t$ = 2010, 2012, 2014, 2016). $u_{it}$ is the idiosyncratic error term. The definition of the variables in the model is as follows:

- *lnC02* = natural logarithm of carbon dioxide emission per capita;
- *LPI* = logistics performance index;
- *lnGDP* = natural logarithm of GDP per capita at constant prices;
- *URBANPOP = urban population*/*total population (%)*;
- *NTTRADE = (export + import)/GDP (%)*; and
- *INDVA = Industry value Added/GDP (%).*

While carbon dioxide emission level is the dependent variable and LPI is the key independent variable, the GDP per capita, urban population ratio, international trade ratio and industry value added ratio are our control variables.

LPI has been calculated by World Bank based on six indicators (Arvis *et al.*, 2018): Custom's efficiency and border management clearance, the quality of infrastructure related to trade and transport, the competence and quality of logistics services, the frequency with which shipments reach consignees within the scheduled or expected delivery time, the ease of arranging competitively priced international shipments and the ability to track and trace consignments. The overall LPI is constructed using the above indicators. The LPI ranges from 1 to 5, where higher index value represents better logistic performance. The original frequency of LPI data is biannual. Therefore, the LPI data is used to construct a strongly balanced panel data set from 2010 to 2016.

## 4. Results

### *4.1 Descriptive statistics*

Table 1 reports the descriptive statistics of the dependent and independent variables.

According to the Table 1, log CO2 per capita of the sampled countries are ranging from 0.446 to 2.141 with the mean value of 1.544 ($\sigma$ = 0.393). On the other side, LPI scores of the selected countries are ranging from 2.380 to 3.510 with the mean value of 2.904 ($\sigma$ = 0.314).

Figures 4 and 5 illustrate the CO2 emissions and LPI scores of the selected Balkan countries, respectively.

As seen in Figure 4, the CO2 emissions of Bosnia and Herzegovina, Bulgaria, Greece and Slovenia are higher than the other countries. Albania has the lowest CO2 emissions in the sample. The trending behavior of lnCO2 emissions in the countries is different from each other. In Albania, Bosnia and Herzegovina and Turkey, InCO2 emissions increased, while

| Variable | No. of observations | Mean | SD | Min | Max |
|---|---|---|---|---|---|
| lnCO2 | 44 | 1.544 | 0.393 | 0.446 | 2.141 |
| LPI | 44 | 2.904 | 0.314 | 2.380 | 3.510 |
| GDP | 44 | 9.096 | 0.589 | 8.317 | 10.201 |
| URBANPOP (%) | 44 | 60.532 | 9.639 | 45.558 | 78.387 |
| INTTRADE (%) | 44 | 90.939 | 26.104 | 45.899 | 146.369 |
| INDVA (%) | 44 | 23.376 | 5.247 | 13.828 | 37.827 |

**Table 1.**
Descriptive statistics

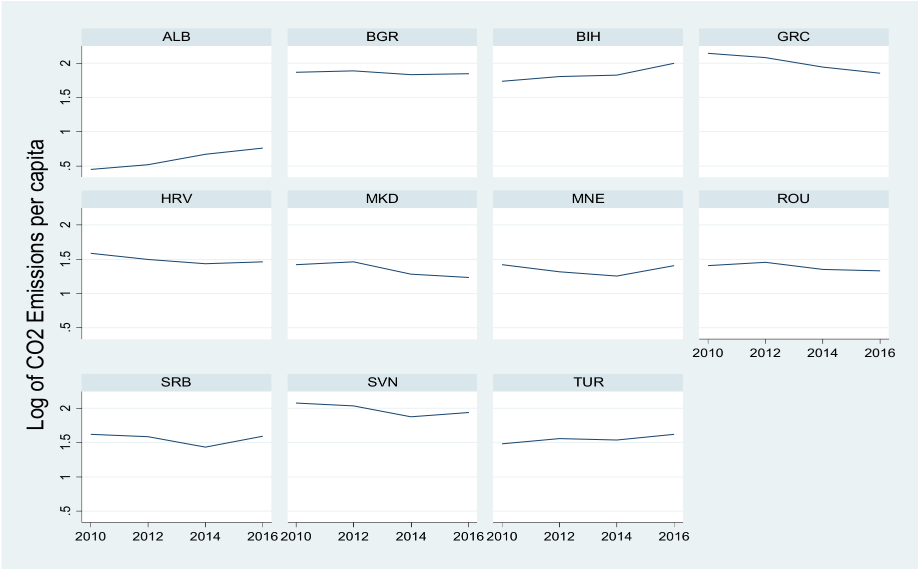


**Figure 4.**
CO2 emissions of the selected Balkan countries (2010–2016)


**Figure 5.**
LPI scores of the selected Balkan countries (2010–2016)

Croatia, Greece, North Macedonia, Romania and Slovenia demonstrated a decreasing trend for the sampled years.

When considering LPI scores, Turkey has the highest score ($LPI_{2016}$ = 3.42), and Montenegro has the lowest score ($LPI_{2016}$ = 2.38) in 2016. As can be seen in Figure 5, the trend of LPI scores varies from country to country. Croatia, Greece, Romania, Serbia, Slovenia and Turkey were able to increase their logistics performance in 2016 compared to 2010. However, the logistic performance of Albania, Bosnia and Herzegovina, Montenegro and North Macedonia decreased in 2016 compared to 2010.

### *4.2 Correlation analysis*

The results of the Pearson correlation analysis are reported in Table 2.

From Table 2, it can be concluded that there is a significant (at 0.01 level) positive correlation ($r$ = 0.4184) between logistic performance and CO2 emission of the countries. Besides the correlation between LPI and lnGDP per capita is significant at 0.01 level and positive ($r$ = 0.6489). But the correlation analysis might be misleading and does not show the *ceteris paribus* effects of LPI on lnCO2. There is a possibility of the change of nature of the relationship between LPI and lnCO2 after controlling for some observables such as lnGDP, URBANPOP, INTTRADE and INDVA. Hence, we estimate the following fixed-effects panel data model to obtain genuine causal effect. The estimation result is reported along with heteroscedasticity and serial correlation robust standard errors to obtain efficient fixed effects estimators.

### *4.3 Regression results*

Table 3 reports the results of the fixed-effects panel regression analysis for CO2 emissions. The rejection of the null hypotheses of F test and BP test for poolability enables us to discard pooled OLS, but the double rejection also leads us to two different types of panel data model: fixed-effects (FE) and random-effects (RE) consecutively. Therefore, we conduct Hausman test to choose between the FE and RE model, and Hausman test indicates that FE estimators are efficient because of the strong rejection of the null hypothesis. That is why we choose FE model to estimate the causal relationship between CO2 emission and logistic performance index.

The coefficient estimates should be interpreted based on the log-level functional form. Our key independent variable, logistic performance index, is statistically significant at 0.05 level, and its sign is in line with our expectation. Ceteris paribus, one point increase in LPI score is predicted to decrease CO2 emission by 14.52%. This result is consistent with the findings of Mariano *et al.* (2017) and Lu *et al.* (2019) and indicates that there is a positive relationship between logistics performance and carbon performance for sampled Balkan countries.

The coefficient estimates on GDP per capita and urban population ratio are also individually significant at 0.01 level. If the GDP per capita increases by 1%, CO2 emission is estimated to increase by 0.7662%, and if the urban population ratio increases by one-

**Table 2.** Pearson correlation matrix

| | lnCO2 | LPI | GDP | URBANPOP | INTTRADE | INDVA |
|---|---|---|---|---|---|---|
| lnCO2 | 1 | – | – | – | – | – |
| LPI | 0.4184*** | 1 | – | – | – | – |
| GDP | 0.5909*** | 0.6489*** | 1 | – | – | – |
| URBANPOP | 0.2606* | 0.3237** | 0.3862*** | 1 | – | – |
| INTTRADE | 0.2149 | −0.1396 | −0.0247 | −0.2657* | – | – |
| INDVA | −0.0654 | 0.332** | −0.034 | −0.3993*** | 0.0941 | 1 |

**Notes:** ***significant at 0.01; **significant at 0.05; and *significant at 0.10

| Dep. variable: the natural logarithm of carbon dioxide emission per capita (lnCO2) | Coefficient | Robust Std. errors | *p*-value |
|---|---|---|---|
| *Key independent variable* | | | |
| Logistic performance index (LPI) | −0.1452** | 0.0568 | 0.029 |
| *Control variables* | | | |
| The natural logarithm of GDP per capita at constant prices (GDP) | 0.7662*** | 0.1079 | 0.000 |
| Urban population/total population (%) (URBANPOP) | 0.0839*** | 0.0134 | 0.000 |
| International trade/GDP (%) (INTTRADE) | 0.0024 | 0.0022 | 0.308 |
| Industry value added/ GDP (%) (INDVA) | −0.0079 | 0.0061 | 0.224 |
| *Time fixed effects* | | | |
| Year 2012 | −0.0643 | 0.0378 | 0.119 |
| Year 2014 | −0.2155*** | 0.0586 | 0.004 |
| Year 2016 | −0.2856*** | 0.0632 | 0.001 |
| Constant term | −9.9753*** | 0.9391 | 0.000 |
| Number of observation | 44 | | |
| *R*-square | 0.751 | | |
| *F* test for overall significance | 122.68*** (0.000) | | |
| *F* test for poolability (POLS vs FE) | 120.32*** (0.000) | | |
| BP test for poolability (POLS vs RE) | 41.30*** (0.000) | | |
| Hausman test (RE vs FE) | 24.41*** (0.002) | | |

**Notes:** ***Significant at 0.01 level; **significant at 0.05 level; *significant at 0.10 level

**Table 3.** Fixed-effects panel regression results for CO2 emissions and logistic performance index

percentage point, CO2 emission is predicted to increase by 8.39%. These results are also in line with the findings of Mariano *et al.* (2017), Lu *et al.* (2019) and Liu *et al.* (2018).

The time fixed effects (year dummies) for 2014 and 2016 are statistically significant and negative. After controlling for the observables, there is a decline in CO2 emissions when compared with the base year 2010.The *ceteris paribus* decrease in CO2 emission might be owing to the global effort for restricting CO2 emissions.

## 5. Conclusion

The world has been facing major challenges in all three dimensions of sustainable development, namely, economic, social and environmental. Accomplishing sustainable development requires taking actions in economic and social development and protecting the environment. As its effects could be felt globally, climate change is the leading challenge for environmental development, and the main factor causing global climate change is carbon emissions. In this regard, logistics industry has a major role in sustainable development of countries because of its contribution to economic and social development and its effect on environment owing to the carbon emissions caused during the processes of ordering, transporting and holding.

To measure the economic performance of countries, World Bank developed a benchmarking tool known as LPI which helps countries to measure their performance. This study aims to analyze the relationship between logistics and carbon performance of Balkan countries by using the LPI scores. As the Balkan region has an important geostrategic position that enables transportation between Europe and Asia, the logistics industry has a critical role for the sustainable development of the countries located in this region. The results of this study indicate that there is a positive and significant relationship between LPI and carbon performance of the selected countries. In other words, Balkan countries that have higher LPI scores are more likely to have less carbon emissions. As it is known, countries which are members, or in the process of becoming a member of European Union, have to adopt carbon reduction targets, apply mitigation policies and measure that they are in line with the EU legislations. As stated before, most of the Balkan countries are already members or in the process of becoming a member of European Union. The efforts to meet the requirements of EU legislations may provide a possible explanation for the positive relationship between LPI scores and carbon performance of selected Balkan countries.

This study is based on only 11 Balkan countries. In this sense, the data used in the analysis is limited. However, the results of the study indicate that LPI can be used as a useful tool by policymakers to both improve the logistics performance and reduce the carbon emissions of the countries. In this sense, the findings of the study may provide useful insights for policymakers to achieve sustainable economic development.

Finally, future studies may provide a comparison of LPI scores and carbon performance of Eastern Europe and Western Europe countries, considering that these countries have different levels of economic development.

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